The impact of regional supply network structure and governance on the resilience of resource extractive regions: The case of South Australia

by

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Table of contents

5

Quantitative study 147

6

Qualitative study 221

7

Discussion **269**

8

Conclusion **317**

References **327**

Appendices **349**

List of figures

List of tables and exhibits

List of publications

Statsenko, L., Gorod A., Ireland V. (2017). **A complex adaptive systems (CAS) framework for regional supply chains governance.** *Supply Chain Management: An International Journal* (under review).

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Thesis declaration

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________________________________1 December, 2017

Larissa Statsenko

Abstract

This thesis examines the adaptation processes among mining equipment and technology services (METS) firms' in the South Australian resource sector from 2014 till 2016 during a global downturn in resource commodity prices. Of special interest was the effect on the METS firms of the structure and governance of the resource industry regional supply network in terms of their ability to adapt to the downturn and the implications for regional resilience.

The research was driven by the common problem faced by METS suppliers operating in resource extractive economies of how to prosper in spite of fluctuating mineral commodity prices. Downturns in commodity prices usually result in significant job losses, reduction in GDP growth and economic decline. It requires resilience at the firm and regional level to not only cope and recover from external shocks, but also to create new technological paths.

Previous research into the regional development of resource-extractive regions has proved that the development of technology and knowledge intensive, value-adding industries around resource extractive activity enhances the resilience of resource economies. A diverse and technology intensive METS sector emerging naturally in proximity to resource extraction sites is potentially able to use its accumulated knowledge and capabilities to overcome the consequences of a decline. In the right environment, METS firms can develop high value-added products and services that can have other industrial applications and find new niches in domestic and overseas markets. The ability of local METS companies to diversify and innovate results in the lateral transfer of technologies developed initially to serve the resource sector, encouraging regional economic diversification and the development of alternative growth paths during a decline in the resource sector.

Supply chain relationships are critical to the strategic diversification and innovation of regional METS experiencing resource constraints. Their ability to innovate and diversify depends not only on their own internal research and development efforts, but mostly on their collaboration with customers and supply chain partners around customer problems and solutions. Since there are multiple shared suppliers and clients, a regional supply network serves as a conduit for information and knowledge transfer. Our knowledge of the impact of the structure and governance in a regional supply network and firm diversification and innovativeness is still limited, however. There is a lack of conceptual explanation specific to how network governance in a regional supply network influences METS firms' ability to respond during those periods when the whole network is experiencing constrained resources.

To address this problem in the current research, a multilevel conceptual framework was developed, and a mixed-method research design adopted. The findings demonstrated that formal and informal instruments of regional supply network governance impact firms' strategies and facilitates both short-term adaptation and the long-term adaptability of regional METS. The research contributes to the economic resilience literature by providing empirical evidence of the role of regional supply network structure and governance as factors influencing regional firms' strategies at the micro-level. In turn, the strategies and behaviour of regional METS firms at the micro level impact adaptability and regional resilience at the meso-level. Therefore, a coordinated effort by governing bodies through policies and resource allocation is required to ensure the formation of well-connected, integrated regional supply networks that can foster long term adaptability and resilience in resource extractive regions.

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I must acknowledge here financial and informational support of the Mining Industry Participation Office, the State Government of South Australia for a Centre of Excellence Research Grant. I would also like to acknowledge the people who supported my ideas and infused me with energy and enthusiasm.

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Also, special thanks goes to Mr. Greg Clothier, who introduced me to the South Australian resource sector and its peculiarities, and to my two other Australian friends, Harry Sipols and Adele Feakes, who provided me with emotional and practical support in helping me to adapt to South Australia. Thanks also to academic editor, Barbara Brougham, who helped me polish the final document for submission.

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Glossary of select terms

Term	Definition
Bollen-Stine p value	The Bollen-Stine bootstrap p is a bootstrapped modification of the model chi-square statistics used to evaluate model fit. It adjusts for the lack of multivariate normality in the data.
Bootstrapping	In a modeling context, statistical bootstrapping is a technique that samples data from within a data set and generates standard errors based on repeated estimates of sample parameters.
Capability diversification	In this research METS capability diversification or service breadth was measured as the number of services and products offered to customers.
CFA	Confirmatory Factor Analysis – is a statistical technique used to verify the factor structure of a set of observed variables. It is used when the model is specified a priory.
Construct	A construct refers to a complex concept.
Construct Validity	Construct validity is the degree of conformity between a theoretical concept and a particular measuring device or procedure.
Convergent Validity	This represents a measure of the extent of the direct structural relationship between an observed variable and a latent construct. Convergent validity is achieved when the correlation (that is, the factor loading) is significantly different from zero.
Dependent variable	Sometimes referred to as a endogenous variable. Endogenous variables are hypothesised to be caused by other variables in a model. This is indicated by arrows pointing to an endogenous variable from another variable.
Discriminant Validity	Discriminant validity represents the degree to which the model constructs are dissimilar. Evaluating discriminant validity is important where the constructs are interrelated. Large correlations between the latent constructs (more than 0.80 or 0.90) suggest a lack of discriminant validity. In order to meet discriminant validity requirements, the average variance extracted for two constructs should be greater than the square of the correlation between the constructs.
Embeddness	The degree to which economic activity is constrained by non-economic institutions (Polaniy, 1944). Granovetter (1985) further defined it as ability of individuals to make decisions not only based on economic benefits but also with consideration of social relations they are embedded in. Embeddedness in supplier-buyer relationships refers to the interdependence or joint dependence of a company and its suppliers and customers (Gulati, & Sytch, 2007; Kim, Choi, & Skilton, 2015)
GDP	Gross Domestic Product
GSP	Gross State Product
Independent variable	Sometimes referred to as an exogenous variable. Exogenous variables have no hypothesised origin in a model and therefore no direct causal arrows point toward them (c.f. an endogenous variable).
Innovativeness	The process of making changes to products, processes, and services that result in new value creation to the organisation and its customers by leveraging knowledge efforts of the firm and (or) that of its supply network partners (OECD, 2009). In this research METS firm innovativeness was measured as the number of new products and services introduced over the last three years.

Latent variable	A latent variable represents a variable that cannot be directly observed. Because a latent variable cannot be observed directly, it cannot be measured directly; thus it must be operationally defined and measured in terms of behaviour believed to represent the particular latent variable (Byrne, 2001). In terms of a latent variable, the measured scores can be produced in terms of responses to particular questions on a survey. These responses which provide 'measured scores' are sometimes referred to as observed variables or indicator items (or items).
METS	Mining Equipment and Technology Services – companies that receive a substantial portion of their revenue, directly or indirectly from mining companies for the provision of goods and services based on specialised technology, intellectual property or knowledge (Martinez-Fernandez, 2010)
PLS SEM	Partial Least Square Structural Equation Modelling. Two types of SEM are used for analysis: covariance-based (CB-SEM) and variance-based partial least square techniques (PLS SEM, Hair, Sarstedt, Pieper, & Ringle, 2012). CB-SEM is aimed at estimating model parameters in a way that the difference between the estimated and sample covariance matrices is minimised, while PLS-SEM maximises the explained variance of the endogenous latent variables by estimating partial model relationships in an iterative sequence of ordinary least squares (OLS) regressions. In this thesis PLS SEM method is used.
Positional embeddedness	*Positional embeddedness* reflects the 'roles' that network actors occupy in the system, irrespective of the specific traits of these peers and the nature of the relationships between them. It goes beyond direct and indirect ties of a focal actor and explains the benefits associated with a certain position in the network through application of network models of equivalence and centrality (Borgatti, & Li, 2009)
Regional adaptability	Adaptability is an accumulation of unspecific capabilities that can lead to unforeseeable innovations and structural changes. Adaptability enables the development of new pathways as an escape from 'path dependence' (Christopherson, Michie, & Tyler, 2010; Grabher, 1993)
Regional adaptation	Adaptation refers to the incremental innovations and increasing specialisation that reproduce existing structures in the regional economy. Adaptation is concerned with changes within existing paths (Christopherson et al., 2010; Grabher, 1993)
Regional resilience	A long-term adaptive capacity of the regions to accommodate external shocks by reconfiguring their socio-economic and institutional structure to develop new growth paths (Boschma, 2014; Martin, 2015)
Regional supply network	For the purpose of this study, a regional industry supply network is defined and limited to a subset of supplier-buyer relations that exist upstream from a resource extraction (mining) companies operating in the resource extractive region
Relational embeddedness	Relational embeddedness is the nature of the relationships of a firm with its direct counterparts. It addresses the nature and quality of relationships between exchange partners, which reflects the degree of their interdependence. In this research relational embeddedness was defined as an aggregate of three dimensions: trust, information exchange and joint problem solving between supplier (METS firm) and client (Gulati, & Sytch, 2007; McEvily and Marcus, 2005). Relational embeddedness is one of the major governance mechanisms in inter-firm networks (W. Powell, 1990).
Reliability	Reliability is the level to which an observed variable measures the 'true' value of a variable and the extent to which it is 'error free' ('reliability' is the opposite of 'measurement error'). It refers to the consistency of measurement and can be It refers to the consistency of measurement and can be conceptualised as that part of a measure that is free of purely random error. In this research, reliability is measured using Cronbach alpha and composite reliability.

Resource extraction	Resource extraction includes mineral and gas extraction, and also resource-specific manufacturing (such as the production of metals and refined petroleum) (James Bishop, Christopher Kent, 2013)
Resource related activities	Resource-related activity includes investment that supports future production of resources as well as the provision of intermediate inputs that are used in the current production of resources. … [I]t captures activities that are directly connected to resource extraction, such as constructing mines and associated infrastructure, and transporting inputs to, and taking extracted resources away from, mines. It also captures some activities less obviously connected to resource extraction, such as engineering and other professional services (legal and accounting work, for example) (Rayner, & Bishop, 2013)
Sectoral diversification	Market diversification is defined as strategic redeployment of existing capabilities and assets in new directions or gradual movement to closely related markets. In this research sectoral diversification of the METS firm was measured as the number of sectors METS firm operates.
SEM	Structural Equation Modeling (SEM) is a general name for the statistical analysis of Structural Equation Models. Structural Equation Models are models that identify relationships among sets of variables. These can be identified by means of path diagrams.
Validity	Validity refers to the accuracy of a measure. It exists when a measure is a perfect representation of the variable being measured.

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The impact of regional supply network structure and governance on the resilience of resource extractive regions: The case of South Australia

In the short run, actors create relations; in the long run, relations create actors.
(Padgett, & Powell, 2012, p.2)

Preface

This research has evolved from a long interest and personal involvement in the resource sector and its challenges. My parents in Kazakhstan ran a medium size company supplying construction services to an asbestos mining company in a small company town, and on completion of my engineering postgraduate degree from Kazakh National Technical University, I began examining the managerial problems faced by mining regional communities. During 2009-2010, as a member of a consultancy team I began working with the senior managers in a mining company implementing a change management initiative. Through this experience, I developed an understanding of the overall problems faced by the mining industry in Kazakhstan. Due to low development of ‘soft’ skills and poor management practices, the industry experienced ‘lock-in’ as a result of an obsolete mindset and inability to see opportunities outside the traditional trajectories. The rigid mindset of engineers and managers working in mining companies and in firms providing services to the mining industry made any change difficult and had resulted in limited innovation within the industry as traditional business practices were enforced. The GFC of 2008 highlighted the need for major transformation in the mining sector in order to sustain it through downturns in mineral commodity prices.

Clusters became a popular paradigm for change in 2012-2015 in Kazakhstan, and were seen as a ‘silver bullet’ to move the mining sector towards innovative development. From 2010 there had been an increasing interest in the development of mining clusters in Kazakhstan, followed by an invitation from Michael Porter, the leading American economist to conduct an analysis of the mining sector.

Western school management practices and approaches to change management became very popular. In Kazakhstan, both Australia and Canada were considered advanced economies that had successfully managed to develop knowledge intensive service industries from natural resource endowments. The Kazakhstan mining leaders have been seeking ways to adopt the experience of Australia and Canada in terms of policy frameworks and regulations of the mining sector to attract foreign investment. These events in Kazakhstan to a large extent influenced my decision to explore management practices in the Australian resource extractive sector to augment my understanding of resource economies in transition.

I travelled to Australia in order to explore mining industry strategies, policies and management practices. In particular, I was interested in the issues associated with the development of mining clusters with an emphasis on local supply chains. I began ongoing discussions with government bodies involved in the South Australian mining industry transformation and the development of the regional supply chains to get a better understanding of the current challenges faced by mining companies and local suppliers [i.e., the mining equipment and technology services (METS) sector].

During the period of downturn in commodity prices, a pessimistic outlook in the sector was prevailing, and deteriorating economic forecasts for regional areas were the major concerns. These single company towns experienced huge job losses due to their substantial dependence on resource and energy enterprises that included Arrium Mining in Whyalla, Alinta Energy (a coal power station in Port Augusta), and the Nyrstar smelter in Port Pirie. The closure of Alinta Energy, the frozen operations of Arrium Mining and the reduced production volume of Nyrstar reminded me of the challenges of small single-industry towns in Kazakhstan. These experiences influenced the development of the research questions addressed in this research and I genuinely hope that the findings of my research make (even a small) difference for the communities dependent on resource industries.

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Chapter 1

Introduction

1.1 Introduction

The thesis explores the case of the South Australian resource extractive industry in 2012-2016 experiencing decline due to downturn in the commodity prices. The primary objective of this thesis is to identify in what way network structure and governance in the resource industry regional supply chains influenced South Australian Mining Equipment and Technology Services (SA METS) strategies and behaviour in changing economic environment. At the firm level, regional supply network acts as an environment for local METS firms that impacts their ability to adapt. In turn, firms adaptability at the micro-level with regional supply network structure and governance at the meso-level both contribute to adaptability and resilience of resource extractive region.

This chapter is organised as follows: Section 1.2 describes the research problem and sets the research questions and objectives, Section 1.3 briefly introduces research design – conceptual framework development and methodology adopted for this study, Section 1.4 justifies significance of the research. Section 1.5 introduces the broader context of this research - Australian resource economy and the nature of global resource sector, in the Section 1.6 the definition of Mining Equipment and Technology Services (METS) is provided. Section 1.7 discusses peculiarities of the South Australian resource extractive and METS sector. Section 1.8 provides outline of the thesis organisation and section 1.9 summarises the chapter. Figure 1.1 depicts chapter structure.

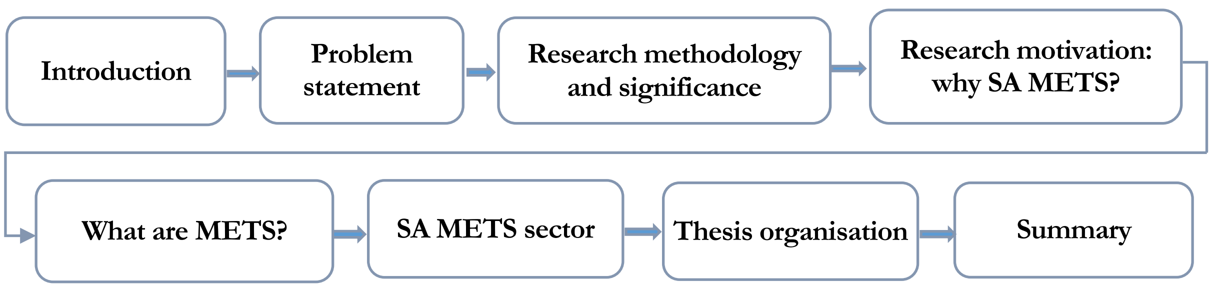

Figure 1.1 Chapter 1 structure

1.2 Problem statement

This research was driven by the common problem faced by many resource extractive economies of how to prosper despite fluctuating mineral commodity prices. Downturns in commodity prices result in significant job losses, reduction in GDP growth and economic decline. It requires adaptability at the firm and regional level to not only cope and recover from external shocks, but to create new technological paths that make the region more resilient in the future.

Previous research into the regional development of resource-extractive regions proved that ability of regional METS companies to diversify and innovate is key to formation of resilient resource extractive regions able to develop alternative growth paths, when there is a decline in the global resource sector (e.g. Chapman, MacKinnon, & Cumbers, 2004; Warrian & Mulhern, 2009). The development of technology and knowledge intensive, value-added industries around resource extractive activity enhances the resilience of resource economies. Since a diverse and technology intensive METS sector emerges naturally in proximity to resource extraction sites to support resource projects, this sector is potentially able to use its accumulated knowledge and capabilities to find ways of dealing with economic downturns. In the right environment, METS firms develop the capacity for high value-added products and services that can be applied in other industry sectors, and find new niches in domestic and overseas markets. Thus, the ability of local METS companies to diversify and innovate results in the lateral transfer of technologies developed initially to serve the resource sector, encouraging regional economic diversification and the development of alternative growth paths during a decline in the resource sector.

Previous research also proved that supply chain relationships are critical to capability development of regional METS often experiencing resource restraints. Their ability to innovate and diversify depends not only on their own internal research and development efforts, but mostly on their collaboration with customers and supply chain partners around customer problems and solutions (e.g. Martinez-Fernandez, 2010; Scott-kemmis, 2013). Our knowledge of the mechanisms acting in a regional supply network is limited, however. There is a lack of conceptual explanation specific to how network governance in a regional supply network influences METS firms' ability to respond during those periods when the whole network is experiencing constrained resources. Organisational studies acknowledge role of network governance and firms embeddness in a network in enhancing operational and innovative performance of participating firms in other industry sectors, including but not limited to biotechnology and apparel industries (Powell, Koput, & Smith-Doerr, 1996; Uzzi, 1996, 1997).

This thesis addresses the above-mentioned gaps by exploring how embeddedness in the regional supply network influences METS firms' ability to diversify and innovate, thus contributing to adaptation of resource extractive regions during downturn in the resource sector.

This PhD research sought to investigate in particular:

1 various kinds of strategies SA METS firms developed to sustain and grow their businesses in 2014-2016 during the downturn in the resource sector

2 structure and governance instruments of the SA regional resource industry supply network

3 the relationships between network embeddedness of SA METS companies' and their ability to adapt through innovation and diversification

4 the relationships between regional resource industry supply network structure and governance and regional adaptability and resilience

Central to this research are the following research questions:

RQ 1. *What kinds of strategies were used by SA METS companies to adapt during the downturn in the resource sector in 2014-2016?*

RQ1.1 *What kinds of adaptability strategies including innovativeness and diversification (involving emergence of value added activities) were used by SA METS during downturn in the resource sector in 2014-2016?*

RQ1.2 *What kinds of short-term adaptation strategies were used by SA METS during downturn in the resource sector in 2014-2016?*

RQ 2. *How does positional and relational embeddedness affect development of adaptability strategies (diversification and innovativeness) of METS firms at the firm level?*

RQ2.1 *Are there relationships between SA METS firm diversification and innovativeness?*

RQ2.2 *What is the impact of SA METS firm positional embeddedness in the regional resource industry supply network on its sectoral and capability diversification strategies?*

RQ2.3 *What is the impact of SA METS firms' positional embeddedness in the regional resource industry supply network on its innovativeness?*

RQ2.4 *What is the impact of SA METS firms' relational embeddedness in the regional supply networks (trust, joint action and information exchange) on METS firms' sectoral and capability diversification strategies?*

RQ2.5 *What is the impact of SA METS firms' relational embeddedness in the regional supply networks (trust, joint action and information exchange) on its innovativeness?*

RQ3. *How do network governance instruments contribute to adaptability and resilience of resource extractive regions through emergence of value-added industries around resource extractive activity?*

RQ3.1 *How effective were governance instruments applied in the SA resource industry regional supply network during downturn from 2014 to 2016?*

RQ3.2 *In what way did regional supply network structure and governance contribute to adaptation and resilience of the SA resource extractive economy during downturn from 2014 to 2016?*

1.3 Research methodology and significance

To answer the research questions, a pragmatist research paradigm with the mixed methods research design was adopted to explore adaptation processes in the South Australian resource-extractive sector from 2014 till 2016, which experienced economic downturn when there was a global decline in the commodity prices.

The research design included three major stages.

- At the *first stage*, the literature search and in-depth exploratory interviews with key informants including state and national government officials, mining companies and Tier 1 EPCM providers, resource industry association leaders were conducted to inform the development of the conceptual framework.
- The *second stage* involved a survey of METS firms operating in South Australia coupled with the analysis of supply network connections among SA METS firms have been conducted to test relationships postulated in the conceptual framework.

- The *last stage* incorporated qualitative interviews with the SA METS firms to get insights into the strategies of adaptation during the downturn in the resource sector, the role of position and relationships within the SA resource supply chain.

In addition, the researcher drew on multiple secondary sources including industry and government reports and field notes from observations, participation in the industry networking events and conferences to build up the case. Mixed methods research design, as well as variety of sources used in the current research ensured the validity of the findings through methodological and source triangulation.

Contribution to theory. This research contributes to the economic geography literature concerned with the evolution of extractive regions and clusters, by exploring transformation processes in the South Australian resource extractive industry during the downturn in commodity prices from 2014 till 2016. The research combined an evolutionary view on regional resilience, network governance and regional development of resource extractive regions literature to develop a multi-level conceptual framework. The conceptual framework developed in this study links regional supply network positional and relational embeddedness with METS firms' ability to adapt during a downturn in the resource sector through innovation and diversification. The moderating effects of tier position within the supply chain structure and membership in industry associations were also tested.

This research also contributes to the regional resilience literature by providing empirical evidence of the micro-level mechanisms – local METS firms' strategies and behaviour and regional supply network structure and governance on – the resilience of mature industrial regions. This research extends the framework for exploring transformation and adaptation of resource extractive regions proposed by (Chapman et al., 2004) and addresses the calls in the literature for the provision of evidence of the role of agency – micro-level strategies and behaviour producing meso-level outcomes.

Furthermore, although much of the thesis clearly articulates with economic geography it is also contributes to complex project management discipline. First, there is an obvious emphasis on what might be termed Complex Project Management theory and practice. Complex Project Management in this sense has a primary focus on projects that involve adaptive and network centric systems co-ordinated by multiple stakeholders to achieve outcomes desired by all parties. Furthermore, regional supply network is a complex system driven by endogenous mechanisms and its development thus is a complex project from the perspective of a governing body. Second, in the context of an industry that is forced by economic circumstances to evolve new forms of operation, through innovation and organisational change, there is a pressing need to bring into play 'big picture' strategic thinking with the recognition of the networked effects of regional supply chain systems and their impact on adaptability and resilience of industrial regions. Third, as the thesis continuously demonstrates, the top-down hierarchical and linear models of management are less relevant in the context of an industry in transition, which is invariably complex. Taken together the thesis has an equally strong interest in the contextual and conceptual aspects of Project Management.

Contribution to practice. From the practical perspective, the findings of this thesis inform policy makers and industry stakeholders involved into the development of the South Australian METS sector. Understanding pathways for economic renewal and diversification and the role of regional supply network structure and governance in this process is particularly important for more effective allocation of resources and development of policies and incentives to ensure resilience and future sustainable growth of the SA economy.

1.4 Research motivation: Why South Australian METS firms?

The selection of the South Australian resource sector as a case for this research was influenced by the following factors. Firstly, the mining industry and related services sector make a significant contribution to exports and the gross state product in South Australia. South Australia will continues to rely on resource sector as a major contributor to its Gross State Product. Secondly, the development of efficient and competitive local supply chains for resource sector is one of the top priorities for the South Australian government. Thirdly, the focus of interest is on the large-scale transformation and restructuring of the South Australian regional supply chains, which took place in the mining sector because of global downturn in commodity prices. Finally, the researcher developed interest and connections with practitioners in the SA resource industry through involvement in resource related projects for the last five years. The researcher has a background and understanding of the resource industry and its peculiarities from her past experience.

1.4.1 Australian resource economy

Since minerals were first discovered in Australia in the 1840s, many regions have been opened up by resource development. Resource regions have become important from both a government and community perspective since resource extraction provides significant economic return, although it does so by expending non-renewable assets. Resource development in Australia has given rise to settlements and infrastructure development, including roads, ports, airports and railways. Other benefits include contributions to rural and regional development, technology innovation and environmental research.

Since 2000 there has been significant growth in mining commodity exports, resulting from the increasing demand for raw materials from China and India, which has contributed significantly to the growth of the Australian economy. Currently, Australia is a major global producer of minerals, and the world's largest exporter of coal, iron ore, bauxite, lead, zirconium and titanium; the second largest exporter of gold, zinc and uranium; the third largest exporter of silver, nickel and aluminum; and the fourth largest exporter of diamonds. In 2015, the mining sector contributed around 8.5% to Australia's GDP and employed 2% of the workforce. Currently, mining made up over 50% of Australia's total export earnings (Austmine, 2015).

The major export markets are China and India, large economies with low levels of GDP per capita and even with the recent downturn in commodity prices, they are likely to remain in the high energy and materials-intensive phase of economic development in the foreseeable future. Australia currently has long-term (over 20-year) contracts to supply gas to China, India, Japan and South Korea. According to forecasts by the Department of Industry and Science, minerals and energy export earnings will increase by around 6% per year between now and 2020.

Despite Australia being one of the few countries that has managed to grow into one of the world's most advanced economies by exploiting its natural resources, its economy is still vulnerable to cyclical downturns in mineral commodity prices, just as are other countries that export natural resources (Rehner, Baeza, & Barton, 2014).

1.4.2 The cyclical nature of the resource sector and its impact on economies

The resource sector globally is characterised by ‘boom and bust’ cycles associated with the volatility of commodity prices. The recent global downturn in commodity prices that began in mid-2011, has resulted in a massive slowdown in the resources extractive sector in Australia since 2013, resulting in currency depreciation and increased unemployment rates (Figure 1.2). Since the resource sector is capital-intensive, price level cycles are mainly driven by liquidity – the availability of investment funding. Mining booms are characterised by periods when investors are willing to pay a premium, and assign high market value to exploration potential, whereas mining busts find investors are risk averse, and miners trade at a discount in value. The lags between demand and supply, the ‘herd behavior’ of stock markets, and the dependence on the overall well-being of major economies consuming resource commodities are major factors contributing to the dynamics of resource production and marketing at the global scale.

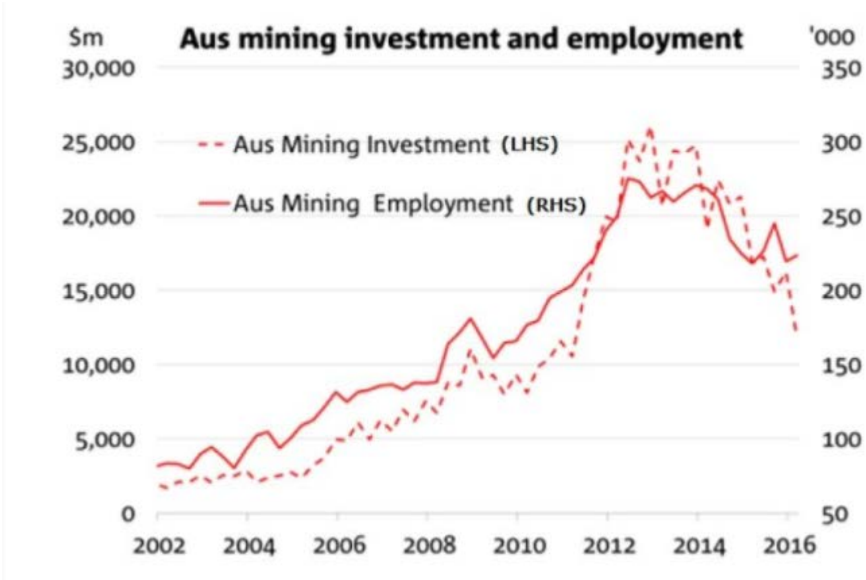

Figure 1.2 **Mining investment and employment in Australia from 2002 till 2016 (ABS, NAB Group Economics[1])**

Boom periods in the mining sector usually lead to increased capital investment, exploration activity and new mines opening. High export commodity prices drive national currency appreciation and disproportionally high wages in the mining sector compared to other sectors of the economy. This leads to an increase in prices for products and services supplied to the mining sector, contributing to an

[1] http://www.abc.net.au/news/2016-06-10/mining-investment-and-employment/7500786, accessed 4 Oct 2017

overall high-cost local economy. Other industry sectors become non-competitive on the export market due to the high value of the domestic currency.

Bust periods are associated with national currency depreciation, massive retrenchment and rising unemployment. The economy is forced to restructure again due to the massive release of a highly-qualified workforce. Service sectors experience reduced demand, and a search for new strategies – including downsizing, diversifying to other sectors and finding new market niches – begins.

These periods of restructuring due to an economic downturn are of great concern to government bodies at all levels. Tax regulations and policies are implemented to mitigate the effects on national and regional economies, and governments often support other sectors by spending, for example, on defence and infrastructure projects, to stimulate local economy and create more jobs. To support local industries supplying goods and services to the resource sector, the government encourages and supports innovation and diversification strategies, export, partnering and alliance formation to survive through the downturn. On a positive note, the decline can be seen as an opportunity for many companies to find new development paths, for governments to re-orient the economy towards the development of more sustainable industries, for entrepreneurs to find new market niches, and a general move away from resource export dependency. During the mining boom, the rapid increase in demand for natural resources usually leads to significant growth in the resource extraction sector triggering the development of other industries providing inputs to resource extraction activity – the mining equipment and technology services (METS). The most recent growth of Australian METS sector occurred in 2010-2012 in response to the massive demand for services from the expanding resource industry. Since then, this resource-related activity has become more intensive in the use of labour, technology and knowledge than the resource extraction sector itself and has provided a significant contribution to the economy in terms of GDP, export and employment.

Since 2013, as a result of a drop in commodity prices largely dependent on slowdown of Chinese economy, there has been a significant reduction in investment in exploration projects and current operating mines in Australia, which has resulted in a decreased demand for METS services.

Nevertheless, according to an Austmine2 survey (2015), in 2015 the METS sector still contributed around $AUD90 billion in revenue to the economy, a large proportion of which came from exported products or services. The average national contribution of METS sector to Australia's GDP came to 4.7% in 2015. The METS sector is one of the most internationalised sectors in Australia, with approximately 66% of companies exporting products and services all over the world. It is also an important contributor in terms of employment, with over 350 000 workers across Australia.

1.4.3 South Australian resource economy

South Australia has had a long engagement in the resource extraction sector, with the major oil and gas company SANTOS being established in South Australia in 1954, and Roxby Downs in 1970 to support the BHP Olympic Dam mine and other mining investments.

In South Australia, as in other states, resource extraction and related activities make a significant contribution to exports and the gross state product and the effects of downturn were more significant than in other Australian states. The South Australian resource economy is considered to be smaller than in other Australian states, e.g., Western Australia, Queensland and New South Wales. South Australia's shares in Australia's key mineral resources are as follows: copper 69%, gold 28% and uranium 81%. The exploration expenditure was AUD 617.4 million in 2014, including AUD 106.7 million for minerals exploration and AUD 510.7 million for petroleum exploration. The capital expenditure in 2013-2014 was 1.8 billion, the mineral production was AUD 5.6 billion and petroleum production – 1.9 billion. In 2015 the sector contributed 39% to state exports, which is AUD 4.5 billion, including AUD 4.3 billion for Minerals and AUD 0.2 for petroleum commodity (Heithersay, 2015).

In the current downturn period, the economy of South Australia has been significantly affected by large-scale mining projects, which are the key sources of market demand for South Australian technology and services suppliers. The major tenements in November 2014 are identified in Table 1.1 and major mining and oil and gas projects in 2014-2015 are illustrated in Figure 1.3.

[2] Austmine is the national industry body for the mining equipment, technology and services (METS) sector. http://www.austmine.com.au/

Table 1.1 Mineral tenements (November 2014) (Heithersay, 2015)

Type of a tenement	Number of tenements
mining leases	861
extractive mining leases	649
private mines	235
operating mines	~450
major operating mines	~20
opal mining claims	380
advanced mineral projects	~30
former mines	3500

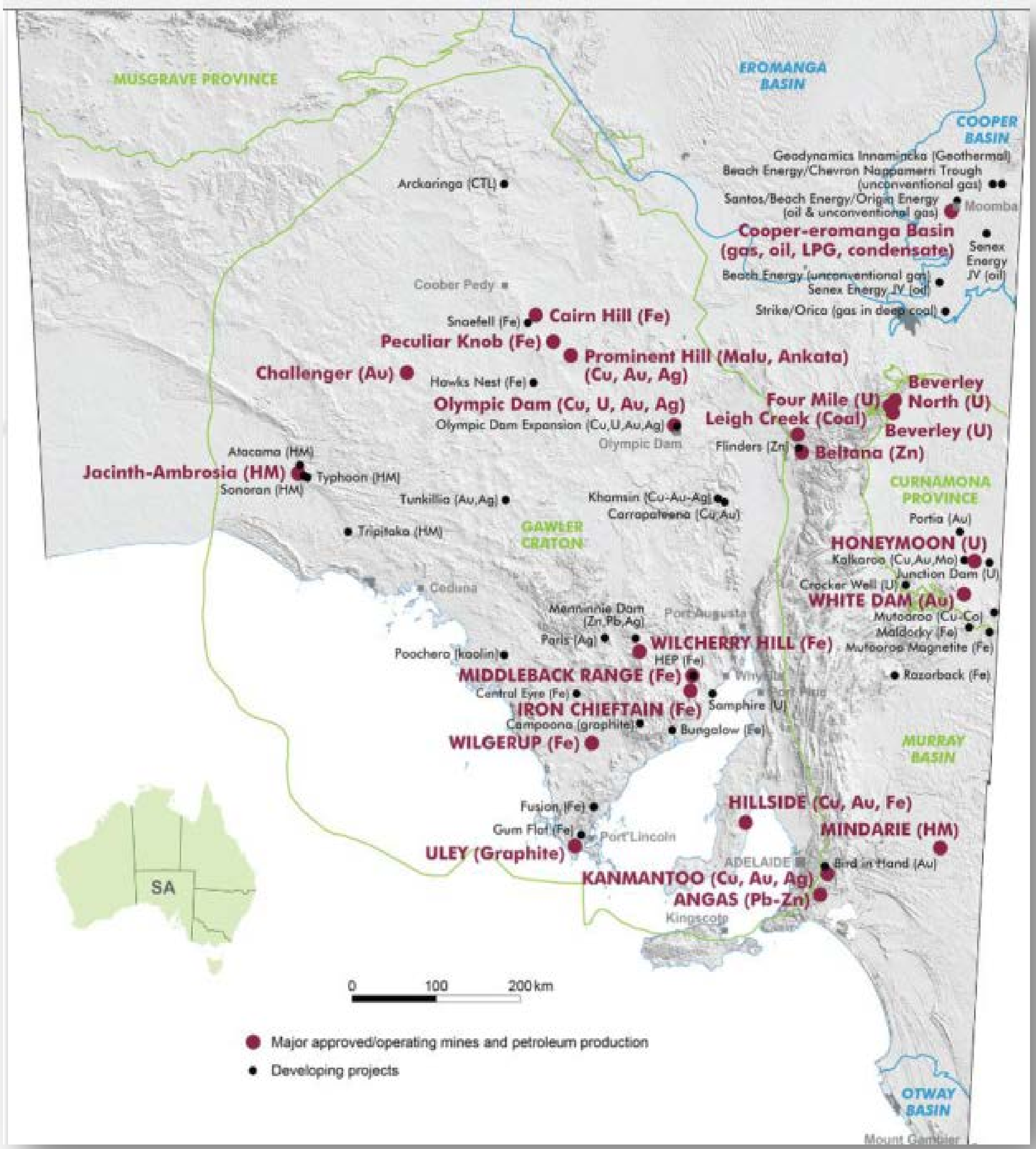

Figure 1.3 Major mining and oil and gas projects (approved/operating and developing) (Heithersay, 2015)

1.5 What are mining equipment and technology services?

The focus of this research was the resource extractive and associated mining equipment and technology services (METS) sector. For the purposes of this research the term resource economy is used to identify resource extraction and resource-related activity.

1.5.1 Resource extraction and resource-related activities

The resource economy is composed of actors that own mines and deposits and conduct exploration activities, such as major and junior mining companies and concentration plants, situated in close proximity to the ore deposits. In this thesis, all economic activity in the resource economies is conceptually divided into three parts: (i) *resource extraction*, (ii) *resource-related activity*, and (iii) *non-resource activity* (Bishop & Kent, 2013). …*Resource extraction* includes mineral and gas extraction, and also resource-specific manufacturing (such as the production of metals and refined petroleum).

> ***Resource-related activity*** *includes investment that supports future production of resources as well as the provision of intermediate inputs that are used in the current production of resources. … [I]t captures activities that are directly connected to resource extraction, such as constructing mines and associated infrastructure, and transporting inputs to, and taking extracted resources away from, mines. It also captures some activities less obviously connected to resource extraction, such as engineering and other professional services (legal and accounting work, for example).*
>
> ***Non-resource activity*** *includes everything else in the economy that does not have a direct relationship to the current and future production of resources. … (Rayner & Bishop, 2013, p. 22)*

By clarifying the differences between these definitions, the authors stress that:

> *Among other things, there are income effects associated with dividend payments to households, the benefits of tax revenue from resource extraction and resource-related activities, and spending by those working in those industries. However, only production, not income linkages, are considered…(Rayner & Bishop, 2013).*

Thus, *resource-related activities* are performed by a diverse range of local companies located in proximity to mining extraction hubs addressing the needs of the major operators of the mining deposits, such as the supply of manufactured inputs and construction services (Bas & Kunc, 2009; Knobblock, 2013). The schematic representation of the resource sector core and related activities is depicted in Figure 1.4.

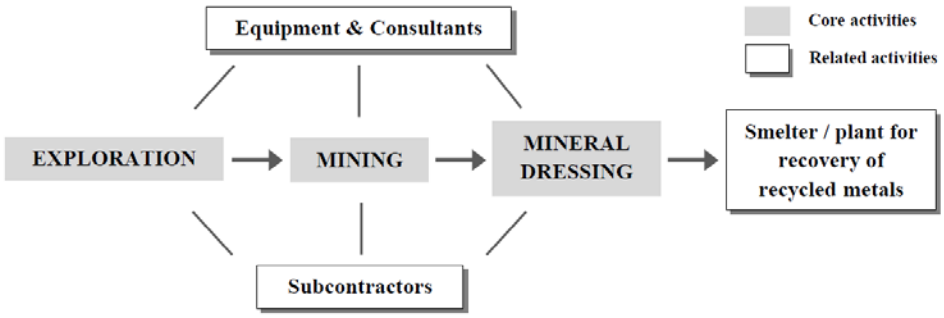

Figure 1.4 Simplified diagram of resource related activities (from Knobblock & Pettersson, 2010)

Resource related services are referred to as *mining equipment and technology services* (Scott-Kemmis, 2013), *mining supply and services* (Warrian, & Mulhern, 2009), *mineral inputs* (M. Walker, & Minnitt, 2006a), *mining technology services* (MTS) (Martinez-Fernandez, 2010), *mining equipment and specialist services* (Kaplan, 2012), *mining core and related activities* (Knobblock, 2013), *specialised knowledge intensive mining services providers* (SKIMS) (Morris, Kaplinsky, & Kaplan, 2012). The more restrictive specification emphasises firms with specialist technology related to the mining life-cycle, while a more inclusive approach incorporates suppliers of contract mining and construction services (Scott-Kemmis, 2013) (Figure 1.5). The Australian Technology Services Action Agenda (MTSAA) group define the MTS as:

> *Comprising of companies, institutions , associations and other organisations that receive a substantial portion of their revenue, directly or indirectly from mining companies for the provision of goods and servises based on specialised technology, intellectual property or knowledge… (Martinez-Fernandez, 2010)*

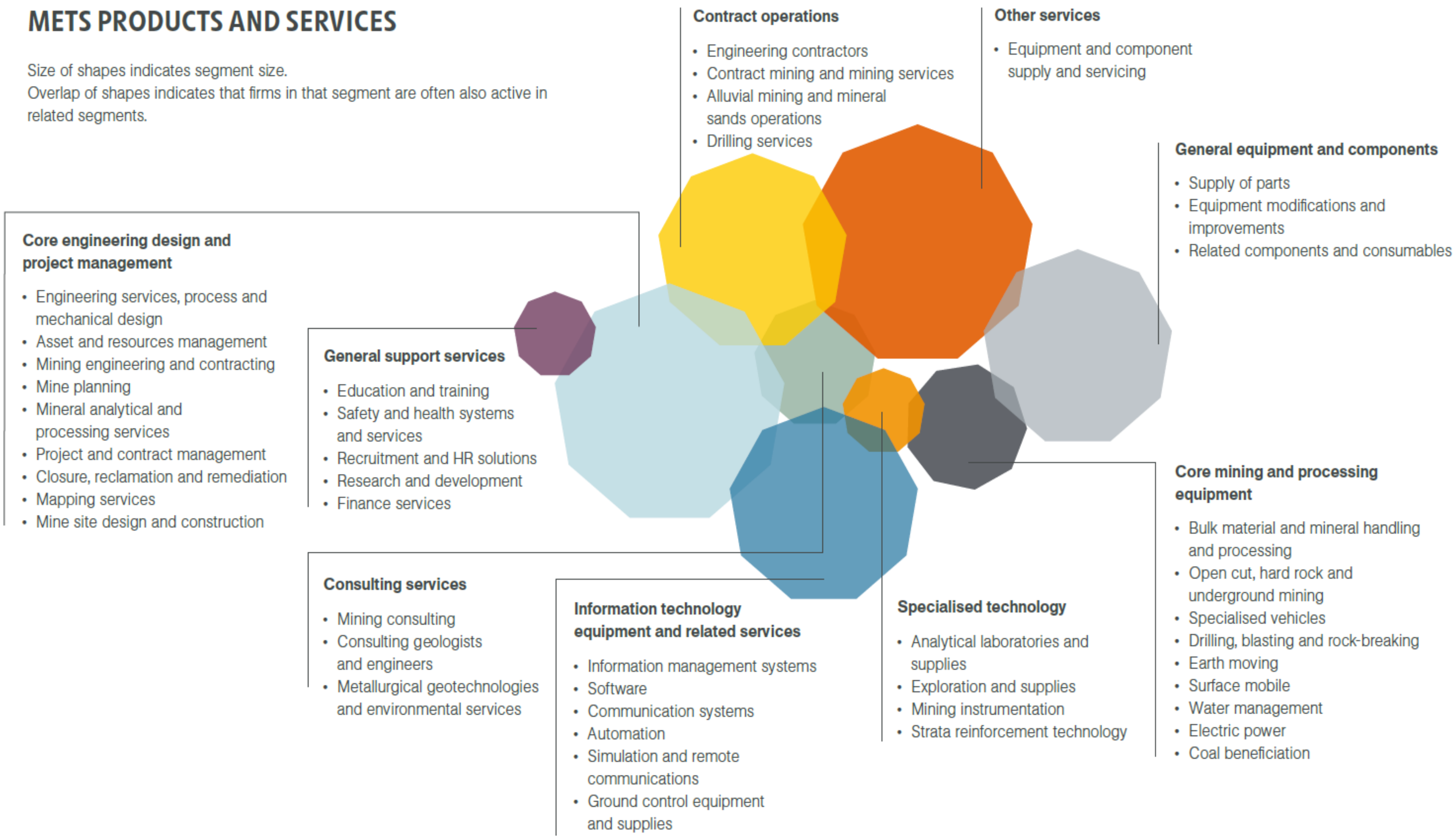

Figure 1.5 The composition of the METS sector (METS Ignited Report, 2017)

1.5.2 Tiered structure of the resource industry supply chains

Despite the output of the resource industry in commodity production, which has less variety and low complexity compared to the products of high-value added industries, it is characterised by significant supply chain complexity due to highly diverse inputs and high integration into the global supply chain.

The typical mining company establishes its supply chain to procure the major stages of mining projects. As shown in Figure 1.6, these major stages include exploration, project management, construction, operation and rehabilitation phases. METS suppliers perform various activities at the different stages of a mining project. A broader definition of resource and energy supply chain also includes downstream links to smelters and metal processing plants (Warrian, & Mulhern, 2009).

Figure 1.6 The METS services involved at the different stages of the mining project (Department of State Development, 2015)

Tier 1 suppliers. The Tier 1 suppliers to mining companies are represented by the Engineering Procurement and Construction Management (EPCM) or Engineering Procurement and Construction (EPC) providers. These large project management and engineering companies cover a broad range of capabilities and are highly diversified. They operate in multiple sectors including the global markets of water, energy and resources, environment, property and buildings, and transportation projects.

These companies can take on the risks of big mining projects and usually provide such services as design, feasibility studies, and execution of the design, procurement, installation and operation of the facility as a single package.

Tier 2 suppliers. Tier 2 suppliers are usually represented by companies, whose core business is in construction, engineering and project management or those of original equipment manufacturers (OEM). These companies are engaged at early stages of a mining project. Tier 2 servicing EPCMs are also large, international engineering companies that are not necessarily associated directly with the resource industry. They usually provide construction, maintenance and industrial services to the resources, energy and infrastructure sectors. OEMs are international companies who may work directly with mining companies or sub-contract to EPCM providers or work with other Tier 2 service providers.

Tier 3 and 4 suppliers. Tier 3 sub-contractors service EPCMs or Tier 2 contractors, including professional services, manufacturing companies, transportation, and small engineering companies. Tier 4 sub-contractors servicing Tier 2 and Tier 3 firms including distributors and Tier 5 are materials and services suppliers to Tier 3 and Tier 4 firms.

Tiered procurement. At each stage of the mining project ‘tiered procurement’ strategy is applied. For example, Tier 1 sub-contractors receive opportunities directly from resource companies. These companies are mainly represented by large-size internationally operating engineering procurement and construction management companies (EPCMs) and more rarely by large size original equipment manufacturers (OEMs).

Tier 2 sub-contractors to a mining project receive opportunities from Tier 1. Tier 2 suppliers are mainly represented by companies sub-contracted by EPCMs to undertake specific aspects of design, management or installation of a mining project, including engineering design, civil construction, electrical engineering or environmental, water or tailings management. Tier 2 suppliers could be OEMs, component manufacturers servicing OEMs with particular types of equipment or processes, and represent a wide spectrum of standard and specialised component manufacturers. Tier 2 input providers may supply chemicals for explosives or reagents for manufacturing or steel production.

Tier 3 suppliers receive opportunities from Tier 1 and Tier 2. They are sub-contractors supplying large work packages in key areas or specialist providers of technology, equipment or services, and have experience working on major projects and the capacity to bid for major projects. Tier 4 suppliers receive opportunities from Tier 2 and Tier 3. Tier 4 are usually suppliers of niche products who lack the systems and project management capabilities of higher tiers. They may lack experience of working with major projects.

Resource sector supply chain, tier structure and relevant companies' capabilities are summarised in Figure 1.7.

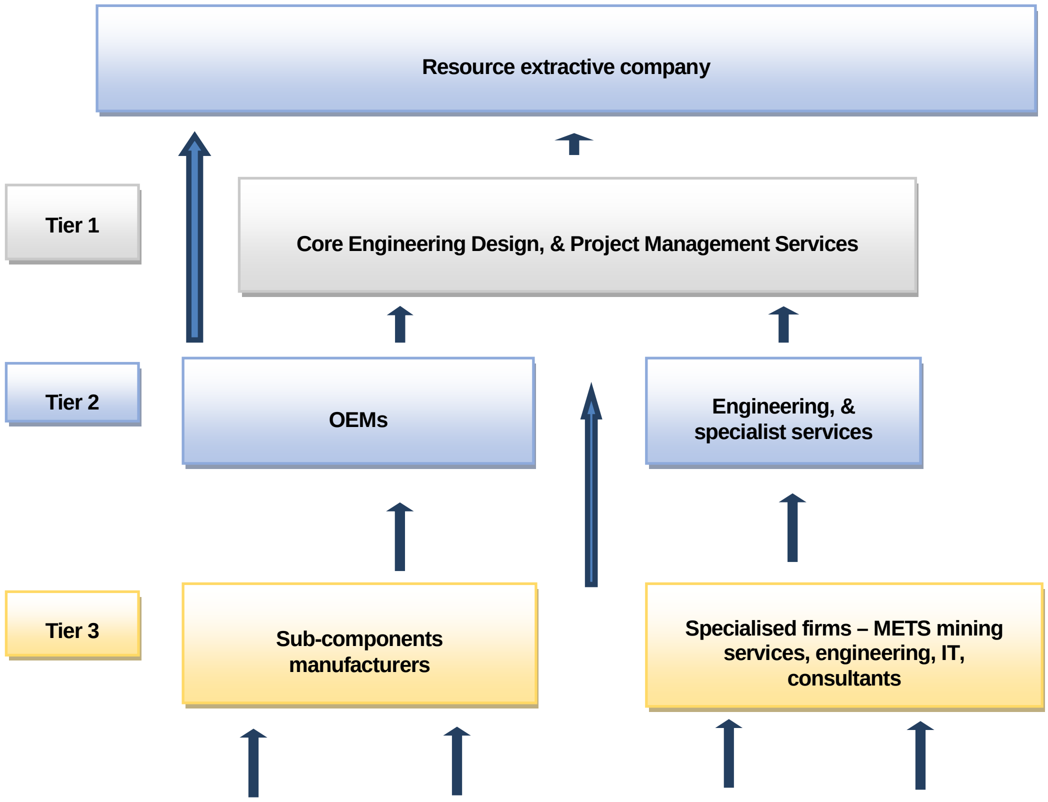

Figure 1. 7 A typical tiered procurement structure of the resource company

Accordingly, the SA METS sector is not confined to direct suppliers or contractors to the resource industry. These are predominantly medium and small size businesses providing specialised goods and services to mining companies and to Tier 1 or Tier 2 suppliers. For example, an EPC or EPCM provider acts as a first-tier supplier, which holds direct contracts with a mining company. It, in turn, engages engineering and construction firms, as well as firms specialised in hydrology, cartography and environmental sciences.

These Tier 2 firms are usually diversified and provide services not only to the minerals and energy industry, but also to other industries, including, but not limited to defence, infrastructure and construction. These Tier 2 contractors are not directly engaged by mining companies. They in turn sub-contract smaller firms that implement specific tasks.

Most of the South Australian METS supplies operate as Tier 3 – Tier 5, due to small turnover and low capability level (Figure 1.8).

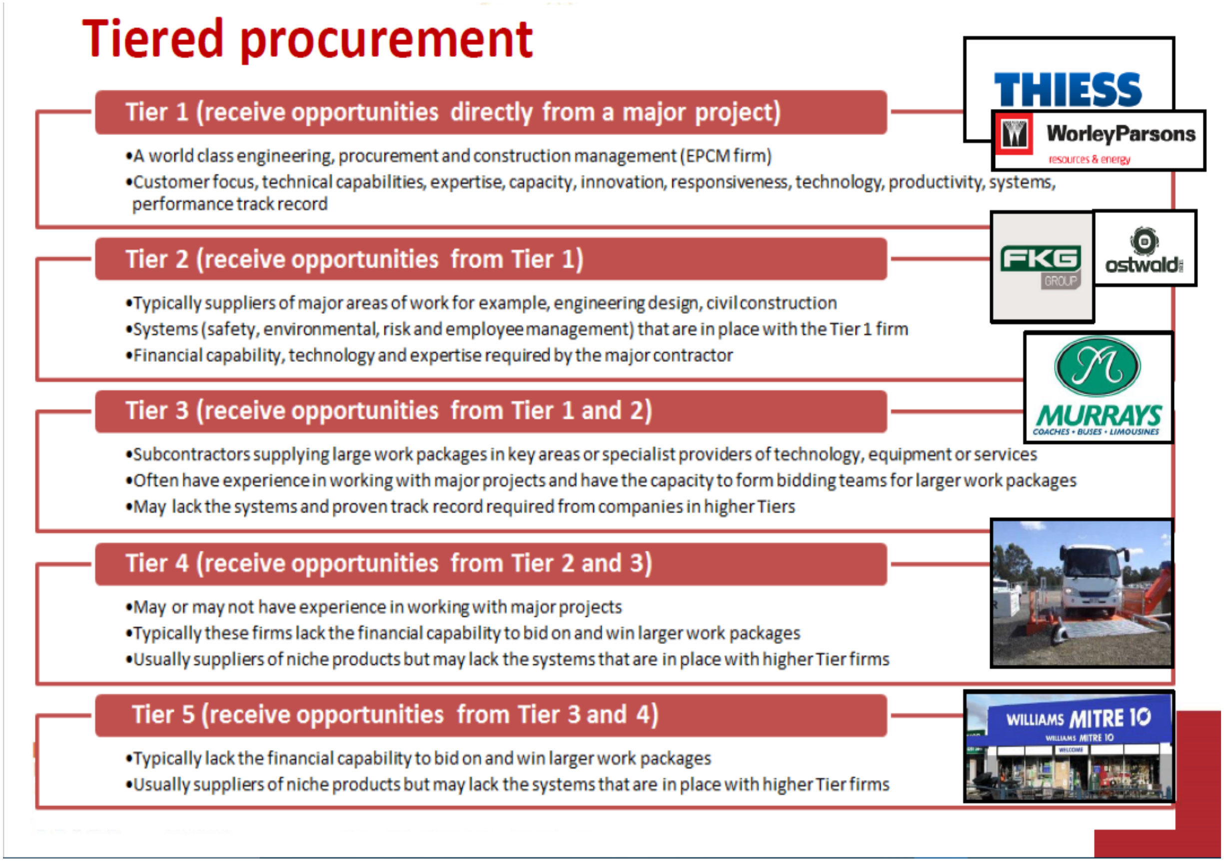

Figure 1.8 **Typical mining company supply chain (Department of State Development, 2017)**

1.5.3 What are regional or local METS firms?

For the purpose of this research, the definition *Mining Equipment, Technology and Services* (METS) firms is used to address *regional* or *local* companies performing resource-related activities and affiliated with the resourse sector through supplier-buyer linkages.

The term *regional* or *local* is applied to locally owned businesses, as well as other businesses that maintain *permanent operational offices* in a given area. Often, from the perspective of regional economy development, ownership is not the critical factor, but rather the extent to which a business integrates with and contributes to the regional economy. A company that has a local branch office, but that only brings in goods and services from outside the region does not impact local economy significantly. Conversely, a foreign-owned firm entering a consortium or taking ownership positions in local firms can be making an important contribution to local economic capacity (A. Esteves, Ogorodnikova, Putz, & Coyne, 2014).

As applied to resource activities, ‘local’ often refers to areas which are adjacent to, or impacted by, a mining company’s operations. Under this definition, the area is generally narrower than the state or territory in which the project is located, although it can cover multiple local government areas, for example, Upper Spencer Gulf, York Peninsula or Roxby Downs in South Australia (A. M. Esteves, Brereton, Samson, & Barclay, 2010).

For the purpose of this research, the SA METS sector is defined as an aggregation of companies performing resource related activities, which do not necessarily have head offices, but operate within South Australia and are part of the SA resource supply chain through contractual relationships with other SA businesses.

1.6 The South Australian METS sector

The South Australian METS sector is located mainly in the state capital Adelaide and the major industrial towns of Whyalla, Port Augusta, Port Pirie and smaller settlements.

1.6.1 The profile of the METS sector in South Australia

In 2012-2013, the SA METS sector was ranked seventeenth in terms of contribution to gross state product (GSP), and ninetieth in terms of taxes (on products and production) less subsidies It also ranked fifteenth in terms of household income and is also ranked fifteenth in terms of gross operating surplus and gross mixed income. The SA METS contributed 2.6% to the GSP, with AUD$2.4 billion and total employment of 17,830 full-time employees (FTE), more than the contribution of the resource sector itself, which is 13,509 FTE (Econsearch analysis, 2015). The sector contributed approximately AUD $1.6 billion in 2012-2013 from gross sales of AUD$3.6 billion.

The South Australian METS sector composition and its value to the resource industry in 2012-2013 are shown in Table 1.2 (the sectors are ranked by *gross production and/or sales of intermediate goods* or *recurrent transactions*). Intermediate sales to the SA resource sector were estimated at over AUD$70 billion. In addition to intermediate sales, the METS sector has significant sales to *final demand*. Approximately AUD$28.4 billion is categorised as capital formation and $14.8 billion in overseas exports. These sales to final demand added up to around AUD$43.2 billion in 2012 -2013, to give total gross sales by the METS sector of approximately AUD$113.4 billion as shown in Table 1.2 (Econsearch, 2015).

Table 1.2 SA METS sector sales to resource sector and final demand, 2012 -2013

Rank	SECTOR	Transactions Value	
		$m	Share
1	Exploration & Mining Serv	22,127	31%
2	Rental Hiring Real Estate	7,221	10%
3	Other Construction	4,579	7%
4	Gas Supply	3,702	5%
5	Construction Services	3,356	5%
6	Finance	2,977	4%
7	Prof Scientific Tech Serv	2,582	4%
8	Wholesale Trade	2,393	3%
9	Oil & Gas Extraction	2,279	3%
10	All Other Sectors	19,053	27%
	Total Intermediate Sales	*70,269*	*100%*
	Capital Expenditure	28,351	
	Overseas Exports	14,817	
	Total Sales to Final Demand	*43,168*	
	Total Sales	**113,437**	

Source: EconSearch analysis (2015)

The direct METS sector employment is higher in the Australian economy (2.4% of total FTE jobs) than in SA (1.6% of the total FTE jobs). There were an estimated 8,400 jobs in the METS sector (1.1 percent of the state total employment) in 2012-2013.

1.6.2 SA METS sector lower tier suppliers

Contribution to the Australian GDP by lower tier METS suppliers in 2012-2013 is estimated to be around AUD$22.2 billion, which, together with direct METS sector activity, gives a total contribution to GDP of around $71.5 billion as shown in Table 1.3. This equates to approximately 4.7% of total Australian GDP.

The METS sector GSP and GDP, as estimated for SA and Australia, are summarised in Table 1.3. The direct METS sector is more prominent in the Australian economy as a whole (3.0% of GDP) than in SA (1.7% of GSP). This relativity is confirmed by the ranking of the sector in the two economies; tenth largest by contribution to GDP in Australia and seventeenth largest in SA.

Lower tier suppliers (second tier suppliers as shown in the Table 1.3 – firms providing goods and services to the direct METS sector – METS firms supplying directly to resource extractive companies) add approximately 50% to the METS sector contribution. In South Australia the direct METS sector and second tier suppliers together contribute 2.6% of GSP ($2.4 billion), whereas at the national level the corresponding figure is 4.7% ($71.5 billion) (Econsearch, 2015).

Table 1.3 Contribution to GSP by 1 and 2 Tier METS suppliers

	South Australia			Australia		
	GSP ($m)	Share (%)	Rank	GDP ($m)	Share (%)	Rank
Direct METS Sector	1,600	1.7%	17	49,300	3.2%	10
Second Tier Suppliers	810	0.9%	-	22,200	1.5%	-
Total METS Sector	**2,410**	**2.6%**	**-**	**71,500**	**4.7%**	**-**

Source: EconSearch analysis (2015)

Second tier suppliers add more than 50% to the METS sector employment contribution as illustrated in Table 1.4. In South Australia, the direct METS sector and second tier suppliers together contribute 2.5% of total jobs (17,800 FTE), whereas at the national level the corresponding figure is 4.0% (almost 400,000 in 2012/13) (Table 1.5). By these estimates, the SA METS sector (including second tier suppliers) makes up around 4.0% of national METS sector employment. That SA's share of national employment is higher than its share of GDP indicates that pay rates are lower in SA than in the rest of the country.

Although the above figures show modest performance in the SA METS sector compared to the Australian average in terms of contribution to GSP and employment in the state, the future potential of the sector is recognised by the state government. Increasing the competitiveness of the METS sector is currently one of the economic priorities for South Australia.

Table 1.4 GDP and employment in METS second tier suppliers – top 20 sectors by FTE, Australia, 2012/13

	Contribution to GDP		Total Employment		FTE Employment		
SECTOR	($m)	(%)	(jobs)	(%)	(fte)	(%)	Rank
Prof Scientific Tech Serv	5,300	23.9%	39,770	26.4%	41,420	26.2%	1
Construction Services	1,620	7.3%	15,210	10.1%	16,650	10.6%	2
Admin Support Serv	1,150	5.2%	11,390	7.5%	10,250	6.5%	3
Wholesale Trade	1,130	5.1%	8,540	5.7%	9,040	5.7%	4
Personal & Other Serv	500	2.3%	7,070	4.7%	6,890	4.4%	5
Rental Hiring Real Estate	1,510	6.8%	6,220	4.1%	6,530	4.1%	6
Other Machinery & Equipment	540	2.4%	5,650	3.7%	6,310	4.0%	7
Road Transport	580	2.6%	4,420	2.9%	5,080	3.2%	8
Transport Support & Storage	630	2.8%	4,570	3.0%	4,750	3.0%	9
Iron & Steel	430	2.0%	4,100	2.7%	4,680	3.0%	10
Metal Products	430	1.9%	3,490	2.3%	3,890	2.5%	11
Retail Trade	260	1.2%	4,060	2.7%	3,340	2.1%	12
Pharma & Oth Chem Products	490	2.2%	2,940	2.0%	3,200	2.0%	13
Education & Training	260	1.2%	3,100	2.1%	2,850	1.8%	14
Finance	1,350	6.1%	2,660	1.8%	2,820	1.8%	15
Public Admin & Regltry Serv	310	1.4%	2,590	1.7%	2,600	1.6%	16
Communication Services	490	2.2%	2,340	1.6%	2,380	1.5%	17
Insurance & Other Fin Serv	410	1.8%	2,230	1.5%	2,380	1.5%	18
Public Order & Safety	190	0.9%	1,980	1.3%	2,150	1.4%	19
Oil & gas extraction	1,340	6.1%	1,600	1.1%	2,150	1.4%	20
All Other Sectors	3,280	14.8%	16,920	11.2%	18,480	11.7%	
Total	**22,200**	**100.0%**	**150,850**	**100.0%**	**157,840**	**100.0%**	

Source: EconSearch analysis (2015)

Table 1.5 Employment in METS sector and second tier suppliers in SA and Australia, 2012/13

	South Australia			Australia		
	Employment (FTE)	Share (%)	Rank	Employment (FTE)	Share (%)	Rank
Direct METS Sector	11,300	1.6%	15	242,000	2.4%	12
Second Tier Suppliers	6,530	0.9%	-	157,840	1.6%	-
Total METS Sector	**17,830**	**2.5%**	**-**	**399,840**	**4.0%**	**-**

Source: EconSearch analysis

1.6.3 SA METS sector development and its major stakeholders

Currently, one of the first economic priorities for the government of South Australia is 'Unlocking the full potential of South Australia's resources, energy and renewable assets '(Department of State Development, 2015). In 2014 the state government of South Australia announced the establishment of South Australia as a Mining Services Hub of the Nation with the increased focus on the development of the METS clusters in SA (Heithersay, 2015). Due to the growing importance of the METS sector, its direct contribution to SA's gross state product (GSP) has recently started to be reported (Econsearch, 2015).

The SA METS sector development and integration into the regional supply chain has involved several stakeholders. Private sector stakeholders include resource extractive companies (mining and oil and gas), engineering, procurement and construction (EPC) and engineering, procurement and construction management (EPCM) services providers, operating as Tier 1 suppliers to resource companies.

The public sector is represented by the departments of the Federal and state government. Non-government organisations include regional, state and national industry associations and organisations (Industry Capability Network - ICN, South Australian Chamber of Mines and Energy - SACOME, Global Maintenance Upper Spencer Gulf Resource Industry Cluster - GMUSG, Resource and Engineering Skills Alliance - RESA, Austmine, METS Ignited).

Table 1. 6 The major stakeholders of METS sector development

	National	State
Government	DI - Department of Industry, Innovation and Science MCA – Mineral Council of Australia Department of Industry and Innovation	DSD – Department of State Development MIPO – Mining Industry Participation Office
Non-government	Austmine – Australian Minerals Industries Association ICN – Industry Capability Network METS Ignited	SACOME – South Australian Chamber of Mines and Energy RESA – Resource and Engineering Skills Alliance GMUSG – Global Maintenance Upper Spenser Gulf Mining Cluster

Department of Industry, Innovation and Science. The Department of Industry, Innovation and Science is a Federal government department that implements a range of programs to support local companies, such as for example Enterprise Connect program aimed at the development of local supplier capabilities. Resource Supply Chain Panel Program run by Enterprise Connect in cooperation with the Global Maintenance Upper Spencer Gulf Resource Industry Cluster (GMUSG) assesses local firms' readiness to become a supplier to the mining sector. The assessment panel is composed of the senior executives of mining and oil and gas companies, major EPCM providers and government.

Department of State Development. The government of South Australia (SA) currently implements a range of programs to facilitate innovative development of high value added METS services with the objective of establishing SA as a mining services hub (Department of State Development, 2015). In 2013 the Mining Industry Participation Office (MIPO) was established in the Department of State Development (DSD) to address challenges faced by the resource sector during the latest downturn in South Australia. Since then, MIPO has developed and implements programs and initiatives to assist the development of local METS. Among them are programs specifically targeted to establish collaborative agreements between large EPCM providers and local METS, negotiating with the large international suppliers to resource extractive companies to establish their facilities in South Australia in order to create more demand for local METS, educating local METS suppliers about building networks across resource supply chains and the tendering process.

Industry Capability Network (ICN). The Industry Capability Network (ICN) is an independent organisation financially supported by Australian, New Zealand, state and territory governments, which is closely affiliated with national and state governments. The ICN database contains information about 70,000 suppliers in the various industry sectors across Australia, and holds information about each member company, including economic performance indicators, major capabilities and sectors it operates. The national ICN consists of Australian state oriented offices and assists project proponents in identification of Australian suppliers of project inputs. The primary objective of the ICN is to provide local suppliers with opportunities in different sectors by informing them about upcoming tenders, as well as assisting project managers of big projects to find local suppliers. It is 'a business network' with the primary objective of matching local suppliers' capabilities with customers in the resource sector, as well as providing information to local companies about upcoming tenders. Registration in the ICN database is free.

METS Ignited. METS Ignited was established in 2016 as a part of the Industry Growth Centres Initiative, aimed at improving productivity, innovativeness and competitiveness by focusing on areas of competitive strength to leverage transition to smart, high value and export focused industries. METS Ignited is an independent national association aimed at facilitating collaboration in the Australian mining industry and METS sector. In 2017, the national METS sector Competitiveness Plan was developed and put into practice in collaboration with the Department of Industry, Innovation and Science and Austmine, The plan represents a detailed strategy for the engagement of local METS, an engagement strategy for key stakeholders and large corporations. The development of the mining sector ecosystem by strengthening relationships between mining companies and local METS, as well as engagement of the broader range of stakeholders, is the primary objective of METS Ignited.

Austmine. Austmine is the national leading industry body in Australia for the METS sector. The association targets a broad range of METS companies, from major OEMs, contractors and EPCMs, through to SME software, equipment manufacturers, consultancies, technology and support services. The association events, such as boardroom luncheons, speed networking, large-scale conferences and international mining missions deliver insights into new mining projects, technology, innovation, operational developments, international markets, and supplier relationships.

South Australian Chamber of Mines and Energy (SACOME). The South Australian Chamber of Mines and Energy is an important industry association, which holds regular networking events for mining companies, service providers for miners, EPC/EPCM providers and METS. The association organises training courses for local METS firms to develop capabilities and conduct information sessions.

GMUSG. The SA government supports the Global Maintenance Upper Spencer Gulf Resource Industry Cluster (GMUSG). GMUSG is a unique organisation operating in SA, which draws its membership from businesses across the Upper Spencer Gulf region involved in engineering and maintenance services to the resource processing sector. It has more than 100 members. The organisation serves as a front-end sub-contractor to higher tier suppliers in the resource sector, drawing on the capabilities of its members. The organisation has a long history and reputation in the region.

RESA. The 'PACE Supply Chain Development Program' was established to provide training and consultancy support in terms of the required certification and accreditation, preparing tender documentation, formulating business value propositions tailored to resource company needs and improve marketing.

1.6.4 The challenges of SA METS related to the latest downturn

The impact of the downturn in commodity prices in the Australian mining industry has negatively affected businesses operating in the sector. It has led to decreased revenue and profitability, in particular in South Australia and the Northern Territory (Figure 1.9).

Figure 1.9 The change in revenue for Australian METS associated with the latest downturn in 2016 (Austmine, 2016)

The financial impacts have resulted in less capital expenditure, employment and investment in R&D across mining and the oil and gas sectors and associated industries. In the resource sector, mining companies, in response to a commodity prices downturn, have a need for innovative cost-effective solutions. This has ultimately led to increased competition in the sectors supplying services for resource companies.

In South Australia, the downturn in the resource sector was coupled with the decline in the automotive and manufacturing sectors. Closure of Mitsubishi's giant Australian automotive assembly plant in 2008 resulted in 1,000 South Australian workers losing their jobs and hundreds of businesses having to shut down or search for opportunities in other sectors including resource and energy. The decision of General Motors Holden to stop making vehicles in Australia by the end of 2017, also negatively affects the manufacturing plant in South Australia with expected job losses of 1600. Former automotive sector suppliers are now actively seeking to enter the resource and energy supply chains, thus creating more competition in the sector. As a result, local suppliers to the resource sector have been forced to adopt new strategies in order to remain competitive in the local and overseas markets.

Since the South Australian METS sector is relatively small compared with other states, there are no incentives for large international original equipment manufacturers (OEMs) or other Tier 2 suppliers to establish their offices and develop local supply chains. Most of these higher tier suppliers are located in other Australian states and accordingly develop their supply chains there. At the mining project design and construction phase, resource companies operating in SA deal directly with the Tier 1 EPC/EPCM provider or OEM. These Tier 1 and Tier 2 companies further distribute work packages through their established supply chains, without engaging SA METS. Furthermore, due to Asian countries' cheap labour and low cost environment, many services are increasingly outsourced, and higher tier suppliers re-locate their offices. For example, Mitsubishi and Holden decided to move their plants from South Australia to Asian countries due to SA's high cost environment.

The major challenges experienced by local METS firms when competing in the resource supply chains were reported by the government of South Australia (Department of State Development, 2015). To be able to find a market niche in the resource sector, many local suppliers were identified to lack essential knowledge and capabilities. The so-called local METS 'capability gap' included:

- weak understanding of the structure of the resource industry supply chain, which results in ineffective bidding for major contracts and tenders
- lack of strategic and business development skills and direction for market positioning as well as the lack of the ability to define value proposition within the resource sector
- inability to bid for projects effectively due to limited understanding of project packages and delays in receiving tender information
- insufficient ability to innovate, and for innovators to commercialise their product and find the partners within the supply chain
- lack of understanding of resource industry pre-qualification requirements, followed by the ability to attain the necessary certifications and compliances, and understand safety requirement specific to resource sector (Department of State Development, 2017).

Furthermore, small local SA METS experience communication problems in receiving information about mining projects packages of work from resource companies and their tier one suppliers. The ineffective communication of project work from resource companies to EPC/EPCM providers and to lower tier local METS suppliers created a 'connectivity gap' in the regional resource supply chain.

Thus, transition of the South Australian resource economy to more knowledge intensive activities though diversification through the development of competitive METS sector was a complex problem including multiple stakeholders, including mining companies, resource supply chain participants and policy makers. There was a need for frameworks that would inform policy makers and industry stakeholders about challenges and drives of SA METS development during a period of downturn in the resource sector to an aligned, coordinated effort to enhance the formation of an internationally competitive and diversified METS sector, contributing to sustainable development of the South Australian economy.

1.7 Thesis organisation

The thesis is structured into eight chapters, a reference section and 13 appendices.

Chapter 1 (this Chapter) introduces research problem and question, discusses the contextual background of the research problem. The chapter finishes with the thesis organisation.

Chapter 2 provides a background and rationale for the development of the conceptual framework developed in chapter 3. The literature on regional resilience and network governance is introduced and the discussion of the current state of knowledge and gaps in development of resource extractive regions.

Chapter 3 defines the conceptual model including the model variables, their inter-relationships, and underlying hypotheses. The literature review supporting the definition of independent, dependent and moderator variables and postulated hypotheses is provided.

Chapter 4 discusses research design and methodology. This thesis adopted a mixed-methods research design – quantitative and qualitative. Data collection, treatment and analysis procedures are described here.

Chapter 5 presents the data analysed with the application of the structural equation modelling and social network analysis and the results of hypotheses testing. The discussion of direct, indirect and moderation effects between variables is discussed in this chapter.

Chapter 6 includes detailed procedure of qualitative data collection and data interpretation by means of thematic analysis.

Chapter 7 is an attempt to interpret the results from both quantitative and qualitative studies in relation to the research questions and with the reference to existing literature related to resource extractive regions and clusters development and regional resilience.

Chapter 8 concludes the thesis by discussing limitations to be address in the future research as well as theoretical contributions and practical implication from the research.

1.8 Chapter summary

To summarise, resource extraction and related activities make a significant contribution to exports and the gross state product of South Australia. The local METS sector has grown in response to the 'resource boom' of 2010-2013, when there was a massive demand for their products and services. However, a drop in the commodity prices has resulted in a decline in the resource and oil and gas sectors in Australia, making resource extractive operators to adopt cost cutting strategies, which negatively influenced demand for local METS. Furthermore, the exit of two large automotive manufacturers from South Australia and the corresponding loss of local automotive suppliers has negatively contributed to the current economic situation. As a result, local METS suppliers to the resource sector have been forced to adapt to remain competitive.

Thus, transition of the South Australian resource economy to more knowledge intensive activities though diversification through the development of competitive METS sector was a complex problem including multiple stakeholders, including mining companies, resource supply chain participants and policy makers.

There was a need for frameworks that would inform policy makers and industry stakeholders about challenges and drives of SA METS development during a period of downturn in the resource sector to an aligned, coordinated effort to enhance the formation of an internationally competitive and diversified METS sector, contributing to sustainable development of the South Australian economy.

This problem faced by SA policy makers and industry stakeholders has informed the current PhD thesis. The need to identify factors influencing the ability of SA METS to adapt, as well as to evaluate efficiency of current governance instruments in the South Australian resource and energy supply was the primary driver of the research presented in this thesis.

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Chapter 2

Literature review

2.1 Introduction

The literature review provided in the Chapter 2 introduces theoretical foundations underpinning the development of the conceptual framework presented in the Chapter 3, which guided current research. The thesis presents an argument that network governance in the resource industry regional supply networks impacts resilience and adaptability of resource-extractive regions.

The structure of Chapter 2 is shown in Figure 2.1.

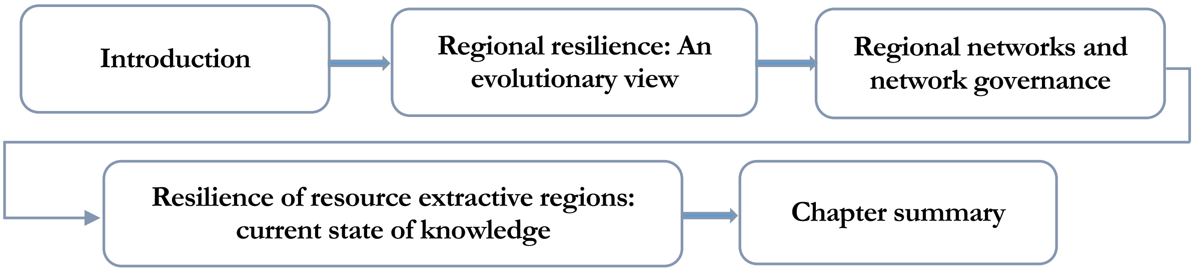

Figure 2.1 Chapter 2 structure

The proposed conceptual framework addresses this at the firm-level by exploring whether and how regional supply network embeddedness impacts regional firms' adaptability strategies, in particular, during downturn in the resource sector. To develop the conceptual framework *evolutionary economic geography*, *network governance and embeddedness* literature were synthesised. Neither of these theoretical perspectives was sufficient, but their combination offered a novel insight into micro-level mechanisms unfolding in resource regions during the global downturn of commodity prices and their contribution to emergence of high value-added knowledge intensive services around resource extractive activity.

Firstly, concepts of *regional resilience, adaptation and adaptability* are discussed since they provide a theoretical foundation of the proposed conceptual framework with the reference to *evolutionary economic geography*. The framework was built on the assumption that the regional firm *adaptability strategies* - *innovativeness* and *diversification* contribute to the regional resilience by fostering formation of value added services in industrial regions. Furthermore, the idea that *interorganisational networks* facilitate innovations at the regional level being a conduit of information and knowledge transfer is also grounded in the *evolutionary economic geography*. Secondly, the *supply networks*, *network governance* and *network embeddedness* literature was used to operationalise the concept of *regional supply network embeddedness* at the firm level as a factor facilitating implementation of adaptability strategies by local firms supplying services to the resource sector. Finally, critical analysis of the literature dedicated to the development of the resource extractive regions was also conducted to highlight the gaps in existing frameworks and the need to address the issue from the evolutionary perspective thus justifying the development of the further proposed framework.

The rest of the chapter is organised as follows. Section 2.1 defines *regional resilience* with the reference to *evolutionary economic geography*. The particular attention was given to *regional adaptation and adaptability*, *related variety* in industrial mix, the interplay between *micro and meso-levels* of regional development, and the role of *local interorganisational networks* as conduits of knowledge and information transfer within industrial regions serving local firms' as a vehicle for capability upgrade.

In the Section 2.3 the concepts of *regional supply networks* and *network governance* are introduced. The relationships between regional supply networks structure and governance and resilience and adaptability of industrial regions at the *meso- level* (region or cluster), and between *network embeddedness* and *firms adaptability strategies* at the *micro*- the individual firm level) are discussed. *Formal governance mechanisms* including standards, processes and network governing bodies – industry associations and policy makers as well as *informal governance mechanisms* or *embeddedness* determine the level of *trust*, *information sharing* and *joint problem* solving in regional supply networks create an environment that impacts firms strategies. *Positional embeddedness* of a firm, that is, how well the firm is connected within the regional supply network also impacts the firms' potential to diversify and innovate as suggested by embeddedness literature

The Section 2.4, contains a critical review of theoretical frameworks used to explore resource extractive economy organisation. *Agglomeration, clusters* and *enclaves* were found to be the dominant theoretical frameworks applied to study the organisation and evolution of resource extractive regions, and the literature related to these theories is critically reviewed. The limitations of existing frameworks applied to explore transition mechanisms in resource extractive regions to knowledge-intensive activities are identified. There are several studies that discuss adaptability and resilience of the resource extractive sector at the meso scale, however none of them investigated how supply network governance relates to the development of adaptability strategies of local firms operating in the resource sector supply chains thus contributing to emergence of high value added services leading to renewal of resource extractive regions.

Thus, the aim of the literature review is to emphasise the importance of investigating the impact of network governance on the resilience and adaptability of resource extractive regions at the meso- level by addressing this process at the micro level. In particular, the literature review provides a background to the development of the conceptual framework that tests how local firms' embeddedness into regional supply networks contributes to the development of adaptability strategies – diversification and innovativeness.

The diagram that demonstrates the main sections of the literature review is presented in Figure 2.2.

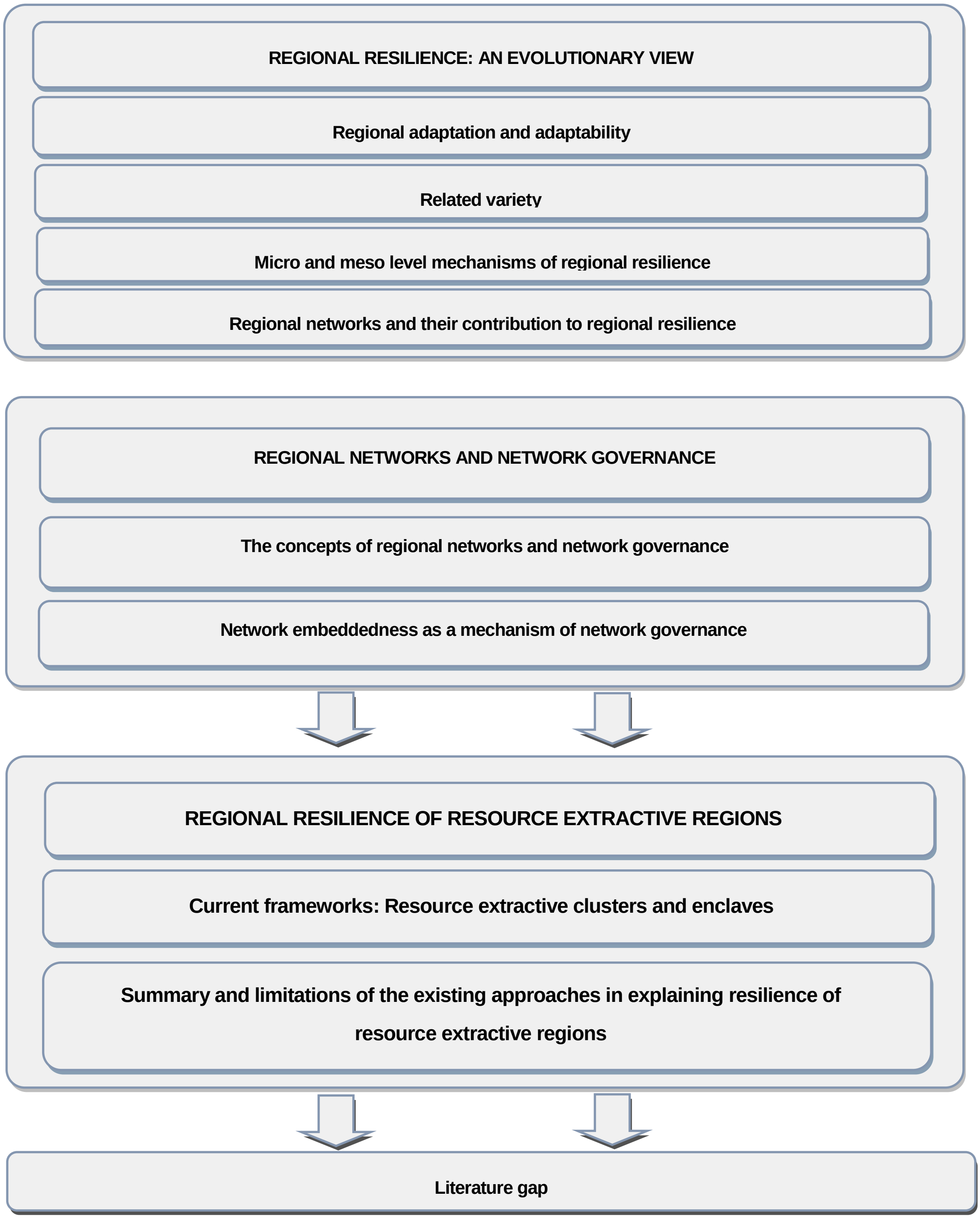

Figure 2.2 The literature review roadmap

2.2 Regional resilience: An evolutionary view

Evolutionary economics emphasises the importance of the evolutionary process naturally occurring in economic and geographic regions, which ‘unfolds in space and time’ (Frenken and Boschma (2007) due to path dependence, and is critical to the ability of industrial regions to develop and sustain long-term competitive advantage (Boschma & Fornahl, 2011; Crespo, Suire, & Vicente, 2013; Martin & Sunley, 2014).

The concept of regional resilience has gained traction in the economic geography literature due to recent economic crises and uncertainty in the business environment. Analysis of regional resilience is currently being used to better understand the success and decline of industrial regions. The general definition of resilience came from the engineering body of knowledge, meaning the ability of a system to ‘to bounce back’ in response to an external disturbance (Holling & Gunderson, 2002). In ecology and social ecology a region is considered resilient if, when affected by a shock, it is able to return to at least its prior path within a relatively short period of time (Hill et al., 2012).

In evolutionary economy, organisational studies and psychology, regional resilience goes a step further, defining resilience as the ability ‘to bounce forward’ (Martin, & Sunley, 2015, p. 4), that is, a long-term adaptive capacity of a region to accommodate external shocks by reconfiguring its socio-economic and institutional structure to develop new growth paths (e.g. Boschma, 2014a, 2015; Crespo et al., 2013). The evolutionary view on regional resilience points to this concept as being under researched (R. Boschma, 2014b; Simmie & Martin, 2010).

The concept of regional resilience has gradually evolved, shifting focus from the static description of factors influencing the success of industrial regions offered by an agglomerations and clusters view of the economic landscape to an understanding of the role of endogenous growth and path dependence in the construction of the competitive advantage of regions (Martin, Mayer, & Mayneris, 2013; Martin & Sunley, 2011).

Evolutionary economics emphasises the importance of the evolutionary process naturally occurring in an economic and geographic region due to path dependence, and is critical to the ability of industrial regions and clusters to develop and sustain long-term competitive advantages (e.g., Boschma & Fornahl, 2011; Crespo et al., 2013; Martin & P. Sunley, 2014).

Evolutionary economic geography (EEG) explains the tendency of industrial regions and clusters to change their technological trajectories, adopting new technologies, participating in new industries, changing, maintaining or enlivening existing networks and institutions in different localities (Frenken & Boschma, 2007). Regions that can develop new growth paths based on the pre-existing *industrial*, *network* and *institutional structures* provide opportunities, which, conversely, also set limits for potential diversification (R. Boschma, 2014b). The role of a trade-off between adaptation and adaptability, related variety and regional networks in regional resilience is important.

2.2.1 Regional adaptation and adaptability: 'Lock-in' vs regional renewal

Resilience is understood to be a dynamic process rather than a static property characteristic of a region or cluster (Bristow & Healy, 2013). It is generally attributed to the system structure and relationships, along with the ability to adapt to a changing environment by reorganising itself. The resilience of regions and clusters has been attributed to a combination of industrial, network and institutional structural dimensions connected in such a way as to allow the members to make the transition from one way of doing things to another (Pike, Dawley, & Tomaney, 2010).

Regional resilience is based on the development of new technological trajectories and diversification within industrial regions and clusters that ensure the long-term success of the industrial regions. Long-term regional resilience is often discussed in relation to balance between regional adaptation and adaptability (Christopherson, Michie, & Tyler, 2010; Grabher, 1993). While adaptation is concerned with changes within existing paths, adaptability enables the development of new pathways as an escape from 'path dependence'. *Adaptation* refers to the incremental innovations and increasing specialisation that reproduce existing structures in the regional economy, while *adaptability* is an accumulation of unspecific capabilities that can lead to unforeseeable innovations and structural changes (Grabher, 1993). Too much adaptation and lack of adaptability may lead to technological lock-in.

The adaptability of industrial regions is predicated on their endogenous mechanisms and structures enabling the emergence of new technological paths for regions and clusters in transition is critical for long-term success. The discussion of regional adaptability was brought up by Saxenian (1994) to explain the role of regional networks in the long term adaptability of industrial regions, drawing on the example of competing regions – Silicon Valley in California and Massachusetts Route 182 in Boston. While Silicon Valley demonstrated rapid technological progress over the long-term, the semiconductor cluster in Boston experienced gradual decline due to 'technological lock-in'.

The notions of regional lock-in and path dependence are defined as:

> *…combination of historical contingency and the emergence of self-reinforcing effects that steer a technology, industry or regional economy along one 'path' rather than another… (Martin, 2010, p.3).*
>
> *Technological lock-in is associated with narrow regional specialisation and inability to change development trajectory. In the situation of external shocks, such as an economic recession or drop in demand in the traditional markets, highly specialised regions may struggle to recover. Conversely, the ability of a regional economy after facing an external shock to develop new growth paths, renew and re-orient itself, moving away from its previous historical legacy has been seen as a sign of resilience (Boschma, 2014b).*

In a regional economy, Grabher (1993) has identified three kinds of lock-ins. A functional lock-in refers to hierarchical, close inter-firm relationships, particularly between large enterprises and small suppliers, which may eliminate the need for suppliers to develop critical functions, such as research and development and marketing. A cognitive lock-in is referred to a common mindset that might confuse secular trends with cyclical downturns. Lastly, closely related to cognitive lock-in is the political lock-in that is attributed to a production cluster (Grabher, 1993). Political lock-ins are referred to thick institutions that preserve traditional industrial structures and thus slow down transformational processes hampering regional adaptability (Hassink, 2010).

2.2.2 Related variety

Regional resilience has also been attributed to industry composition in the region. Unlike Marshallian agglomeration theory, which argues for the benefits of sectoral specialisation, when firms learn from others in the same industry (Marshall, 1920), the theory of Jacobian externalities (Jacobs, 1969) suggests that diverse regional economies encourage more knowledge spillovers due to heterogeneity of knowledge and ideas from different industries. Evolutionary economists argue that industries develop knowledge transfer across existing *related industries* or *complementary sectors*.

This observation produces the concept of *related variety*, which emphasises that industries that are cognitively proximate can benefit from shared competencies, innovation and knowledge transfer (Frenken, Van Oort, & Verburg, 2007). Related variety means that a region has a wide range of related industries that can draw on a local pool of skills and capabilities providing potential for inter-industry learning. Related variety is claimed to be the most common form of regional diversification (Frenken & Boschma, 2007). Boschma, Coenen, Frenken, and Truffer (2017) provide a simple example, pointing out that for the region it is easier to move from producing motor cycles to trucks, rather than from bananas to computers.

Related variety has been advocated to ensure both adaptability and adaptation properties in industrial regions due to inter-sectoral knowledge spillovers and lateral technology transfer (R. Boschma, 2014b; Morrissey & Cummins, 2016). Adaptation is possible since related industries provide an environment where related technologies and knowledge can be copied and recombined (R. Boschma, 2014b). Thus new industries branch-out from existing ones by recombining technologically related capabilities and knowledge (Boschma, Minondo, & Navarro, 2013). Adaptability, as a more important property for the long-term success of industrial regions, is ensured since regions with related variety can diversify into new activities related to their existing activities by drawing on existing local capabilities (Boschma, 2017; Frenken & Boschma, 2007).

However, another view argues that regions with unrelated activities have more chances for technological breakthroughs because they have opportunities to creatively combine previously unrelated knowledge domains (e.g. Boschma et al., 2017; Castaldi, Frenken, & Los, 2015). These recent studies argue that unrelated variety provides more long-term source of competitiveness (Boschma et al., 2017).

The third view is that resilient region combines both unrelated variety (i.e., diversity into unrelated knowledge domains), and related variety (i.e., diversity within each knowledge domain). While the former ensures adaptability, the latter secures adaptation (Castaldi et al., 2015).

2.2.3 Micro and meso level mechanisms of regional resilience: Agency perspective

Another important factor discussed in the evolutionary economic geography to explain the ability of industrial regions and clusters to change their technological trajectories is co-evolution of entrepreneurs firms, technologies, industries, networks and institutions in different localities (e.g. Frenken & Boschma, 2007). Recent studies of regional resilience highlight for the need to understand adaptive capacity of industrial regions taking agency perspective (Bristow & Healy, 2014; Bristow & Healy, 2014; Martin & Sunley, 2007; Martin & Sunley, 2011; Neffke, Hartog, Boschma, & Henning, 2014).

The interplay between micro-meso levels in constructing regional resilience has been highlighted by a number of EEG scholars (Dopfer, 2011; Dopfer, Foster, & Potts, 2004; Giulliani, 2005). The evolutionary view attributes the development of economic landscapes – agglomerations, clusters and networks at the macro level – to the dynamics of interactions among economic agents – firms – at the micro-level (Boschma & Martin, 2007; Frenken & Boschma, 2007). As social-economic spatial entities, these regional economic landscape patterns are seen as ‘emergent properties of the unplanned meso-outcomes of individual actions and behaviours of numerous individual economic agents…’ (Martin & P. Sunley, 2007).

Relationships between micro- and meso- levels and the role of human agency have been associated with a *complex adaptive systems* view of regional resilience. The concept of complex adaptive systems refines the concept of agglomerations and clusters by emphasising the fact that the collection of agents in a regional economy – businesses and institutions – are interdependent and interact in ways that affect the whole of the region or cluster. The central idea is that the system is characterised by dynamic networks of interconnected actors whose interactions with one another and their environment produces system-wide changes, which leads to emergence of macro structures over time.

Pike et al. (2010) attributed regional adaptability to the ability of the actors and their social agency to anticipate, evolve, and so adapt to disturbed and cyclic economic environments. (Bristow & Healy, 2013) further developed this view, drawing attention to the role of human agency and behaviour at the micro-level shaping regional resilience at the meso-level. Human agents adapt and learn through trial and error and create emergent patterns and waves of innovation and development through their contingent co-evolution with technologies (Martin, & Sunley, 2007).

2.2.4 Regional networks and their contribution to regional resilience

The concept of *industrial variety* mainly views the collection of industries, technologies and knowledge bases as an essential pre-determinant of regional adaptability. Regional networks provide an explanation of how these resources are connected within the region. Although the role of regional knowledge networks in building resilience and adaptability of industrial regions has been acknowledged (Crespo et al., 2013), the research investigating how related variety is linked to regional resilience and how networks contribute to this relationship is still scant (Boschma, 2014b).

The evolutionary view discusses knowledge networks, their structure and openness as parameters that influence regional resilience. Inter-organisational networks are the major conduits of knowledge and information transfer in the regions. It has been suggested that the structure of networks in a region affects its capacity for resilience (Crespo et al., 2013). Excessive network connectedness and embeddedness as a result of regional development, in particular with a core-periphery structure, reveals high cognitive proximity and specialisation among the network's participants, while less connected networks in a region indicate that presence of non-redundant knowledge, with higher scores for adaptability. However, less connected regional networks may lead to the lack of regional cohesiveness, which weakens efficiency and control of collective behaviour. The trade-off between adaptability and adaptation of network structures can be seen in modular network structures, when the network consists of several densely interconnected clusters or nodes loosely attached to each other (Crespo et al., 2013). The nature of network relationships also provides insight into regional resilience, as well as regional network structure. R. Boschma (2010) offered to view network relationships through the prism of proximity: cognitive, social, organisational, institutional and geographical.

In the resource extractive regions, scholars have found that knowledge exchange happens mainly through sub-contractual relationships, when companies collaborate with the clients around their problem (e.g. Martinez-Fernandez, 2010; Scott-kemmis, 2012). Supplier-customer relationships based on trust emerge due to social and geographic proximity, and regional supply networks in the resource extractive regions are often socially embedded (Knobblock, 2013; Scott-kemmis, 2013).

This research is particularly focused on the role of regional supply network governance in forming the resilience of resource extractive regions, so the concepts of regional supply networks, network embeddedness and network governance in relation to development of innovative capabilities of firms in industrial regions are discussed in the following section.

2.3 Regional supply networks and network governance

Concept of interorganisational networks located in geographical proximity, named in this study *regional networks*, is well-developed in the organisational studies literature. The concepts of *networks*, *network governance* and *network embeddedness* are closely related, since all of them refer to a specific form of inter-organisational relationship, where social aspect plays a key role and the network actors are usually located in close geographic proximity. The following sections introduce the concepts of *regional supply networks*, *network governance* and *network embeddedness* .

2.3.1 The concept of regional supply networks

The diversity of possible arrangements between firms, and the multiple definitions of networks of relationships between firms, requires limiting a subset of inter-firm relationships to be studied (Heide & John, 1990). Thorelli (1986) states that networks are long-term relationships established by two or more organisations, which are neither arms-length transactional or market-based nor hierarchical relationships under official organisational structures, but rather something in between.

Interorganisational ties can be distinguished as vertical, that is ties between buyers and supliers or professional services and client firms, and horisontal – ties between competitors, such as alliances, joint ventures and partnerships (Polidoro, Ahuja, & Mitchell, 2011). The focus of this study was the vertical ties between firms supplying services to resource-extractive companies, since in the resource sector collaboration more often occurs vertically (Martinez-Fernandez, 2010; Scott-kemmis, 2013).

Network governance in the *inter-organisational networks based on vertical ties*, e.g., supplier-buyer relationships was the major focus of this study. Given a variety of definitions of inter-organisational networks formed as a result of supplier-buyer relationships – transaction networks, exchange networks (Cook & Emerson, 1978), production networks (Gereffi, Humphrey, & Sturgeon, 2005; Sturgeon, Van Biesebroeck, & Gereffi, 2008), business networks (Håkansson & Snehota, 1989) for the purpose of this study the term *supply networks* was used to define vertical ties among firms.

Supply networks. Supply networks are defined as sets of supply chains enabling the flow of goods and services (Yusuf et al., 2014). Supply network participants are nodes (actors) and supplier-buyer relationships as connections between nodes. The underlying assumption is that the supplier-buyer relationships are often socially embedded and supplemented by other types of relationships between organisations, such as collaborative ties and knowledge exchange, thus positively affecting the business performance of firms that are a part of the network (Borgatti & Li, 2009; Ter Wal, 2013; Yu & Lee, 2009; Yusuf et al., 2014). These multifaceted relationships have been referred to in social capital and embeddedness literature as 'multiplexity'.

Thus, supply networks could be defined as a set of supply chains delivering goods and services to the end customer, involving supply chain members located within close geographical proximity. This definition describes a supply network as an aggregate of multiple supply chains in geographical proximity, which is not tailored to one particular firm.

The term *supply network* has gained traction due to increasing product and service complexity, e-business, outsourcing, and globalisation of supply chains and the distributed nature of production. The need for reducing uncertainty and risk reduction called for new management approaches that go beyond firms' direct transactional partners. In their seminal work, Choi et al. (2001) defined supply networks as supply chains that are comprised of not only a focal firm's direct ties to each of its supply network partners (e.g., suppliers and customers) but also its indirect ties to partners of the firm's direct partners. Harland et al. (2003) defined a supply network as:

> *[a network] nested within wider inter-organisation[al] networks and consists of interconnected entities whose primary purpose is the procurement, use and transformation of resources to provide packages of goods and services. (Christine M. Harland, Lamming, Zheng, & Johnsen, 2002)*

Innovation diffusion in supply networks due to spillover effects has been attributed to several factors. The role of customers as sources of knowledge about new technologies and innovative solutions for suppliers has been recognised by researchers (M. Bell & Albu, 1999). The exchange of technological information and commitment to joint activities between suppliers and customers, such as product modification or joint learning, increases the probability of innovative outcomes (Choi & Krause, 2006). Both the structure of a firm's network, and where each firm and its contacts are located in the structure determine the likelihood of a firm gaining benefit from the network (Bellamy, Ghosh, & Hora, 2014).

Networks as a particular form of governance are distinguished from market or hierarchy, because they operate with specific coordination mechanisms, which are discussed in the following section.

2.3.2 The concept of supply network governance

The concepts of inter-organisational networks, network governance and network embeddedness are closely related, since all of them refer to a specific form of inter-organisational relationships, where social aspect plays a key role and the network actors are usually located in close geographic proximity.

Network governance was defined as:

> *A select, persistent, and structured set of autonomous firms (as well as nonprofit agencies) engaged in creating products or services based on implicit and open-ended contracts to adapt to environmental contingencies and to coordinate and safeguard exchanges. These contracts are socially- not legally-binding…(Jones et. al., 1997, p. 914)*

The distinctive feature of network governance is that it is an intermediate hybrid form of governance between the market and the hierarchy. Network governance emerged in response to a changing business environment, where both hierarchical and market mechanisms were ineffective (W. Powell, 1990). Competitive networks of interconnected firms with the ability to deliver complex products under time pressure have emerged in the semiconductor (Saxenian, 1994), textile (Lazerson, 1995), film (Faulkner & Anderson, 1987), and apparel industries (Uzzi, 1996, 1997) demonstrated the benefits of network organisation (Jones et al., 1997). Product complexity and customisation have created the need for asset specificity, increased frequency of communication, knowledge sharing and inter-organisational learning between supplier and customer (Jones et al., 1997).

The *supply network governance* concept emerged in response to recent supply chains trends that led to decentralisation of the production process, shifting focus from a single organisation to global supply networks and value chains. This includes globalisation, outsourcing, business environment and demand uncertainty (Gereffi et al., 2005; Pilbeam, Alvarez, & Wilson, 2012; Sturgeon et al., 2008).

Disaggregation and outsourcing of non-core capabilities by large leading firms shifted emphasis from managing vertically integrated production to coordination of decentralised networks of suppliers (Hollstein, Matiaske, Schnapp, & Schnegg, 2017; Jones, Hesterly, & Borgatti, 1997). Infrastructure and communication technology development led to 'just-in-time' production, service based economy (Hollstein, Matiaske, Schnapp, et al., 2017; Jones et al., 1997) and flexible virtual enterprises (Pilbeam et al., 2012). On the other side, political, macro-economic and social uncertainty and associated risks in supply chains created the need for decentralisation, flexibility and adaptability to quickly react to changes in the business environment (Pilbeam et al., 2012).

The global value chain literature refers to 'relational value chain governance' as a type of industrial organisations where product specifications are hard to codify, transactions are complex and suppliers capabilities are high (e.g. Gereffi et al., 2005; Sturgeon et al., 2008). It is based on reputation, spatial and social proximity and ethics. When suppliers capabilities are low given high complexity of products and transactions 'captive value chain governance' takes place, which requires control and intervention of the lead firms, transactional dependence and lock-in suppliers with the narrow capability range. Apart from these forms four other governance types of value chains were identified – markets, modular value chains, and hierarchies (Gereffi et al., 2005).

Network governance refers to the set of instruments that coordinate participating organisations to deliver collective outcomes, mechanisms of reaching and implementing decisions cooperatively, as opposed to coordination mechanisms based on hierarchy or market regulations (Hollstein, Matiaske, Schnapp, et al., 2017). *Supply network governance instruments* include formal and informal structures that support cooperation and collaboration among organisations participating in the supply network (Pilbeam et al., 2012). *Formal instruments of network governance* may include standards, processes, contracts, and formal structures, such as network administration organisations (NAO) (Pilbeam et al., 2012; Provan & Kenis, 2008). *Informal instruments of network governance* are also referred to as *network embeddedness* (Grandori & Soda, 1995; Jones et al., 1997; Pilbeam et al., 2012; Provan & Kenis, 2008). This refers to social norms that encourage or discourage particular behaviour of firms within the supply chain, including norms, value systems, beliefs and culture (Choi & Kim, 2008; Choi, Dooley, & Rungtusanatham, 2001; Gereffi et al., 2005; Pilbeam et al., 2012)..

Formal governance instruments. *Standards* specify the threshold of the quality that acts as network inclusion or exclusion criteria. Standards could be set by the leading company or external party and coordinate relationships in the networks (Nikoloyuk, Burns, & de Man, 2010). *Legal contracts* also act as a coordinating mechanism in networks, which is particularly important for new network members, who have not established rapport and reputation. *Government legislation* is also seen to impact supply network governance. *Network coordinating bodies*, which may include industry associations or leading firms that may act as network administrating associations (NAO) fall into this domain (Pilbeam et al., 2012; Provan & Kenis, 2008).

Informal governance usually develop as a bottom-up process with no relation to formal policy or management, based on individual contacts formed as a result of long-term and socially bonded relationships between actors (Pahl-Wostl, 2009). This type of relationships is seen to be more effective than market or hierarchy, since social attachments and the shift in the logic of opportunism to a logic of trustful cooperative behaviour creates a new basis for knowledge transfer and learning across firm boundaries (Provan, 1993). Informal instruments of network governance support innovation and social learning, formation of informal networks is essential for adaptability of the whole system, since it allows to explore novel ideas and forms of governance (Pahl-Wostl, 2009).

Furthermore, it was highlighted that strength and co-existence of formal and informal instruments and mechanisms plays a vital role in adaptability and resilience of the system governed (Pahl-Wostl, 2009). With the dominance of formal instruments over informal the adaptability of the system is low with the tendency to bureaucratic organisation, otherwise more diverse governance structures can emerge and informal networks may challenge established dominant formal structures and influence established policy. If the goals of formal and informal instruments are aligned and complement each other then efficiency and effectiveness of the governance process is increased. Otherwise, formal instruments become ineffective and two rule systems compete with each other. In the latter case corruption, non-transparent decision making and dominance of power structures can be expected.

While formal network governance interments in supply chains are well researched, the need for more empirical evidence on how informal instruments operate in various contexts was reported (e.g. Pilbeam et al., 2012). *Network embeddedness*, being an informal instrument of *supply network governance* as the core of this research, is explained in more detail in the next section.

2.3.3 Network embeddedness as an informal mechanism of supply network governance

In economic sociology the concept of *embeddedness* as '…the degree to which economic activity is constrained by non-economic institutions…' was initially introduced by Karl Polaniy (K. Polanyi, 1944). Mark Granovetter (Granovetter, 1985) further developed this approach, clarifying that social embeddedness contests the basics of neo-classical economics, where a rational, calculating *homo economicus* makes decisions based solely on optimising economic gain. Instead, individual economic agents:

> *Do not behave or decide as atoms outside a social context, nor do they adhere slavishly to a script written for them by the particular intersection of social categories that they happen to occupy. Their attempts at purposive action are instead embedded in concrete, ongoing systems of social relations… (Granovetter, 1985, p. 487)*

Transactional cost economics (TCE) introduced *relational contracting* as an alternative form to markets and hierarchies, referring to the 'bounded rationality' of economic agents in conditions of uncertainty and the costs of opportunism. TCE thus explains how social mechanisms influence the cost of economic exchange at the dyadic level (Williamson, 1985).

A relational view of firm competitiveness was further developed in *strategic management research* (Dyer & Singh, 1998). Dyer and Singh (1998) characterised arm's-length market relationships as those with nonspecific asset investments, minimal information exchange, low levels of interdependence of technological and functional systems within each firm, and low transaction costs and minimal investment in governance mechanisms. The *relational view* offered an explanation of firm competitiveness by associating it with advantages stemming from the network of relationships in which the firm is embedded (Dyer & Singh, 1998). The relational view emphasised long-term relationships between suppliers and customers, as opposed to market relationships, which were '..cool, impersonal, atomistic, and actors are motivated by instrumental profit seeking…' (Uzzi & Lancaster, 2003, p. 384).

Thus, organisational theorists and economic sociologists associated the concept of embeddedness with relational or network governance forms, implying that organisations not only compete to exist in a capitalist economy, but also cooperate with a higher-level vision, which goes beyond individual firm efficiency and profit (Gulati & Gargiulo, 1999; W. Powell, 1990; Provan & Kenis, 2008; Uzzi, 1997). These developments in economic sociology and organistional studies literature led to the emergence of concept of *inter-organisational networks* as an abstract metaphorical term referring to holistic entities, ‘organic and informal social systems’ (Jones et.al., 1997, p.913) characterised by interfirm coordination and delivering benefits for all network members.

Embeddedness in supplier-buyer relationships refers to the *interdependence* or *joint dependence* of a company and its suppliers and customers (Gulati & Sytch, 2007; Kim, Choi, & Skilton, 2015; Provan, 1993). This joint dependence between exchange parties increases the depth of economic interactions, which often evolve into long-term relations (Jon, Imanol, & Jon, 2016; Uzzi, 1996, 1997) and stronger relational orientation (Gulati & Sytch, 2007; Uzzi, 1996).

This logic emerges due to an increasing ‘infusion of sentiment’ into supplier-buyer relations as well as a practical rationale stemming from perceived benefits of maintaining smooth relationships (Gulati & Sytch, 2007). Companies working together as a part of embedded networks act very differently from those who pursue purely transactional relations. Building an on-going effective supply chain relationship requires social elements, such as trust, long-term orientation and relational behavior. If the social aspect plays a role for business partners, then common values and norms (Jones et al., 1997; Pilbeam et al., 2012; Powell, 1990) or schema (Choi et al., 2001) are mutually acquired.

Spatial proximity facilitates the emergence of embedded relationships in supply chains through the increased possibility of social interactions since it increases the probability of firm leaders and employees belonging to the same social group, and social interactions lead to the development of multidimensional relationships between organisations (Broekel & Boschma, 2012; Hsueh, Lin, & Li, 2010; Li, Li, & Liu, 2011; Presutti, Boari, & Majocchi, 2013). Such ‘multiplex’ relationships play a key role in the formation of embedded inter-firm networks (Lazega & Pattison, 1999).

Recent supply network literature has been particularly influenced by the logic of network embeddedness as a driver of supply chain performance. Supply network researchers used this view, emphasising the role of network embeddedness in improved coordination, efficiency, and supply chain innovations (T. Choi & Kim, 2008; Day, Fawcett, Fawcett, & Magnan, 2013; Galaskiewicz, 2011; Gulati & Sytch, 2007; Pilbeam et al., 2012; Wu & Pullman, 2015; Yan, Choi, & Kim, 2009; Yan, Choi, Kim, & Yang, 2015). Managing inter-organisational and relational aspects of the supply chains allows for improvements of the overall supply chain system, as well as individual firms (C.M. Harland & Knight, 2001).

In the supply chain context, embedded relationships serve as a vehicle for information and knowledge exchange among supply network participants (Bellamy et al., 2014; Carnovale & Yeniyurt, 2015; Kim, Choi, Yan, & Dooley, 2011). Choi et al. (2001, p. 352) stress that the supply network '…refers not only to the networks of the materials flow but also to the networks of the knowledge flow…'. The assumption is that if two firms interact closely and repeatedly on business matters they will inevitably exchange ideas and information (Borgatti & Li, 2009). Under conditions of uncertainty, managers learn through direct and indirect ties by mimicking and adopting strategies (Galaskiewicz & Wasserman, 1989). Informal governance mechanisms through embeddedness contribute to the enhanced innovative capacity of network members, while formal mechanisms lead to performance improvements (Bellamy et al., 2014; Pilbeam et al., 2012).

However, a number of researchers hold the opposite view, reporting negative effects of over-embeddedness and strong buyer-supplier relationships on firms' performance (Day et al., 2013; Gulati & Sytch, 2007; Uzzi, 1997). Embedded ties may lead to relational inertia, resource misallocation, and malfeasance (Day et al., 2013), knowledge leakage to competitors and technological lock-in due to limitation of information sources (Gulati & Sytch, 2007). Embeddedness provides benefits to a firm only up to a certain threshold, thus showing an inverted u-shape relationship (Charterina, Basterretxea, & Landeta, 2016; Uzzi, 1996). Once this threshold is crossed, embeddedness becomes a constraint for organisational learning and innovativeness. Tim Rowley (2000), examining the steel and semiconductor industries, found that relational and structural embeddedness are contingent on the industry context.

Other types of embeddedness have also been proposed, including relational, structural, resource, positional, political, and cultural embeddedness (Hsueh et al., 2010).

Structural, positional and relational embeddedness. Structural, positional and relational embeddedness are often discussed in the context of network governance as informal governance mechanisms (e.g. Borgatti & Li, 2009; Gulati, 1999; Jones et al., 1997; Rowley, Behrens, & Krackhardt, 2000).

Structural and positional embeddedness. In the economic sociology literature, the seminal works of Burt (1992) explore *structural embeddedness* as the social capital of the firm. How the firm and its contacts are positioned in the social network structure determines the likelihood of benefits derived from the network. It is defined as a property of an organisation to be included in a network of suppliers and customers, and the extent of dependence on those ties (Choi & Kim, 2008).

Positional embeddedness reflects the ‘roles’ that network actors occupy in the system, irrespective of the specific traits of these peers and the nature of the relationships between them. It goes beyond direct and indirect ties of a focal actor and explains the benefits associated with a certain position in the network through application of network models of equivalence and centrality (Borgatti & Li, 2009; Wasserman & Faust, 1994). Positional embeddedness is usually operationalised and measured with the application of social network analysis (SNA). The commonly used metrics in organisational literature are degree, betweenness, closeness and eigenvector centrality (Borgatti & Li, 2009; Wasserman & Faust, 1994).

The *information advantages* and *reputational benefits* resulting from network centrality are often discussed in economic sociology and organisational studies literature. Central actors are better informed and able to disseminate information about opportunities (Gulati & Gargiulo, 1999). In a supply chain setting, increasing a firm’s betweenness means increasing the number of firms (customers and suppliers) that form bridges. Advantages may include better access to the critical information about upcoming project opportunities, which reduces uncertainty and improves the quality of decision making (Borgatti & Li, 2009).

From the perspective of reputation and market power, a well-connected firm benefits from increased visibility and attractiveness to other organisations in the network, even if it does not directly or indirectly deal with them (Polidoro et al., 2011). Thus, centrally positioned firms enjoy higher levels of relational embeddedness. However, network structure and a firm’s position in the network are seen to be both opportunities and constraints (Rowley et al., 2000). Since over-embeddedness was reported as a hurdle to influx of new information and ideas, thus being central in the network may limit opportunities for exploration outside the network(Day et al., 2013)(Day et al., 2013)(Day et al., 2013)(Day et al., 2013)(Day et al., 2013)(Day et al., 2013)(Day et al., 2013)(Day et al., 2013)(Day et al., 2013) The role of positional embeddedness on companies' business and innovative performance in supply networks has been investigated in new materials related to industrial automation and the automotive sector (Gulati, 1999; Kim et al., 2011), the chemical industry (Polidoro et al., 2011), the electronics industry (Bellamy et al., 2014), biotechnology (W. W. Powell et al., 1996), apparel (Uzzi, 1997), and the maritime industry (Greve, 2009). In the resource sector (West, 2014) investigated the influence of network position on market power in alliance networks between mining companies and services providers.

Relational embeddedness is the nature of the relationships of a firm with its direct counterparts, while *structural* embeddedness goes beyond immediate ties and recognises the informational value of the structural position the partner occupies in the network (Gulati, 1998; Rowley et al., 2000). Jones et al., (1997) define relational embeddedness as a quality and depth of a single dyadic tie, and refer to Granovetter (1985) structural embeddedness definition as the 'extent to which dyad's mutual contacts are connected with one another'. Thus, structural embeddedness reflects not only to direct interactions, but also links to third parties. Rowley et al. (2000) argue that relational and structural embeddedness could only be understood with reference to each other.

In the organisational literature structural embeddedness is defined as an '…architecture of network ties…' (Uzzi, 1996, p. 675), which extends beyond immediate ties and is associated with informational advantages (Gulati, 1998; W. Powell, 1990). In the network governance literature structural embeddedness is identified as the key informal mechanism of network governance. It is combined with restricted access, reputation, macroculture and collective sanctions. Restricted access keeps the network closed to non-members. Network members guard their reputations, and develop a macroculture of shared norms, values and beliefs across firms. Collective sanctions are used to punish malfeasance in the network (Jones et al., 1997).

Relational embeddedness is one of the major governance mechanisms in inter-firm networks (W. Powell, 1990). Lawson, Tyler, and Cousins (2008) defined it as a range of integration activities in working practices between buyers and suppliers. It addresses the nature and quality of relationships between exchange partners, which reflects the degree of their interdependence (Gulati & Sytch, 2007).

Uzzi (1996) in his ethnographical study of US apparel industry identified trust, fine-grained information exchange and joint problem-solving as key factors of structural embeddedness. Later (Gulati & Sytch, 2007; McEvily & Marcus, 2005) trust was operationalised as fine-grained information exchange and joint problem solving as dimensions of structural embeddedness. Firms involved in high level, symbiotic exchange relationships generate value and synergies across the value chain. Lower levels of trust and information exchange, on the other hand, reduce joint-action and are characterised by overall low flexibility and procurement efficiency.

The literature review provided in Sections 2.1 and 2.2 introduced theoretical foundations for development of the conceptual framework presented in the Chapter 3. Since the proposed framework was developed specifically to investigate the contribution of supply network governance to resilience of resource-extractive regions, an in-depth review of the literature in economic development of resource extractive regions and specificities of local resource industry supply chains was conducted. The next section provides a critical review of frameworks used to explore mechanisms and factors contributing to the development of resilient resource extractive regions and clusters, thus highlighting the gaps to be addressed by the current research.

2.4 Resilience of resource extractive regions: current state of knowledge

Types of resource extractive regional economies appear in the economic geography literature and resource policy studies from different perspectives, including resource dependence (Ross, 2015), the development of forward and backward linkages from the resource sector to the local economy (Fessehaie & Morris, 2013; Morris, Kaplinsky, & Kaplan, 2012; Morrissey & Cummins, 2016), economic restructuring (Knobblock, 2013; Knobblock & Pettersson, 2010), formation of agglomerations and clusters (Arias, Atienza, & Cademartori, 2014b; Bas & Kunc, 2009; Milanez & Puppim de Oliveira, 2013; Satchwell, 2012), and local capability development (Atienza, Aroca, Stimson, & Stough, 2016; Figueiredo & Piana, 2016; Kaplan, 2012; Scott-kemmis, 2013; Silvestre & Neto, 2014; Walker & Minnitt, 2006). As scholars point out the debate on contribution of the natural resource related industries to industrial development is based on predominantly macro-level approaches, methodologically varied and far from consensual (e.g. Andersen et al., 2015; Figueiredo & Piana, 2016).

Two opposing lines of thought could be distinguished in the literature in regard to the contribution of the resource sector to regional development. The negative view often portrays the resource sector as operating in isolation, making a weak contribution to the local economy, experiencing technological stagnation and backwardness, low competitiveness, with fewer opportunities for innovation (e.g. Ejdemo & Söderholm, 2011; Phelps, Atienza, & Arias, 2015; Piana, 2015; Söderholm & Svahn, 2015; Warrian & Mulhern, 2009). According to this view, the resource extraction sector usually makes little investment in the domestic economy and uses limited production inputs sourced from other local industries (Agyei, Sarpong, & Anin, 2013). Since the resource commodities are often exported overseas, very few value added products are developed locally. Such non-sustainable organisation of local economy is associated with a *hub-and-spoke* structure of regional supply chains. There are a few influential companies that dominate the region surrounded locally by small and medium satellite suppliers.

More positive views in the literature depict successful examples of strong and resilient local economies developed in regions endowed with mineral resources. Such resource-extractive regions benefit from a variety complementary industries developed around resource extractive activity (e.g. Knobblock, 2013; Walker & Minnitt, 2006; Warrian & Mulhern, 2009). The development of a local technology and knowledge-intensive supplier base creates multiplier effects, spurs innovative development and local economy diversification (Kaplan, 2012; Knobblock, 2013; Morris et al., 2012; Walker & Minnitt, 2006; Warrian & Mulhern, 2009). Such a positive dynamic allows resource extractive regions to avoid 'lock-in effects' and leads to development of resilient regional economy, with the gradual shift towards high-value added knowledge-intensive industries.

Thus, relationships between firms operating within the same industry as well as relationships between local industries have been a subject of research since the beginning of the 20th century in an effort to understand why some resource extractive regions have a negative history and others demonstrate sustained economic growth. Observations of the relationships have resulted in several models being developed and researched. The literature concerned with resilience of resource-extractive evolved around three major theoretical streams – enclave, agglomeration and cluster theories.

2.4.1 Resource extractive enclaves

Enclaves as a type of the economic organisation of the resource extractive regions are characterised by less resilient resource economies, more often found in developing countries (e.g. Arias et al., 2014b; Phelps et al., 2015). They often host productive enclaves, in which economic activity takes place quite apart from most activity in the surrounding area. Enclaves are characterised by the import of knowledge-intensive services and a qualified workforce from outside of the region, weak forward and backward linkages from the resource sector to local economy and low engagement of local firms into the resource supply chains, resulting in insufficient development of local capabilities (Arias et al., 2014b; Atienza et al., 2016; Bloch & Owusu, 2012; Farooki, 2012; Silvestre & Neto, 2014).

Some scholars in regional geography literature advocate industrial *enclave* frameworks as the most relevant form of economic organisation for resource regions in developing economies (e.g. Arias et al., 2014b; Phelps et al., 2015). An industrial enclave is defined as:

> *A physically, administratively, or legally bounded territory whose geography or morphology is intimately related to the following economic characteristics: dependence on one or a few large firms; high specialisation in one activity; and weak integration into the local economy, which is used primarily to access some local factors of production…(Phelps et al., 2015, p. 120)*

The discussion of enclaves started with the seminal work of Singer (1950), who introduced the concept of an enclave in a resource extractive economy as a means of organising resource extraction characterised by capital intensity, low numbers of jobs created and weak links to local suppliers (Morris et al., 2012).

Enclaves in resource extractive economies are noted for the *macroeconomic impact of resource extraction* on relative prices and incentive systems (Morris et al., 2012). Enclaves reinforce the impression that nations rich in natural resources, but poor in knowledge, awareness and governance systems, experience a *resource curse.* In spite of their natural resources, they often lag behind nations with fewer natural resources, but with greater experience and more robust political and economic systems (Boyce & Herbert Emery, 2011; Humphreys, Sachs, & Stiglitz, 2007; Sachs & Warner, 2001).

In these circumstances, the long-term cyclical trends and volatility of world commodity prices often result in the so-called *Dutch disease* (Boyce & Herbert Emery, 2011; Corden, 2012; Forsyth, Dwyer, & Spurr, 2014; Sachs & Warner, 2001; Söderholm & Svahn, 2015). Dutch disease is characteristic of an economy booming in a single sector, leading to local currency appreciation, making other industry sectors less competitive in export markets. In the absence of other counterbalancing positive effects, economies highly dependent on natural resources are seen as unstable and usually decline over time (e.g. Boyce & Herbert Emery, 2011; Scott-kemmis, 2013).

Resource enclave economies have low resilience in the long term, being highly vulnerable to external shocks, such as downturns in commodity prices, although in the short term, they may grow rapidly and contribute to export and gross domestic product (Phelps et al., 2015). Low resilience is determined by the fact that the resource sector treated as an enclave often makes little investment into the domestic economy and does not contribute to the development of high-value added activities in the region, using limited production inputs sourced from other local industries (Agyei et al., 2013). Since resource commodities are often exported overseas, very few value added products are developed locally.

Lack of forward and backward linkages leaves few opportunities for local capability development, leading to technological stagnation and 'lock-in' (Ejdemo, & Söderholm, 2011; Evans, & Sawyer, 2009; Phelps et al., 2015; Piana, 2015; Söderholm, & Svahn, 2015; Warrian, & Mulhern, 2009). This scenario has been reported mainly in developing countries, such as Chile and Brazil (Arias et al., 2014; Atienza et al., 2016; Silvestre, & Neto, 2014), South Africa, Ghana and Zambia (Bloch, & Owusu, 2012; Farooki, 2012; Fessehaie, & Morris, 2013; Lydall, 2009)

2.4.2 Industrial agglomerations and clusters

Agglomeration economy is often used discuss development of human settlements and industrial regions. The earliest literature on the relationships between organisations and how their tendency to cluster in close proximity was firstly mentioned in relation to the concept of 'industrial districts', which were later called *agglomerations* (Marshall, 1920). It was observed that the geographic proximity of individual industries resulted in a thick labour market, division of labour, and knowledge spillovers.

Later Paul Krugman (1991) and Michael Porter (1990) have exerted the greatest influence on the development of agglomeration and cluster theories. Thus, Porter (1990) found that agglomeration of suppliers, customers and competitors in geographical proximity, linked by complementary expertise, stimulates the emergence of economic linkages and knowledge spillovers, which enhance efficiency and increase specialisation, resulting in the formation of economies of scale and scope. Krugman (1991) introduced a model linking increasing returns to a scale yielded by externalities within a geographically bounded region, arguing that the spatial agglomeration of economic activity was a source of increasing returns. The economy of agglomeration attributed the benefits that economic agents acquire by their aggregation in a particular socio-economic space to:

- sufficient demand that encourages firms to develop differentiated products
- availability of specialised inputs for customers at lower transactions costs from differentiated input suppliers within the region
- spillovers that confer benefits arising from the proximity of businesses within an agglomeration.

Frameworks of industrial agglomerations were further developed by Markusen (1996), and McCann and Gordon (2000). Thus, Markusen (1996) put forward three structural types of agglomerations:

- *hub-and-spoke industrial district*, revolving around one or more dominant, externally oriented firms
- *a satellite platform*, an assemblage of unconnected branch plants embedded in external organisation links
- *state-anchored district*, focused on one or more public sector institutions.

Gordon and McCann (2000) distinguished three types of industrial agglomerations based on different types of processes underlying their formation:

- pure agglomeration
- industrial district
- social network.

depending on the nature of relationships within the agglomeration. The social network agglomeration draws attention to the close, socially bonded relationships between firms based on a high level of trust and collaboration.

In 1990 Michael Porter introduced the definition of industry *clusters*, as a geographical concentration of interconnected companies and institutions in a particular field. Later, the fact that firms compete as well as cooperate in a cluster was added. Industry clusters could be observed in geographic concentrations with industries related by skill, technology, supply, demand, and other features (Delgado, Porter, & Stern, 2014). Porterian clusters were spatial agglomerations of firms bound together by input-output exchanges on the basis of their production complementarities. The benefits for regional development in Porterian clusters stem from the external division of labour across firms. Clusters include firms working in related or supporting technologies, and an infrastructure of institutions and relationships that promote the interest of the whole cluster.

The competitive advantage of firms within a cluster is created in the interfaces between firms and their customers and suppliers, and thus highly capable firms are usually located in close proximity to each other (Porter, 1990). Porter (1998) identified four factors that clusters benefit from:

- specialised demand
- input factors in the form of capital, labour, natural resources
- infrastructure, knowledge; complementary and supporting industries
- provision of goods and services including research and education at the different stages of the value chain and competition among firms in the core sector.

Thus, cluster frameworks developed around static combinations of factors, which have to be present in the region to ensure the growth and competitiveness of the region. The key universal characteristics of clusters, with no regard to the particular industry, are the nature and intensity of relationships among organisations in a cluster. They should be based on trust and cooperation, thus enhancing organisational learning of firms in a cluster. Most importantly, clusters are able to evolve and adapt to a changing business environment to more complex and high value added forms (Florida, 2002).

Phelps et al. (2015) propose that real world resource economies often balance between an enclave and a cluster (see Figure 2.3). This framework produces a spectrum of types of agglomeration for resource-extractive economies.

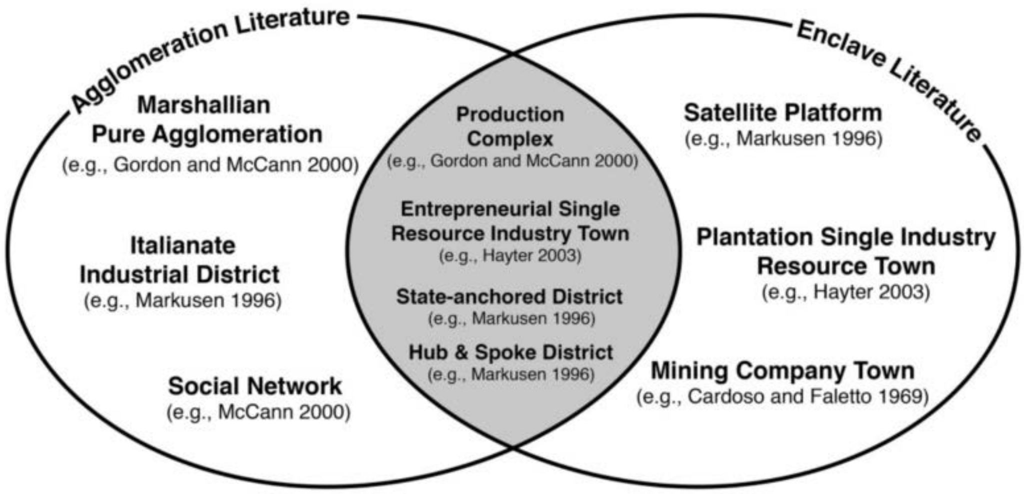

Figure 2.3 A framework showing overlaps between agglomeration and enclaves literature in relation to resource economics organisation (Phelps et al., 2015)

2.4.3 Resource extractive clusters

Resilient resource extractive economies in developed nations are formed by capitalising on resource endowments to make a transition to a high value added economy (e.g.Cappelen & Mjøset, 2009; Cumbers, 2000; Karlsen & Nordhus, 2011). In such a case, the establishment of strong backward and forward linkages from the resource sector to other sectors of the regional economy, agglomeration effects and positive externalities due to the formation of clusters of collaborative suppliers in proximity to mining sites lead to the gradual accumulation of capabilities, technology and knowledge in the local supplier base (e.g. Kaplan, 2012; Morris et al., 2012; Ritter, 2004; Scott-kemmis, 2012; Walker & Minnitt, 2006; Warrian & Mulhern, 2009). This generates sustainable growth, economic diversification and gradual transition from purely extractive activity to the development of high-value added knowledge-intensive industries (Arias et al., 2014b; Figueiredo & Piana, 2016; Phelps et al., 2015).

Factors of cluster formation at the meso- or regional level. The key factors contributing to the formation of resilient resource regions are discussed in the cluster literature. Firstly, a collaborative attitude and the engagement of local multinationals in the development of local suppliers are key to the growth of knowledge-intensive industries (Arias et al., 2014b; Phelps et al., 2015).

Secondly, the active involvement of the state and regional governments in distributing revenue from extractive activity to stimulate other sectors of the economy is essential (e.g.Cumbers, 2000). Thirdly, the presence of a favorable business environment, including the availability of venture capital, established procedures of knowledge transfer among resource companies and local firms, and investments in research and development in relevant fields, is needed to stimulate innovative development (Scott-kemmis, 2012).

If these factors coincide, regional innovative clusters of knowledge-intensive suppliers emerge in the region, further stimulating technological growth and increasing returns to the local economy. Thus, the development of local knowledge-intensive industries around resource extractive activity is brought about by supplier companies providing knowledge-intensive services to the resource sector, by acquiring expertise and upgrading their technological capabilities (Scott-kemmis, 2012). Technology and innovative solutions developed to serve the needs of the resource extractive companies is then transferred to other sectors of the economy. This technological development contributes to the formation of new niches in the existing sectors, as well as new industries in the region, thus stimulating economic growth (Arias et al., 2014b; Walker & Minnitt, 2006; Warrian & Mulhern, 2009).

As the regional economy becomes more diversified, there are more opportunities for direct and indirect interactions between industries, economic growth in terms of investments, employment and income, thus making the region less reliant on resource extraction (Ivanova, 2014). A simple example of forward linkages establishment could be the usage of metal produced by local manufacturers for consumer durables, such as aircraft, maritime, electronics, and communications companies, or when steel and aluminum are used in the construction industry.

Oil and natural gas usually serve as input to the transportation sector, plastics manufacture and industrial, commercial and domestic heating firms. When non-core activities associated with resource extraction are sub-contracted or outsourced to local firms that cannot be considered part of the mining industry, but belong to other economic sectors (Knobblock, 2013), a cluster is developing. Capital equipment and mining equipment providers, contract mining services, geological and exploration services, providers of mining consumables, professional services including engineering and consulting, mining information technology and software providers can add value to an economic cluster.

Bas, Amoros, and Kunc (2008) offered a framework showing how value added industries form based on resource-extraction activity (Figure 2.4).

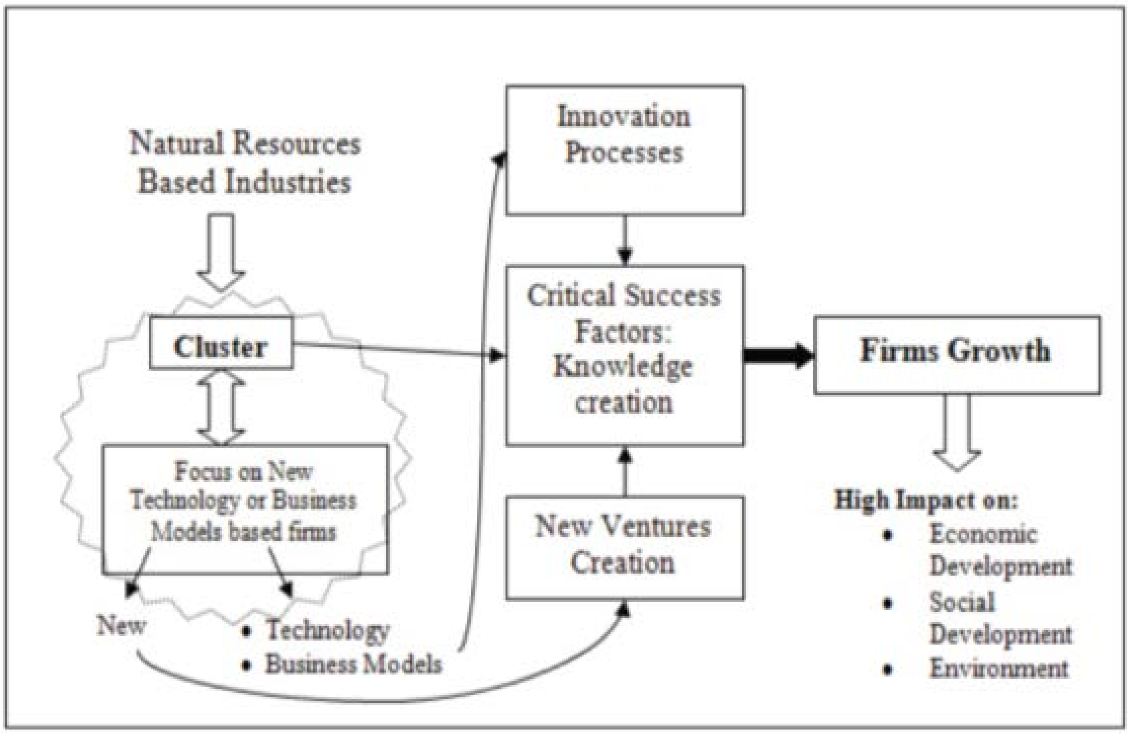

Figure 2.4 A framework for development of value added activities from resource extractive industries (from Bas et al., 2008)

Successful development of local linkages contributing to the formation of knowledge-intensive industries has been reported in Sweden, Norway, Finland, Canada, and Australia (Knobblock, 2013; Phelps et al., 2015; Ritter, 2004; Scott-Kemmis, 2012; Scott-Kemmis, 2013; Söderholm, & Svahn, 2015; Warrian, & Mulhern, 2009). The Bothnian Gulf in the frontier of Sweden and Finland is an example where the mining industry catalysed the development of the metal processing, manufacturing, consulting, research and education sectors (Arias et al., 2014). Norway was able to use the oil industry as a basis for the development of machinery, ICT, engineering, transport and services sectors (Cappelen, & Mjøset, 2009; Cumbers, 2000; Karlsen, & Nordhus, 2011).

Canada has developed a mining cluster with strength in exploration services, contract drilling, consultancy, specialist engineering, procurement and construction (EPC), as well as specialist engineering services (e.g., electrical, water, ventilation systems) and financial services (Ritter, 2000; Warrian & Mulhern, 2009).

In the Australian resource economy, clusters of competitive METS companies were developed around resource extractive activity in Western Australia, Queensland, and New South Wails (Martinez-Fernandez, 2010; Scott-Kemmis, 2012; Townson, Matthews, & Wrigley, 2016)

Drivers and mechanisms of resource clusters formation at the micro-level. At the micro-level, economic geography literature discusses the diversification of resource extractive economies from the perspective of the development of local companies' capabilities, building a collaborative culture to facilitate value co-creation in the resource supply chains (Figueiredo, & Piana, 2016).

Several factors are identified in the literature as contributing to the development of resource related clusters of technology suppliers. Migration of a qualified workforce from MNCs to set up businesses in proximity to service these MNCs (Knobblock, 2013). 'Lateral migration' of technologies – the widespread application of the technology developed by resource sector suppliers across other unrelated industries (e.g., automation and process control, logistics, pumping, materials handling, construction etc.) (Walker, & Minnitt, 2006). Reorganisation and technological upgrades of resource supply chains due to globalisation and outsourcing of non-core activities by mining companies (Jacquier-Roux, & Bourgeois, 2002; Knobblock, 2013; Scott-Kemmis, 2013). The restructuring of resource sector supply chains generates new business opportunities in subcontracting, consultancy and equipment production, thus contributing to the development of knowledge service suppliers to the resource sector and related industries (Jacquier-Roux, & Bourgeois, 2002). The accumulation of tacit knowledge and expertise increase the local capacity to continuously upgrade and innovate by providing solutions for customer problems tailored to the local context (Scott-Kemmis, 2004; Walker, & Minnitt, 2006). Clusters demonstrate collaboration and knowledge transfer between the mining companies, local suppliers and other regional actors (Kaplan, 2012; Morris et al., 2012; Walker, & Minnitt, 2006; Warrian, & Mulhern, 2009).

Outsourcing of non-core activities by mining companies, including exploration, mining operations and specialist services, stimulates the development of a broader range of services and the diversification of the local supplier base. The knowledge-intensive nature of the services required drives innovativeness, specialisation and the upgrading of technological capabilities of local firms (Jacquier-Roux, & Bourgeois, 2002; Walker, & Minnitt, 2006).

A number of successful examples associated with the formation of collaborative networks of local suppliers around mining companies, stimulating horizontal knowledge transfer and capability upgrade have been recorded (Ritter, 2004). Vertical knowledge spillovers occur through the direct relationships of local suppliers with MNCs (e.g., Javorcik, & Spatareanu, 2009). However, a number of studies from developing (e.g., Atienza et al., 2016; Phelps et al., 2015; Silvestre, & Neto, 2014) and developed economies (e.g., Chapman, MacKinnon, & Cumbers, 2004; Martinez-Fernandez, 2010; Warrian, & Mulhern, 2009) have not observed the same tendency. Scott-Kemmis (2012) has also reported a similar barrier for innovative development of knowledge-intensive services in Australia. Due to the hierarchical structure of mining companies, the MNC subsidiaries operating in resource regions usually do not perform knowledge-intensive activities, since the main research occurs in the corporate headquarters located in urban centres.

Scott-Kemmis (2012) identified five primary mechanisms of Australian METS capability development:

- direct operational experience
- knowledge transfer from established firms
- problem solving based on use of available knowledge
- research and development activities often involving generation of new knowledge and collaboration with other organisations
- knowledge diffusion.

In the Australian context, the development of resource clusters is driven by:

- sophisticated customers
- mining companies with an increased demand for innovations
- tough competition in the sector
- the availability of other METS with complementary capabilities enabling collaboration and alliances
- the availability of a qualified labour force
- specialised research, education and training organisations.

The formation of clusters is driven by endogenous development through companies' internal research and development and inter-networks serving as conduits of knowledge, technology and strategic information diffusion (Scott-kemmis, 2013) (Figure 2.5).

Martinez-Fernandez (2010) assessed knowledge generation and transfer between knowledge-intensive service suppliers to mining companies from the perspective of a 'mining innovation ecosystem', recognising the roles of organisations indirectly contributing to a capability upgrade and the innovativeness of firms supplying services to the resource sector. Mining sites provide an environment where suppliers exchange knowledge and network.

The transformations of individual firms from purely resource-extraction oriented to more technology focused has also been documented in the literature, such as Mitsubishi, which was initially formed as lead-zinc mine. Other examples include diversification upstream and downstream, such as Alcan. Absorptive capacity and participation in networks leading to alliances formation enhance resource related firms' abilities to build up their capabilities to knowledge-intensive services (Bas et al., 2008).

Thus, formation of clusters of technology and knowledge intensive firms around resource extractive activity, enabling knowledge transfer across local supply networks contributed to regional resilience and adaptability of the resource-extractive regions.

Figure 2.5 Drivers of capability development of Australian METS suppliers (Scott-kemmis, 2013)

2.4.4 Regional supply networks as a catalyst for formation of clusters in resource-extractive regions

Paths of regional development of resource extractive regions are often associated with the development of regional networks stimulating knowledge transfer across regional suppliers to the resource sector (Chapman et al., 2004; MacKinnon, Chapman, & Cumbers, 2004; Martinez-Fernandez, 2010; Warrian, & Mulhern, 2009). These networks represent a set of interconnected supply chains of resource companies, with shared suppliers and customers (Statsenko, Ireland, & Gorod, 2016). METS suppliers learn and develop their capabilities and get more opportunities for gaining more work in the sector through collaboration around customer problem (Martinez-Fernandez, 2010; Scott-Kemmis, 2012).

The supply networks in the resource industry are usually geographically bounded, due to location specificity of the resource extractive activity. Supply chains are located close to resource extraction due to efficiency and cost advantages (Silvestre, & Neto, 2014).

For example, MacKinnon et al. (2004), examined the role of networks of small firms operating in Aberdeen oil complex in getting access to industry-specific information and knowledge, however, highlighting the importance of extra-regional networks over domestic ones. Atienza et al. (2016) discussed the role of vertical linkages among mining companies and local suppliers, thus confirming positional advantages of METS relationships with mining companies and large EPCM providers in the resource supply chain. Researchers argue that firms supplying to major resource extractive companies in the region exceed in their performance and innovative capability in comparison with other local firms which are not directly connected to major customers (Atienza et al., 2016). Figueiredo and Piana (2016), drawing on the qualitative empirical study of Brazilian METS companies, note that relational embeddedness and the pressing need for innovative solutions play key roles in organisational learning of local suppliers to the resource sector.

The most intensive organisational learning occurs through a search for innovative solutions to face market problems followed by joint R&D projects conducted with clients and R&D training related to the implementation of new activities that derive from R&D projects. Knowledge transfer through joint tests, experimentation and engineering is the next important pillar of organisational learning, occurring when METS suppliers evaluate new technologies within the mining company. Technical assistance and service provision to mining companies through diagnosis and offering a solution to the clients' problem is the next most important channel of knowledge transfer. Links with universities, general and technical training follow as the least important channels for METS organisational learning.

The key factors influencing a local capability upgrade are knowledge transfer through supply chains, R&D and innovation leading to the upgrade, the presence of organisational nodes facilitating networking and knowledge creation and exchange among firms (Warrian & Mulhern, 2009).

Vertical collaboration between customer and supplier is more often discussed in the literature related to innovative development of resource extractive industries (Atienza et al., 2016; Martinez-Fernandez, 2010; Scott-kemmis, 2013). Suppliers and customers establish long term relationships, often through collaboration around customer problems, which is particularly true for the resource sector and related industries, where local suppliers are often preferable due to low-cost benefits and the proximity to mining sites (Knobblock, 2013; Scott-kemmis, 2013).

Recently, suppliers to the resource sector have increasingly adopted design-led innovation approaches that require constant and in-depth engagement between customer and supplier (e.g.Townson, Matthews, & Wrigley, 2016). Several empirical studies highlight the role of customer relationships for METS' innovative development and capability upgrade (Jacquier-Roux & Bourgeois, 2002; Knobblock & Pettersson, 2010; Yusuf et al., 2014). The shift of innovation and technology development from large multinationals to supplier networks in resource extractive industries is mainly associated with outsourcing of non-core capabilities to supplier firms. This has encouraged closer collaboration between METS and clients to solve their problems, leading to long-term relationships and partnership formation.

The sensitive information that parties exchange requires a high level of trust. In the resource industry, collaboration with customers around their problems, apart from other forms of collaboration (with universities for R&D purposes, with government and NGO) has been cited as the most common form of collaboration (Dalitz, Holmén, & Scott-Kemmis, 2012; Martinez-Fernandez, 2010). The relationships between mining companies, suppliers and sub-contractors allows for reducing information uncertainty and identification of new projects and opportunities.

Horizontal collaboration in the resource supply chain occurs when there is a need for supplier companies to get complementary capabilities in order to fulfil project requirements. In this case, an informal alliance or partnership is created (West, 2014). Collaboration may occur between an original equipment manufacturer, pipe and hose distributor, and engineering and project management company that will supply an engineering service to a mining company.

2.4.5 Adaptability and resilience of resource extractive regions

In spite of being popular in economic geography, an evolutionary view of adaptability and adaptation in resource extractive regions applying an evolutionary view has received scant attention. Hu and Hassink (2015) discussed evolution and adaptation of old industrial regions in China applying an evolutionary lens by considering the concepts of lock-in, path dependence, and related variety. However, ttransformation or adaptation of resource extractive regions was discussed from the perspective of industrial supply chains restructuring from vertically integrated to more decentralised structures (Arias et al., 2014b; Cappelen & Mjøset, 2009; Ritter, 2004; Scott-kemmis, 2013; Silvestre & Neto, 2014; Walker & Minnitt, 2006; Warrian & Mulhern, 2009).

Scholars often report the verticality and conservative nature of the mining industry, which impedes development of high-value added services a collaborative culture and hinders innovative development of the local supplier base (Silvestre & Neto, 2014; Warrian & Mulhern, 2009). Although firms operating in the resource industry recognise the ‘ability to change’ as the most important capability for innovation (Martinez-Fernandez, 2010), the legacy of the vertical integration of resource supply chains and often outdated management approaches impede this process (Chapman et al., 2004; MacKinnon, Chapman, & Cumbers, 2004; Warrian & Mulhern, 2009).

Martinez-Fernandez (2010), for example, reported on the barriers to innovative development of knowledge-intensive suppliers to resource sector firms. These included organisational management resources constraints, lack of skilled personnel, high costs and the risks associated with the development and implementation of innovations. With the increasing automation of mining operations and integration of mining equipment and information technology, the demand shifts from the basic labour intensive services and skill sets towards more decision-making, innovative and creative capabilities involving both soft skills and ability to combine and apply complex technological tools and techniques (Scott-kemmis, 2013).

Warrian and Mulhern (2009) reported the following challenges that mining services firms face in resource related clusters in Canada:

- the need to quickly absorb and utilise complex knowledge to navigate in a networked economy, due to previous integration into vertical supply chains
- the inability to transform vision due to internal organisational and attitudinal legacies as commodity suppliers
- additional pressure of the need for cost reduction caused by reorganising in global supply chains
- a shortage of skilled and motivated labour, due to low attractiveness of the mining sector in comparison with high tech industries
- underdeveloped links between small suppliers and research organisations coupled with an inability to protect intellectual property
- weak cooperation between local suppliers does not allow the addressing of structural bottlenecks in local supply chains
- weak cooperation and collaboration between local firms impedes synergetic benefits of value co-creation within the local mining industry supply chains (Warrian & Mulhern, 2009).

Scott-kemmis (2013), analysing opportunities for the innovative development of Australian METS firms, acknowledged that the low inter-firm collaboration between mining services suppliers and other organisations such as R&D and universities, contributes to the capacity gap. The solution is seen in institutional innovations leading to enhanced inter-organisational collaboration in the Australian mining sector. Walker and Minnitt (2006) analysing the issues of the dynamics and competitiveness of the South African mining industry supply sector, stress the importance of networking and collaboration for innovative development. Atienza et al. (2016) discussed the importance of best practice differences between local suppliers according to their closeness to MNCs, which provide implications for policy makers involved in network development initiatives.

Arias et al. (2014b) drawing on the example of the Chilean mining region, Antofagasta, argues that although policy makers have proposed the formation of networks of interconnected suppliers, many still follow the economic model of productive enclaves. These enclaves are characterised by the 'hub-and-spoke' structures of the local mining industry supply chains, with a large multinational corporation (MNC) acting as the only hub for the region with a high degree of vertical integration and much less horizontal interaction. Such a structure of economic connections limits opportunities for a local supplier base to develop, hindering the emergence of new knowledge-intensive economic sectors. Accordingly, knowledge transfer and innovation diffusion does not happen to the extent that allows the development of a diversified and sustainable local economy. Further skepticism about the economic development of resource-based countries relies on the assumption that the mining and energy sectors, due to high level of integration into global supply chains, provide limited opportunity for local 'technological learning' and as a result, development of enclave-like structures (Arias et al., 2014b; Piana, 2015). This results in the situation where the economic benefits from resource regions are not always retained locally.

Chapman et al. (2004), drawing on the example of the North Sea Aberdeen oil cluster, highlighted the importance of the evolutionary perspective in cluster development scenarios. The authors proposed a framework that linked the meso and micro-levels of a regional economy through mechanisms of re-orientation (see Figure 2.6).

The framework links firm-level strategies to development scenarios of resource-extractive clusters at the regional level. Two development scenarios of the resource extractive regions: *renewal,* which involves significant change, enabling sustained prosperity and resilience to external shocks, and *adjustment*, which is associated with lock-in effects, stagnation and gradual decline. Two types of firm strategies are also distinguished – *adaptability and adaptation*. The *adaptability strategies – diversification* and *innovativeness* contribute to the long-term regional resilience of the resource extractive regions and lead to the emergence of high-value added knowledge-intensive industries. *Adaptation strategies*, otherwise, help to sustain business but may lead to technological lock-in and gradual decline.

According to this view, firms' responses to changing economic conditions at the micro-level result in cluster evolution at the meso-level. At the firm level the horizontal axis represents a continuum between firm adaptation and adaptability strategies. The researchers refer to *adaptation* as a firm's short-term survival strategies to maintain competitiveness, while *adaptability* is defined as '…the more fundamental capacity to redeploy existing assets and capabilities in new directions…' (Chapman et al., 2004, p. 384). Based on the previous findings (Chapman et al., 2004; MacKinnon et al., 2004) it was assumed that these strategies implemented by regional suppliers in resource extractive regions lead to formation of clusters in resource extractive regions contributing to resilient resource extractive economy.

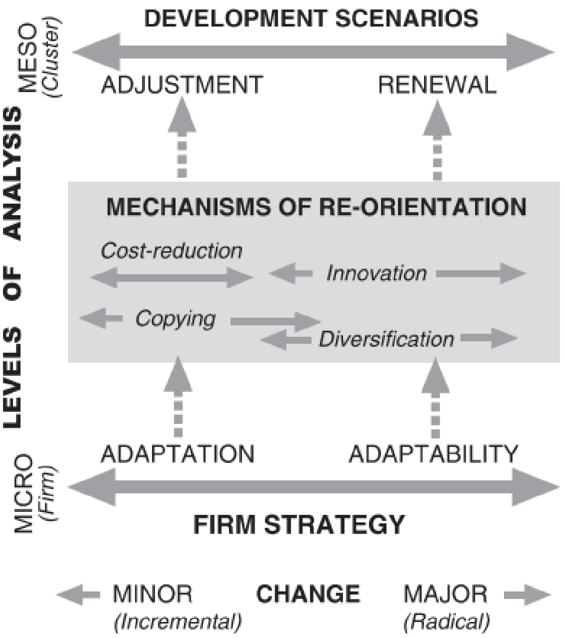

Figure 2.6 The dynamics of re-orientation and renewal in mature clusters (from Chapman et al., 2004)

In many cases, for example, adaptation refers to short-term incremental changes within the old paths, while adaptability is more related to radical change, innovation and new path creation (Chapman et al., 2004; Xiaohui Hu, 2015).

Mechanisms of reorientation within a network relate the firms' strategies to network development scenarios ranging from minor or incremental (network adjustment) to major or radical (network renewal) ones. Cost-reduction and copying lead to short-term survival, while innovation and diversification increase a firm's adaptability, leading, at the meso-level, to renewal.

Although being important for understanding micro and macro level transformational processes in resource extractive regions, the literature discussing evolution of resource extractive regions through adaptability and resilience lens is very limited. There are only a few works found attempting to investigate processes of capability development at the firm level with the consideration of the meso-level and macro level factors and influences, thus acknowledging the environment and its role in the formation of resilient resource economies able to give rise to other value-added industries. The role of regional networks has been emphasised as major conduits of knowledge and information transfer.

2.4.6 Summary of frameworks applied to understand economic development of resource extractive regions

A summary of theoretical approaches and frameworks adopted by scholars investigating economic developement of resoure extractive regions is presented in Table 2.1. Previous research suggests that there are multiple factors contributing to the development of resilient regions based on resource extraction (Atienza et al., 2016; Kaplan, 2012; Phelps, Atienza, & Arias, 2015; Scott-kemmis, 2013). The scholars report that the literature related to the innovative development of resource extractive regions is limited (Phelps et al., 2015):

> *Research on extractive industries has received scant attention in economic geography despite the critical relevance of this activity … there is a need for a broader debate about the dynamics of mining regions, … to what extent traditional enclaves are evolving toward either competitive clusters or new forms of enclave, which will determine the sustainability of the host region's growth and its development possibilities…(p. 12)*

There is extensive evidence in the literature about the negative impact of resource extractive activity on local economies, especially in developing countries (Phelps et al., 2015; Scott-Kemmis, 2012; Weller, & O'Neill, 2014). A number of works in *agglomeration and industry clusters* literature proved limitations of this view providing empirical evidence of resource regions being able to transform successfully to more knowledge-intensive economies through the development of the METS sector around resource extractive activity. The regional economic development literature highlights the need for diversification and development of forward and backward linkages from the resource sector to other sectors of the economy (Atienza et al., 2016; Knobblock, 2013; Morris et al., 2012; Scott-Kemmis, 2012). This has often been associated with the formation of clusters of the local supplier base in proximity to mining operations (Chapman et al., 2004; Knobblock, 2013; Scott-Kemmis, 2012; Walker, & Minnitt, 2006; Warrian, & Mulhern, 2009). However, policy frameworks in resource extractive regions are often criticised. Scholars argue that Porter's cluster model has often been applied to facilitate the development of resource regions, without considering the peculiarities of resource supply chains historically where vertical integration is the norm with limited horizontal collaboration (Arias et al., 2014; Warrian, & Mulhern, 2009).

Table 2.1 Theoretical approaches and frameworks adopted by scholars investigating economic development of resource extractive regions

Theoretical framework	Reference	Arguments	Identified gaps / limitations
Linkages development with local economy	(Andersen et al., 2015; Fessehaie & Morris, 2013; Figueiredo & Piana, 2016; Ivanova, 2014; Kaplan, 2012; Morris et al., 2012)	Backward and forward linkages from the resource sector are developed paving path for industrial development for industrial development in resource extractive economies. Linkages may include fiscal, consumption and production. Production linkages lead to diversification - Hirshmann 'one thing leads to another' (Fessehaie & Morris, 2013; Morris et al., 2012) Reorganisation of mining industry with de-verticalisation through outsourcing of a range of activities from operational maintenance to engineering specialise services and research and development contributed to the emergence of specialised knowledge intensive mining services (Figueiredo & Piana, 2016)	Merely 6% of the existing knowledge stock focuses on the domain of natural resources related industries (Andersen et al., 2015) numerous studies associated with contribution of natural resource related industries to industrial development are '…predominantly based on macro-level approaches, methodologically varied, and far from consensual …' (Figueiredo & Piana, 2016, p. 405) …different (and conflicting) perspectives on linkages and innovative activities exist in the mining industry…(Figueiredo & Piana, 2016, p. 406)
Economies of agglomeration	(Arias et al., 2014b; Badia-Miró, 2015; Morris et al., 2012; Phelps et al., 2015; Scott-kemmis, 2013; Walker & Minnitt, 2006)	Resource based regions are specialised forms agglomeration between enclave and cluster (Arias et al., 2014b). Hub-and-spoke district (Markusen, 1996) rather than cluster model suites best to describe characteristics of many mining agglomerations. It is characterised by the presence of one or more MNCs, which form the 'hubs' of the productive system, with high degree of vertical integration. They are usually export oriented, and surrounded by a set of local suppliers, organised as the spokes. Marshall's framework (1890/1920) is applied to distinguish between cluster and enclave mode of regional economy (Arias et al., 2014b).	There is a need for a broader debate about the dynamics of mining regions, the role played by MNCs and to what extent traditional enclaves are evolving toward either competitive clusters or new forms of enclaves, which will determine the sustainability of the host region's growth and its development possibilities (Arias et al., 2014b; Phelps et al., 2015)
Natural resource based clusters	(Atienza et al., 2016; Basco & Calabrò, 2016; Chapman et al., 2004; Milanez & Puppim de Oliveira, 2013; Ritter, 2004; Scott-kemmis, 2012; Silvestre & Neto, 2014; Walker &	Clustered pattern of industrial organisation is characterised by regional concentrations of networked suppliers, inter-firm learning and a decentralised and flattened production chain (Chapman et al., 2004; MacKinnon et al., 2004; Warrian & Mulhern, 2009). The resource clusters, when compared to more knowledge-intensive industries, experience a unique challenge in undergoing adaptation and transition from one vertical form of industrial production to more flexible organisation (Warrian & Mulhern, 2009);	More precise studies of the mechanisms by which path dependencies constrain and shape the process of clusters in resource related industries formation and the relative impact of embeddedness on their potential adaptation (Warrian & Mulhern, 2009) What are the common denominators of successful adaptation and are they applicable to other sectors?

Theoretical framework	Reference	Arguments	Identified gaps / limitations
	Minnitt, 2006; Warrian & Mulhern, 2009)	Formation of a mining cluster is hampered by segregation of local suppliers into two groups: first-tier mining suppliers, directly related to large corporations, follow business practices that promote international certification, quality control, and investment in innovation, and second-tier small and medium enterprises, which are more focused on avoiding insolvency and client orientation (Atienza et al., 2016). '…Natural resource-based clusters can be described as 'hub and spoke' clusters (Markusen, 1996), which are characterised by the presence of a few big export- oriented firms (commonly multinational corporations) which operate in a region with a large number of SMEs related to the main activity (organised as spokes) and other firms to support the general economic system of the region based on population's consumption… ' (Basco & Calabrò, 2016, p. 282)	(Warrian & Mulhern, 2009) '…The analysis of mining clusters has received scant attention in the literature that was predominantly based on the experience of manufacturing regions…' (Arias et al., 2014b, p. 75) '…contradictory information about the benefit of natural resource-based clusters and their effects on firms' innovative behaviour…' (Basco & Calabrò, 2016, p. 282) '…conception of power as a differential capacity that is activated and realised within industry networks…' as well as the need for identification of different types of networks in terms of balance between processes of collaboration and competitions and assessment of specific ways in which these networks enable or constrain innovation (Cumbers, Mackinnon, & Chapman, 2003)
Industrial restructuring and technological change	(Figueiredo & Piana, 2016; Jacquier-Roux & Bourgeois, 2002; E. Knobblock, 2013)	Globalisation and technological development led to restructuring in the resource and energy industries, with implications for individual firms and regional economies: Many resource-rich nations and resource-based communities have moved from resource-based economies to those based on service (Knobblock, 2013) Productivity increase causes downsizing in mining employment (Knobblock, 2013). Constant influx of qualified workforce to resource related services and the growth of the METS sector outside of extractive activity (Ivanova, 2014; Knobblock, 2013) Multilayered subcontracting leads to a more flexible production mode in the mining industry and less vertically integrated supply chains based on flexible specialisation (Warrian & Mulhern, 2009).	'…Further research on relatedness between industrial sectors could contribute to a more holistic and conjunctive understanding of growth potential and industrial development …'(Knobblock, 2013).

Theoretical framework	Reference	Arguments	Identified gaps / limitations
		Mining companies outsource a substantial part of their activities to subcontractors and consultants, thus transferring risks, and are able to adjust production and costs more effectively (Atienza et al., 2016; Figueiredo & Piana, 2016; Knobblock, 2013). Innovations are shifted from mining companies to small clusters of firms, international consortia and technology licensing (Jacquier-Roux & Bourgeois, 2002) The overall role of suppliers in the resource sector has increased over the last decade. Suppliers increased their technological efforts despite constraints of medium size and incomes through cumulative learning and acquiring specialised capabilities so that they are able to market to other customers (Jacquier-Roux & Bourgeois, 2002)	
Resource enclaves	(Arias et al., 2014b; Bloch & Owusu, 2012; Morris et al., 2012; Phelps et al., 2015)	The difficulties faced by policy makers when attempting to facilitate sustainable development of enclave like economies: Level of vertical integration is high, and the mining companies often play a dominating role in the region (Arias et al., 2014b). The relative isolation and the lock-in effects of path dependency among local businesses, a lack of alternative strategies for local development (Knobblock & Pettersson, 2010) MNE subsidiaries and affiliates undertaking knowledge activities are increasingly located in the spikes of the world urban systems, while peripheral regions play a secondary role, performing ancillary tasks, where the possibility of knowledge transfer is very limited (Atienza et al., 2016) Limited vertical transference of knowledge from the headquarters of the mining MNCs to the local firms, 'absence of mutual dependence' between mining companies and their direct suppliers, has not favored the emergence of collaborative long-term agreements that permit the vertical transfer of knowledge and these agreements, as well, do not affect the results of SMEs…'(Arias et al., 2014b, p. 185)	Research on extractive industries has received scant attention in economic geography despite … its strategic significance for industrial economies…(Arias et al., 2014b)

Theoretical framework	Reference	Arguments	Identified gaps / limitations
Evolutionary economic geography	(Chapman et al., 2004; Hu & Hassink, 2015; Hu & Hassink, 2017; Plummer & Tonts, 2015)	'Path dependence', 'lock-in', 'path creation' and 'relatedness', as well as 'institutional and leadership approaches' are useful concepts for a better understanding of the evolutionary processes and mechanisms of old industrial areas in China (Hu & Hassink, 2017) Identification of path-dependent trajectories in local economies, the case of Western Australia (Plummer & Tonts, 2015) Significant degree of diversification by SMEs in the Aberdeen oil complex into export markets and more limited movement into non-oil markets. The position of the cluster identified as a midway between adjustment and renewal. Importance of extralocal networks alongside localised relations (Chapman et al., 2004; MacKinnon et al., 2004)	'…impact factors and determinants of regional resilience remain under-explored, and lack in-depth empirical evidence…' (Hu & Hassink, 2015, p. 21)
Organisaitonal learning through resource supply chain relationships	(Atienza et al., 2016; Chapman et al., 2004; Figueiredo & Piana, 2016; Javorcik & Spatareanu, 2009; Martinez-Fernandez, 2010; Piana, 2015; Scott-kemmis, 2012, 2013; Townson et al., 2016).	Vertical linkages in the resource supply chain (from customer to supplier) are channels of knowledge spillovers (Atienza et al., 2016; Chapman et al., 2004; Javorcik & Spatareanu, 2009; Martinez-Fernandez, 2010). Collaboration around customer problems is the main strategy for local suppliers, through which vertical transfer of knowledge occurs (Martinez-Fernandez, 2010; Panesar, Markeset, & Kumar, 2008; Scott-kemmis, 2013) increase in subcontracting by MNCs become a mechanism for long-term cooperation that facilitates the vertical transfer of knowledge to local enterprises (Atienza et al., 2016; Martinez-Fernandez, 2010) The long-term relationships with both clients and suppliers/contractors so that become a source of expertise that the firm needs to absorb is the common strategy for knowledge-intensive services in Australian resource sector (Martinez-Fernandez, 2010) Relational embeddedness contributes to innovative development of the regional firms through 'learning linkages'(Figueiredo & Piana, 2016)	'…understanding of mining enclaves to complement the ideal type of enclave with recent cluster research on social networks analysis, knowledge transfer and industry life cycle…' (Arias et al., 2014b, p. 92) …study that makes a distinction between the self-selection issue (i.e., the possibility that more productive firms become MNC suppliers) and the learning effect (i.e., the productivity benefits accruing to suppliers from their interactions with MNCs (Javorcik & Spatareanu, 2009) '…there is a paucity of micro-level qualitative empirical studies that explore the nature of knowledge-intensive or learning linkages and their implications for innovative activities in the mining industry in a resource-rich … economy…' (Figueiredo & Piana, 2016)

Theoretical framework	Reference	Arguments	Identified gaps / limitations
The network organisation of supplier technological innovation	(Fessehaie & Morris, 2013; Jacquier-Roux & Bourgeois, 2002; Knobblock, 2013; Martinez-Fernandez, 2010; Piana, 2015)	Innovation is an interactive processes and the network organisation in the resource extractive sector based on of supplier–customer relationships. Dynamics of networks of technological innovation shifts towards upstream suppliers in the resource sector in a majority of technology fields. Suppliers rebuild network relations with their own 'upstream' suppliers, with an aim of continuing the vertical interactive learning essential to knowledge creation dynamics (Jacquier-Roux & Bourgeois, 2002) In developed countries, mining activities are socially embedded, which is characterised by strong formal and informal networks and business relations between mining companies and related companies. '…Social embeddedness creates an innovative business climate, where functional proximity increases a firm's possibilities to interact, collaborate, and deepen social contacts, which in turn enables innovation diffusion. Companies engaged in core and related activities recognise the importance of collaboration between firms for innovation purposes…' (Knobblock, 2013) The informal networks are source of knowledge and expertise for knowledge-intensive servises in the Australian resource sector. Some firms find them important for getting ideas and information, while others rather prefer formal contractual arrangements (Martinez-Fernandez, 2010)	'…it is important to understand how… MNCs could engage in a process of collaboration and knowledge transfer to the network of local suppliers, in a context where, apparently, there are not enough incentives for such type of behaviour…' (Arias et al., 2014b, p. 92)

Due to its maturity, the resource industry provides a unique context for cluster formation, which differs from knowledge-intensive growing and nascent industries. In the resource sector and related industries, cluster 'adaptation' or 'transition' versus cluster 'formation' is often highlighted (Chapman et al., 2004; Hu, & Hassink, 2015; Warrian, & Mulhern, 2009). Since path dependence constrains and shapes the process of cluster formation, more precise studies of the mechanisms and the relative impact of embeddedness on the potential for successful resource economy adaptation among clustering organisational forms is desirable (Warrian, & Mulhern, 2009, p. 299).

Given the path dependent trajectory of resource extractive regions, historical and industrial context are important when considering policy frameworks aimed at enhancing the competitiveness of the region. Scholars studying resource extractive industries stress the importance of regional adaptability, diversification and innovation during downturns to overcome the constraints imposed by industrial legacy (Chapman et al., 2004; Hu, & Hassink, 2015; Warrian, & Mulhern, 2009).

However, there are a limited number of works related to understanding how METS suppliers survive and develop during resource supply chain restructuring and industry downturns by diversifying into other sectors, developing technological capabilities and innovation in the context, when path dependence constrains the process of industry reorganisation (Chapman et al., 2004; Warrian & Mulhern, 2009). Scholars highlight the fact that the lack of studies at the firm level, which would be able to capture the nuances and variability of the resource related firms innovativeness, creates a generalised negative perception of the resource industry as but a modest contributor to innovative development in a region (Piana, 2015).

Furthermore, the literature on resource extractive regions highlights the role of supplier buyer relationships in the local firms' capability development. However, there are no studies that would explain how suppliers' networks contribute to firm level adaptability during external shocks and how this impacts regional resilience.

2.5 Chapter summary

Chapter 2 introduces theoretical foundations for the conceptual framework elaborated in Chapter 3.

The literature review aimed at justifying the main argument of this study that the regional supply network structure and governance impacts the development of adaptability strategies among local firms operating in the resource sector, thus contributing to enhanced regional resilience of the resource extractive regions. For this purpose, *evolutionary economic geography*, *supply network governance and embeddedness literature* were synthesised.

The existing framework grounded in *evolutionary economic geography* developed by Chapman et al. (2004) was used as a basis to draw the relationships between firm-level and regional level mechanisms of regional resilience of resource extractive. The framework links firm-level strategies to development scenarios of resource-extractive clusters at the regional level. The *adaptability strategies* that include *innovativeness and diversification*, were selected in this study as dependent variables in the proposed conceptual framework. Based on the previous findings (Chapman et al., 2004; MacKinnon et al., 2004) it was assumed that these strategies implemented by regional suppliers in resource extractive regions lead to formation of clusters in resource extractive regions contributing to resilient resource extractive economy.

The *network governance* and *embeddedness literature* was reviewed to introduce concepts of *regional supply network structure and governance* as essential determinants of regional resilience at the *meso-level* (region or cluster) and *network embeddedness as an antecedent of firms adaptability strategies* (at the *micro*- the individual firm level). The role of regional networks in building adaptability and resilience of regions and clusters has been widely researched in organisational studies, evolutionary economy and supply network literature (e.g., Balland, Belso-Martínez, & Morrison, 2014; Crespo, Suire, & Vicente, 2016; TerWal, & Boschma, 2007). At the regional level, interorganisational networks based on trust and collaboration allow for innovation and knowledge diffusion to occur within industrial regions thus contributing to the emergence of new industries. *Network governance* mechanisms were discussed as enablers or hindrances for creation a favourable environment in the region or cluster for firms to implement innovation and diversification strategies. At the firm level *positional embeddedness* emphasises the role of firm position in the supply network among other factors that drive firms' innovativeness and capability diversification. Being a part of regional supply networks allow firms to draw not only on internal resources such as investment in R&D, but also on external knowledge (e.g., McEvily, & Marcus, 2005; Uzzi, 1996; Uzzi, 1997). The concept of *relational embeddedness* emphasises the nature of supplier-buyer relationships and relates them to firm adaptability strategies. *Trust*, *joint action* and *fine-grained information exchange* are the key dimensions of relational embeddedness, which contribute to the ability of local firms to innovate and diversify.

Previous research related to the development of the resource extractive regions suggests that there are multiple factors contributing to their resilience (Atienza et al., 2016; Kaplan, 2012; Phelps et al., 2015; Scott-Kemmis, 2013). The regional development literature highlights the role of regional diversification through development of forward and backward linkages from the resource sector to other sectors of the economy (Atienza et al., 2016; Knobblock, 2013; Morris et al., 2012; Scott-Kemmis, 2012). This was often attributed to the formation of 'clusters' of local firms in proximity to mining operations (Chapman et al., 2004; Knobblock, 2013; Scott-Kemmis, 2012; Walker, & Minnitt, 2006; Warrian, & Mulhern, 2009). Due to its maturity, resource industry is a unique context for cluster formation, which differs from knowledge-intensive, growing and nascent industries. In the resource sector and related industries, cluster 'adaptation' or 'transition' versus cluster 'formation' is often highlighted (Chapman et al., 2004; Hu, & Hassink, 2015; Warrian, & Mulhern, 2009). Since path dependence constrains and shapes the process of cluster formation, more precise studies of the mechanisms and the relative impact of embeddedness on the potential for successful resource economy adaptation towards clustering organisation forms is desirable (Warrian, & Mulhern, 2009, p. 299).

There are scant empirical studies that would investigate the transformational processes in the resource-extractive regions leading to emergence of high-value added activities at both firm level and regional level (Chapman et al., 2004; MacKinnon et al., 2004; Warrian, & Mulhern, 2009). Currently, there is still limited knowledge about the adaptability and resilience of resource extractive regions from the evolutionary perspective (e.g., Chapman et al., 2004; Hassink, 2010; Hu, & Hassink, 2015; Warrian, & Mulhern, 2009). There are a limited number of works related to understanding how resource sector suppliers adjust their strategies to a changing business environment to sustain their business and grow their capability base, especially through frequent periods of downturn in the resource industry (Chapman et al., 2004; Warrian, & Mulhern, 2009). Scholars also highlight the lack of studies able to capture the nuances and variability of the innovative strategies at the firm level, which creates a generalised negative perception of the resource industry as a modest contributor to the innovative development of the region (Piana, 2015).

At the firm-level the role of local supply networks in the development of suppliers' capabilities in resource-extractive regions still needs to be better understood. The development of capabilities has been discussed mainly from a customer relationship perspective (Atienza et al., 2016; Jacquier-Roux, & Bourgeois, 2002; Martinez-Fernandez, 2010; Scott-Kemmis, 2012), the role of multinational corporations in regional development (Arias et al., 2014; Atienza et al., 2016), and macro-level factors influencing industrial dynamics in the region (Knobblock, 2013; Scott-Kemmis, 2012; Warrian, & Mulhern, 2009). Since the mining industry is characterised by long-term relationships collaborative between buyers and suppliers, knowledge exchange and learning for local suppliers occurs through collaborative problem–solving for customers, regional supply networks in the resource extractive regions may serve a major conduit of knowledge to local suppliers. Thus, there is a scope for research to better understand how supplier firm adaptability strategies are formed and what is the role of supply network relationships in this process. The proposed conceptual framework addresses this gap by investigating the role of regional networks in the development of adaptable and resilient resource extractive regions.

Thus, the primary objective of the literature review is to introduce a theoretical background for the development of the conceptual framework that addresses the highlighted gap in the literature concerned with the development of resilient resource extractive regions. The framework aims to explore and explain the mechanisms of emergence of high-value added industries in the resource extractive regions. In particular, the framework was developed to answer the research question about how regional supply network embeddedness at the firm level contributes to firms' adaptation strategies in a changing business environment, which in turn contributes to the transition of resource extractive regions to value-adding activities at the regional level.

Chapter 3

Conceptual framework of the research

Chapter 3 describes the conceptual framework developed in this research. It explains theoretical assumptions underpinning the conceptual framework, and outlines constructs and variables of interest and hypothesised relationships.

The Chapter is organised as follows (see Figure 3.1): Section 3.2 provides a brief overview of the conceptual framework developed in this study, Section 3.2 describes dependent variables – METS firm innovativeness and diversification as well as relationships between them, Section 3.3 describes independent variables – positional, relational embeddedness and absorptive capacity and their relationship to independent variables, Section 3.4 introduces moderating variables reflecting specificity of the METS sector, including position of the supplier in the tiered structure of the resource supply chain and membership in industry associations. Company size was also added as a moderator variable.

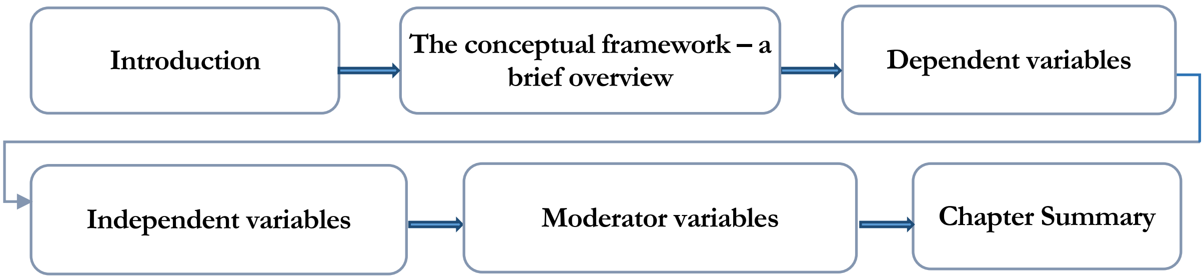

Figure 3.1 Chapter 3 structure

3.1 The conceptual framework – a brief overview

The conceptual framework includes a combination of variables and relationships derived from the literature. Resilience literature was used to determine the dependent variables, while organisational studies provided a guide to the independent variables. Figure 3.2 articulates the relationships between specified constructs and variables. The following sections explain the details of the development of the conceptual framework.

Selection of the *dependent variables* – firm *innovativeness* and *diversification* – was informed by resilience literature, which argues that regional firms *innovativeness* and *diversification* are adaptability strategies contributing to the renewal and resilience of resource extractive regions.

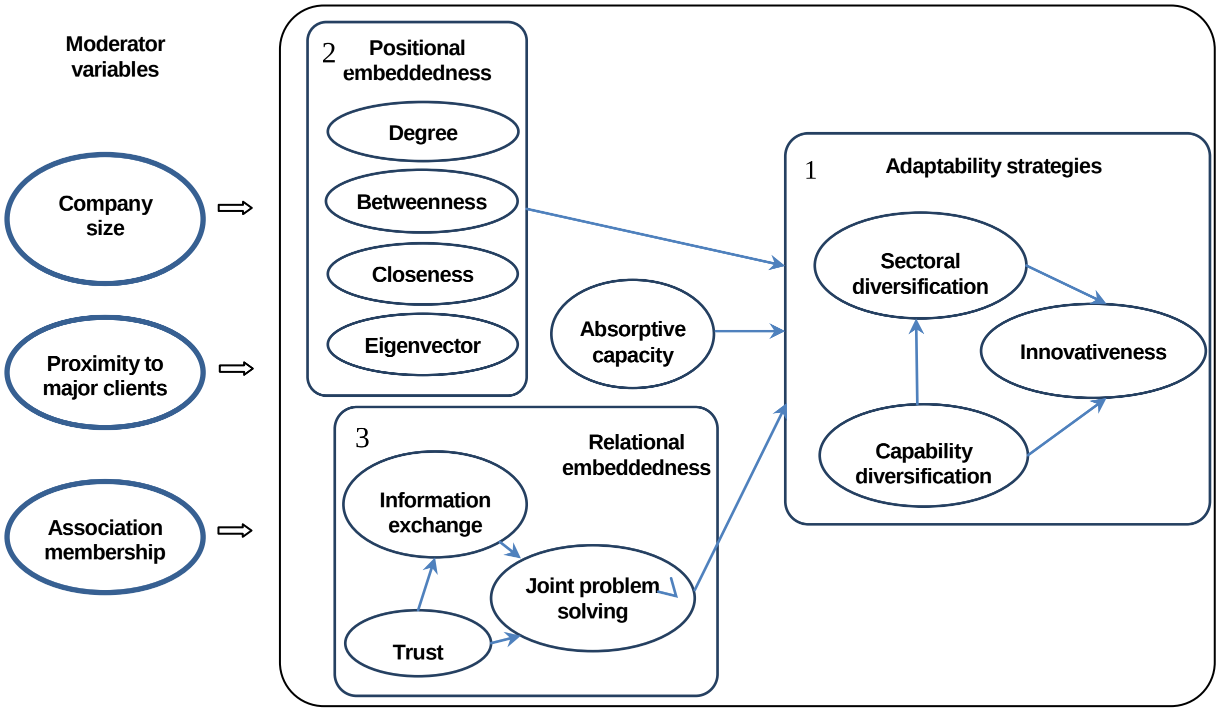

Figure 3.2 Conceptual framework of current research

The literature concerned with the evolution of resource extractive regions and clusters transitioning to high value-added services economies also suggest that capability development and adoption of innovation and diversification strategies by METS firms is a way to survive and renew a business in a time of slowdown and change. Previous research into regional resilience claims that regions are able to sustain and develop through external shocks if regional firms are adaptable, that is, able to innovate and diversify. This allows for new industries and market niches to emerge in the region, when there is a decline in the traditional industry sectors.

Independent variables were identified in various types of organisational studies, such as research in the areas of inter-organisational networks, network governance, embeddedness, and regional development literature. Organisational studies reflect regularly on the importance of regional networks and supply chain relationships for developing new knowledge and firms' capabilities. Therefore, the *relational* and *positional embeddedness* of METS firms in regional supply networks were selected as independent variables, which determine the variety of knowledge sources and opportunities that can be used to develop the capabilities that allow firms to diversify and innovate.

To complement the argument that regional supply networks are a source of external knowledge that can be transformed by a METS firm into new capabilities and innovative outcomes, *absorptive capacity* was also included as an independent variable into the model. Since networks are treated as knowledge sources, firm *absorptive capacity* was included to measure METS firms ability to absorb and utilise external knowledge to produce innovative outcomes.

To reflect the peculiarities of the resource extractive sector, three *moderator variables* were included – *company size*, *tier position* in the resource sector supply chain structure and *membership in industry associations*. The moderator variables were derived from the literature concerned with the regional development of resource extractive regions and consultations with SA industry stakeholders.

3.2 Dependent variables

The choice of dependent variables was determined by the importance of firms' adaptability strategies for building the resilience of resource extractive regions. Following a framework offered by Chapman et al. (2004) adaptability strategies in this study are defined as METS firms' *innovativeness* and *diversification*. Operationalisation of dependent variables and the relationships between them are discussed in the following sections.

3.2.1 METS firms' adaptability strategies – *diversification* and *innovativeness*

Regional firms' *diversification* and *innovativeness* are essential drivers of industrial renewal and the adjustment of resource extractive regions to economic shocks (Chapman et al., 2004; Scott-Kemmis, 2013; Walker, & Minnitt, 2006). If regional firms are able to diversify and innovate, finding new niches in the traditional markets or expanding into new industries and geographies, industrial regions can develop alternative paths when traditional industries experience decay, avoiding technological lock-in (Crespo, Suire, & Vicente, 2013; Frenken, & Boschma, 2007; Martin, & Sunley, 2006). In a resource regions context, such a scenario is described as regional renewal (Chapman et al., 2004) or transformation (Warrian, & Mulhern, 2009), leading to the formation and development of resource clusters. The alternative scenario often associated with the long-term specialisation, often common in many industries, hinders the regional renewal and may lead to lock-in and decline of resource regions and clusters (Crespo et al., 2013).

Thus, *innovativeness* and *diversification* of local suppliers were selected as dependent variables in the proposed framework, which at the firm-level represent strategies that lead to regional renewal and adjustment associated with resilient resource extractive regions and clusters (Chapman et al., 2004). To operationalise variables being part of the conceptual model with the special reference to the context of the resource extractive regions, a literature review on small-firm diversification was conducted.

Small-firm diversification. Firm diversification is seen as a form of an organisational adaptation strategy for managing the increasing levels of uncertainty and technological opportunities associated within growing technological trajectories (Almeida, & Kogut, 1997; Tushman, & Rosenkopf, 1992). While extensive literature has been dedicated to corporate diversification and internationalisation in large firms, fewer studies can be found related to diversification in small firms (Robson, Gallagher, & Daly, 1993), in particular in the resource-related industries (Chapman et al., 2004), and the literature emphasises that small firms often pursue specialisation rather than diversification strategies due to resource limitations (Colombo, Piva, & Rossi-Lamastra, 2014; Robson et al., 1993).

Diversification. In the literature, definitions of *product and market diversification* sometime semantically overlap, and the investigation of either falls into the category of diversification studies. Product diversification is defined as expansion into product markets new to the firm (Hitt, Hoskisson, & Kim, 1997). Market diversification is defined as strategic redeployment of existing capabilities and assets in new directions or gradual movement to closely related markets (e.g., Chapman et al., 2004). It may involve product, so as service diversification as it has been defined in diversification studies (e.g., Qian, 2002).

Strategic diversification and specialisation. Strategic diversification requires investments in exploration search and large-scale research and development (R&D) operations, as well as a substantial amount of management time and effort when attempting to enter new product markets and support new lines of activity (Qian, 2002). Small firms often adopt diversification strategies when they experience difficulties with the major line of business or adopt diversification strategies to increase their technological capabilities in activities complementary to their core business, and survive by relying on these complementary lines (Colombo et al., 2014; Corradini, Demirel, & Battisti, 2016).

Given the resource constraints, small firms more often focus on well-defined niche markets by concentrating on a few specialised products and services and innovate through established cooperative relations with larger companies to avoid excessive R&D spending (Chapman et al., 2004; Qian, 2002). Such strategies work well, given the condition of a relatively stable demand for a firm's product or service. However, the danger of excessive specialisation focused on pursuing production efficiencies has been highlighted in the previous research. Specialisation involves 'learning by doing', which does not contribute to organisational diversity, and undermines organisational absorptive capacity and innovativeness, which are critical for survival and success in a volatile market environment (Cohen, & Levinthal, 1990). Avoiding proactive investments in strategic diversification could be a short-term view for a firm operating in industrial contexts which experiences cyclical upturns and downturns, such as the resource extractive sectors. During periods of industry decline, when clients reduce production volumes, highly specialised firms struggle to secure work and cash flows in the traditional sectors, and are forced to reactively diversify to other sectors or find new niches in existing ones (Chapman et al., 2004).

Servitisation. Servitisation is often seen as a path for diversification for manufacturing companies (Visnjic, Neely, & Wiengarten, 2012). Servitisation strategies have been discussed in the SME literature as a viable path for manufacturing businesses to introduce a combination of goods, services and support (Dachs et al., 2014; Kumar, Singh Panesar, & Markeset, 2009; Panesar, Markeset, & Kumar, 2008). For METS firms with manufacturing as a core capability, introduction of complementary services to the manufactured product can be a fruitful approach.

Sectoral diversification. Sectoral diversification involves the lateral transfer of resources related experience to non-resource markets through the supply of particular goods and services (Chapman et al., 2004). It generally involves supplying the same or similar products and services across several industry sectors, and is measured as the number of industries which the firm is able to market to.

Capability diversification. In this research, METS *capability diversification* or service breadth was measured as the number of services and products offered to customers (Benedettini, Swink, & Neely, 2013). There was no practical way to obtain SIC codes (Standard Industrial Classification) since to the author's knowledge, there is no source that provides information about SIC codes for SA METS companies. Australian industry classification ANZSIC does not precisely fit the capabilities of METS companies. Thus, METS capability classification was developed based on the Australian industry associations reports and databases.

Small firm innovativeness. Innovations are defined as something new that creates value in the eyes of the consumer (Sundbo, 1998). Within this definition, there are two different perspectives: innovation as an output and innovation as cause. The former is seen as innovation in a product, service, process and/or organisational method, such as a patent (Basco & Calabrò, 2016). The latter is seen as innovative behavior or tendency '…to engage in and support new ideas, novelty, experimentation and creative processes…' to improve or create new products, services or processes (Lumpkin & Dess, 1996).

According to the OECD (2009), innovations may include the development of new products, services, operations, organisational issues, financial, engineering, and/or marketing strategies. The key driver of the innovation process is the ability of a firm to generate new ideas and put them into practice. It is worth noting that the ideas may be new to the firm, but not necessarily to the market.

The OECD defines *product innovation*, for example, as:

> *The introduction of a good or service that is new or has significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics… (2009, p. 48)*

Product innovation also includes innovative goods and services, which exhibit quite different characteristics and/or uses from those products previously produced (OECD, 2009). For example, major improvements to existing products can be achieved by altering the kinds of materials used or the components of the product.

Hurley and Hult (1998) define innovativeness as related to an organisational culture that creates the ability of a firm to innovate and innovative capacity as an ability to implement new ideas, processes and products successfully to build organisational capabilities. Innovativeness and innovative capacity are seen as a firm's ability to adapt to the external environment.

In supply chain management literature, innovation is defined as:

> *The process of making changes to products, processes, and services that result in new value creation to the organisation and its customers by leveraging knowledge efforts of the firm and (or) that of its supply network partners… (Narasimhan & Narayanan, 2013, p. 28)*

The rationale for measuring innovativeness as the number of new products and services introduced. Despite the growing number of empirical works that assess the innovative performance of firms in various contexts, there is still no widely adopted measurement scale for the concept of innovation (Charterina, Basterretxea, & Landeta, 2016). However, the idea of novelty is central across a diversity of measurement instruments (Johannessen, Olsen, & Lumpkin, 2001; Nohria, & Gulati, 1996).

Innovativeness has been acknowledged to be a multifaceted concept, and the use of a single measurement scale might threaten content validity (Hadjimanolis, 1997). However, usage of a single measure is justified if the main purpose of a study is to evaluate specific dimensions of innovativeness (Wang, & Ahmed, 2004).

The most widely accepted measure a firm's innovativeness is the number of patents a firm has introduced over a certain period of time (Acs, Anselin, & Varga, 2002). Nevertheless, the limitations of applying this measure for firms engaged in resource-related activities, has been highlighted by scholars (Figueiredo, & Piana, 2016; Scott-Kemmis, 2012). It has been argued that the propensity for patenting varies considerably across industries, with a general perception of resource-related industries being more traditional, with low innovativeness and creativity (Piana, 2015).

The limitations of using patent data to measure firm innovations in the resource extractive sector has been highlighted by researchers (Bell, & Pavitt, 1995; Figueiredo, 2001), since patent data does not reflect multidimensionality and the process of accumulation of innovative technological capabilities in the resource sector; and neglects activities such as imitation, copying, adaptation, experimentation, adoption of new products, processes and organisational arrangements.

The macro-economic specificity of Australia is characterised by the lowest expenditure on innovations among OECD countries, the prevalence of small businesses in the economy, low levels of R&D

spending and underdeveloped links between universities and businesses (Scott-Kemmis, 2004). Although patent measures have been applied in resource-related technology innovation studies (e.g., Arias, Atienza, & Cademartori, 2014; Kaplan, 2012), Australian researchers in regional innovation systems (e.g., Kinnear, & Ogden, 2014), in describing the regional innovation activity point out that:

> *There are no particular values or metrics that are specific to innovation related to resource–sector activity. Neither is there a clear way to ascribe particular types of innovation activity to the presence of the resource sector, compared with other sectors …(Kinnear, & Ogden, 2014, p. 48)*

> *A focus on R&D and patents misses the level of dynamism in technology adaptation and application...(Scott-Kemmis, 2004, p. 54)*

Furthermore, previous research suggests that many service firms are innovative, but that they more often make non-technological innovations that are disembodied, organisational, and market-oriented (Sarkar, & Mohapatra, 2006). These arguments are confirmed by pilot study results, involving a survey of 41 South Australian METS suppliers. When companies were asked to identify the number of patents/trademarks that the company had introduced over the last three years, 95% of the respondents indicated zero patents or trademarks.

Number of new products and services as an innovation measure. A firm's *innovativeness* has often been defined and measured as the number of new products or services it generates in a given period. The ability to create new products is one of the key components of a firm's innovative capabilities. New products are a critical mechanism by which organisations diversify, adapt, and reinvent themselves in changing market and technical conditions (Schoonhoven, Eisenhardt, & Lyman, 1990). New products and services represent the potential commercial value of a firm's R&D activities; most innovations do not influence firm performance until they are introduced to the market. Product innovation is measured as '…the number of new products a firm introduces…' (Katila, & Ahuja, 2002, p. 1184).

A construct of product introductions also complements other, more intermediate proxies for firm innovation, such as knowledge, R&D investment, and scientific publications.

> *Yet relatively few … studies have explored the determinants of new product introductions… (Katila, & Ahuja, 2002)*

Ability to diversify and innovate are closely related to firm *absorptive capacity*, which defines the ability of firms to accumulate and transform knowledge (Soosay, & Hyland, 2008). Absorptive capacity as an important concept that impacts METS firm adaptability strategies is discussed in the next section.

3.2.2 The relationship between small firm diversification, innovativeness and absorptive capacity

The knowledge-based theories of a firm highlight the role of strategies of external knowledge sourcing along with internal investments in innovative development of small and medium firms (e.g., Leiponen, 2012). The ways to access new knowledge through external sources, called open innovation search strategies, play an important role in a firm's innovativeness (Laursen, & Salter, 2006). Open innovation literature highlights the role of collaborative innovative efforts as source for innovation within the small firms (Chesbrough, 2004).

Strongly supported by the empirical evidence is the argument that innovation in smaller firms is less dependent on internal R&D than is innovation in larger firms, and more dependent on external knowledge obtained either through collaboration or spillovers (Ganotakis, & Love, 2010; Love, & Roper, 2015). The innovativeness of small and medium enterprises differs from that of large companies due to their flexibility and proximity to the market, and includes product-market combinations, and modifications to existing products for niche markets. Furthermore, small firms can take advantage of knowledge spillovers from large firms' corporate R&D departments through collaboration (Acs, Audretsch, & Feldman, 1994).

In the resource extractive industries, supply chain relationships are the major source of technological knowledge for METS firms (Scott-Kemmis, 2013). Collaboration with large mining companies around their problems that results in the development of advanced design and effective solutions to improve mining operation processes is a major driver of innovations for METS suppliers (Martinez-Fernandez, 2010; Scott-Kemmis, 2013; Warrian, & Mulhern, 2009). Apart from formal research and development activity, new ideas could be developed through customer feedback and collaboration, as well as information and knowledge exchange between supply chain partners (e.g., Basco, & Calabrò, 2016).

This leads to the argument that firms with a more diverse range of clients from different sectors are exposed to a broader range of customer problems. This creates the need for further development and broadening of the capability base through introduction of new services and products. Therefore, it is postulated that:

> ***H1a*** *There is a positive relationship between METS firm capability diversification and sectoral diversification*

Furthermore, previous studies, mainly in large firms, confirm that a diversified technological portfolio is positively related to firm innovation performance (Lin, & Chang, 2015) . Diversified firms possess more opportunities for the internal use of new knowledge, and innovativeness may increase through economies of scope (Katila, & Ahuja, 2002). The combination of existing knowledge and capabilities stimulates the introduction of new products and services. Relationships between breadth of knowledge sourcing and innovative outcomes of METS firms were reported (e.g., Leiponen, 2012).

However, firm diversification may also have a negative effect on new product development. On the other hand, the resource based view (RBV) (Barney, Wright, & Ketchen, 2001) and agency perspectives, as Hoskisson and Hitt (1988) have noted, show that as firms become more diversified, management understands the firm's R&D activities less, so innovation decreases.

In this research, it was hypothesised that the broader range of capabilities the METS firms possessed, the more innovative products and services they would be able to introduce. It was therefore proposed that:

> ***H1b*** *There is a positive relationship between METS firm capability diversification and innovativeness.*

Taking the view that the diversity of knowledge sources the firm has access to, will increase the opportunity for innovation, the same relationship is assumed between *sectoral diversification* and *innovativeness*. That is, firms diversified across a broader range of industries are exposed to a broader range of various industry specific problems and develop a broader knowledge and capability base and more often introduce innovative products and services. It was therefore proposed that:

> ***H1c*** *There is a positive relationship between sectoral diversification and METS firm innovativeness.*

3.3 Independent variables

The primary objective of the proposed conceptual framework is to test the impact of *positional* and *relational embeddedness* as dimensions of networks governance on the METS firms innovativeness and diversification. Based on the assumption that regional supply network serves as an external source of information, knowledge and opportunities, it is assumed that these variables will positively affect METS firms' innovation and diversification capabilities. Furthermore, *absorptive capacity* was included as an independent variable to also assess the role of internal knowledge sources in firms innovativeness and diversification.

The independent variables *positional* and *relational embeddedness* in the regional supply network are described in the following sections. For the purpose of this study, a regional industry supply network is defined and limited to a subset of supplier-buyer relations that exist upstream from a resource extraction (mining) companies operating in the mining region. *Positional embeddedness* was operationalised through four variables commonly used in the inter-organisational networks literature that reflect a METS firm position in the regional supply network: *degree*, *betweenness*, *closeness* and *eigenvector centrality*. *Relational embeddedness*, also being a complex construct was operationalised using three sub-constructs – *trust*, *information-exchange* and *joint problem-solving* following scales developed in the previous research (Gulati & Sytch, 2007; McEvily & Marcus, 2005). The rationale for postulating relationships between independent – *positional* and *relational embeddedness*, *absorptive capacity* and dependent variables – METS firms *innovativeness* and *diversification,* including mediational relationships is also provided.

3.3.1 Absorptive capacity

The concept of *absorptive capacity* is referred to as a firm's ability to recognise, assimilate, leverage, and deploy the available external knowledge (Cohen & Levinthal, 1990). Later, absorptive capacity was defined as 'a set of organisational routines and processes by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organisational capability' (Zahra & George, 2002, p. 1986).

Scholars comment that the concept is fuzzy, with the empirical literature measuring its various dimensions to relate it to innovation and economic performance indicators (Abreu et. al., 2008).

Widely used in the range of theories, including regional development and organisational studies literature, various measures have been adopted to define and evaluate the absorptive capacity of organisations**.** These include:

- the education and knowledge levels of their managers (in OECD 2009)
- the commitment and concern of the management of the company towards R&D (Jansen, Van Den Bosch, & Volberda, 2005; Tu, Vonderembse, Ragu-Nathan, & Sharkey, 2006)
- cooperation for knowledge acquisition (Abreu et. al., 2008); Zahra, & George, 2002)
- the percentage spent on R&D in relation to total sales (Boschma, & Ter Wal, 2007; Broekel, & Boschma, 2012).

The measures related to organisational human resources that are often used to represent absorptive capacity are:

- the proportion of R&D employees in total employment (R&D) (e.g., Broekel, & Boschma, 2012)
- the proportion of employees with at least a university Bachelor's degree (e.g., Carnovale, & Yeniyurt, 2014)
- the number of technically qualified personnel (Giuliani, & Bell, 2008).

However, some authors claim that the availability of a highly-qualified workforce, in particular, with university qualifications, is not essential for innovation *per se* (Abreu et. al., 2008).

Absorptive capacity is essential for METS ability to benefit from knowledge diffusion in the inter-firm networks through organisational learning (Scott-Kemmis, 2012; Silvestre, & Neto, 2014; Soosay, & Hyland, 2008). The literature discussing the development of resource-related clusters claims that METS firms' capabilities in absorptive capacity are often related to the percentage of qualified professionals with technical and managerial capabilities (Scott-Kemmis, 2012).

Scholars researching METS capability development acknowledge that investment in R&D in resource and related activities is lower than in knowledge-intensive sectors. However, in the resource sector, supplier innovations emerge in the process of solving customer problems and not as technical advances or R&D breakthrough per se (Martinez-Fernandez, 2010; Scott-kemmis, 2013; Walker & Minnitt, 2006; West, 2014). Absorptive capacity is further increased by firms that involve their suppliers and customers in their decision making. Thus, the absorptive capacity of companies operating in the resource extractive sector is often significantly underestimated (Piana, 2015), since the level of technological collaboration in not counted as formal R&D activities.

To incorporate these perspectives, absorptive capacity of METS firms was measured in this study as:

- the percentage of turnover of a firm attributed to new, dramatically improved products/services introduced in the last three years
- the percentage of spending on research and development (R&D) (e.g. Broekel & Boschma, 2012; Ter Wal & Boschma, 2007)
- the percentage of R&D employees
- the percentage of employees with a university degree (e.g. Broekel & Boschma, 2012)
- the percentage of qualified technicians employed by the firm (Elisa Giuliani & Bell, 2008).

Relationships between absorptive capacity and firms diversification. Increasingly, empirical evidence shows a positive relationship between diversification, innovation and innovative competencies (Garcia-Vega, 2006; Modrego, McCann, Foster, & Olfert, 2015; Quintana-García, & Benavides-Velasco, 2008). The argument that through technological diversification firms increase their absorptive capacity enabling technology development thus avoiding technological lock-in is well advanced (e.g., Breschi, Lissoni, & Malerba, 2003; Suzuki, & Kodama, 2004). Since diversification is aimed at broadening a firm's technological competencies, it requires specific capabilities similar to those essential for innovation (Corradini et al., 2016). These include the ability to increase the scope of technological search, recognising and absorbing opportunities in new areas, while recombining accumulated knowledge into new ideas, which contributes to a firm's absorptive capacity (Cohen, & Levinthal, 1990; Garcia-Vega, 2006; Lin, & Chang, 2015; Quintana-García, & Benavides-Velasco, 2008). Technological diversification plays a central role in increasing a firms' absorptive capacity, enabling them to explore and exploit new opportunities, allowing for economies of scope in technology development (e.g., Corradini et al., 2016).

On the other hand, the resource constraints experienced by many small firms dictate that innovative activities are possible only through cumulative technological change around the firms' core technologies (Antonelli & Scellato, 2015; Dosi, Freeman, Nelson, Silverberg, & Soete, 1988; Nelson & Winter, 1982), thus too much diversification does not allow to focus innovative effort in one direction. Barney, Wright, and Ketchen (2001) and Hoskisson and Hitt (1988) argued that as firms become more diversified there is less control and understanding firm's R&D activities. For example, Toh and Kim (2013) claim that firms facing technological uncertainty should focus more on specialisation to surpass their competitors.

Previous qualitative research related to supplier capability development in the resource sector argues that incremental capability growth happens when suppliers undertake R&D to solve customer problems (e.g. Martinez-Fernandez, 2010; Scott-kemmis, 2013). Thus, exposure to a more diverse range of customer problems acts as a driver for supplier's knowledge development and recombination and as a result requires higher absorptive capacity.

Thus, in the current research, it was postulated that:

H2a *There is a positive relationship between METS firm absorptive capacity and capability diversification.*

H2b *There is a positive relationship between METS firm absorptive capacity and sectoral diversification.*

The relationships between firms' absorptive capacity and innovativeness are well established in variety of industry contexts (e.g., Abreu et. al., 2008; Ter Wal & Boschma, 2007; Zahra & George, 2002). The role of absorptive capacity in firm innovativeness was evident, but it was included in the model as a key internal source of knowledge and determinant of firm innovativeness. Thus:

H2c *There is a positive relationship between METS firm absorptive capacity and innovativeness.*

3.3.2 Positional embeddedness

Positional embeddedness in the supply network context reflects the 'roles' that firms occupy in the network is commonly operationalised through network centrality measures. Identification of a firm's positional embeddedness in a network is one of the primary uses of social network analysis methods (SNA) (Borgatti, Everett, & Johnson, 2013; Borgatti, 2005; Wasserman, & Faust, 1994). Network centrality reflects the relative importance of individual nodes in a network (Borgatti, & Li, 2009).

Organisational behaviour and social capital theorists associate centrality with social status (Bonacich, 1972), power (Coleman, 1973), and prestige (Burt, 1993). There are different types of centrality metrics that manifest different aspects of the importance of network players. The most widely used are *degree centrality, betweenness centrality, closeness centrality,* and *eigenvector centrality* (Everett, & Borgatti, 1999; Krackhardt, 1990; Marsden, 2002).

Degree centrality. Degree centrality corresponds to the number of direct ties an actor has. The degree centrality concept implies that the more links a node has in a network, the more central it is; that is, when a node is connected to many other nodes, the node possesses high degree centrality. Multiple studies have proved a positive relationship between degree centrality and a firm's business and innovative performance: the more direct partners a firm has, the better it performs (Johannisson, 2000) for a number of reasons. Firstly, a node with high degree centrality is more visible in the network and is likely to have access to and control over network resources (Borgatti, 2005). Secondly, access to the information and a common knowledge base in the regional supply network is often seen as a function of a firm's direct contacts (G. G. Bell, 2005).

However, the degree centrality measure only reflects the benefits a firm gets from direct relationships. It does not allow for measuring the indirect effects from second and third tier contacts. If a firm wants to benefit from diverse knowledge and resources that reside in the regional supply network, it is important to relate to other well-connected firms to easily access a maximum number of resources. These more complex dependencies are addressed by other types of centralities – *betweenness, closeness* and *eigenvector*. If a firm is connected to many actors (degree centrality) and these actors are themselves connected with many actors, then the firm should benefit considerably from regional knowledge spillover, technology and innovation diffusion (Lechner, & Leyronas, 2012). This argument has been advanced in the maritime (Greve, 2009), aerospace (Varga et al., 2009), automotive (Kim, Choi, & Skilton, 2015), electronics (Bellamy, Ghosh, & Hora, 2014) and construction industries (Capó-Vicedo et al., 2011).

Betweenness centrality. Betweenness centrality is defined as the possibility of a firm being an intermediary in communications between other firms in the inter-organisational network. In other words, betweenness centrality measures the extent to which the firm is located in the shortest path between pairs of other firms in the network. In a supply network context, high betweenness centrality reflects the possibility of a firm being an intermediary in communication between others in the network with high visibility. This results in reputational benefits leading to more referrals and opportunities. (Fernández-Olmos, & Díez-Vial, 2013; Maurizio, John, & Carlo, 2015). This in turn leads to getting more referrals. As client numbers grow, the firm can expand its capabilities, diversify and expand to new markets. This is in line with the idea that a firm diversify in response to the clients' needs by developing product or service (Craighead, Hult, & Ketchen, 2009).

Eigenvector centrality. Eigenvector centrality calculates a type of relative importance of a firm in the network, i.e., important firms must be neighbours of other important firms (Borgatti, 1995). Furthermore, highly central firms in the network may perform a hub function, acting as a connector in the network. This also leads to the proposition that firms that are connected to hubs (a property known as eigenvector centrality) will have more information and power than firms that are connected to an equal number of less connected others.

Given the importance of a few major clients in the SA resource supply chain – major resource extractive companies and a number of large EPCM providers – if a local supplier is dealing directly with those locally important companies, it has an advantageous position in the business network (e.g., close to major customers, regional 'hubs', well connected firms in South Australia), and it has an advantage of access to valuable information and knowledge. This enhances the chances of a supplier developing innovative solutions, building-up technological capabilities, reducing uncertainty and improving the quality of decision making.

Positional embeddedness and METS firm diversification and innovativeness. The assumption behind positive relationships between a METS firm's positional embeddedness and its propensity to innovate and diversify is that network connectedness increases the chances of accessing diverse knowledge.

Innovative activity and diversification require novel capabilities and knowledge. Thus, access to a variety of information and knowledge is of importance (Greve, 2007; Jansen, Van Den Bosch, & Volberda, 2006), since it increases the number and variety of possible combinations and the potential for highly novel solutions (Fleming, 2001). In the inter-organisational network context, access to more diverse knowledge enhances the possibility of combining and exchanging new information and may also increase the possibility of a firm gaining value given the required level of absorptive capacity (Smith, Collins, Clark, & Smith, 2005).

In contrast, firms that exploit established competencies in their innovative problem-solving efforts typically experience more certain and immediate returns, but produce mostly incrementally innovative solutions (Audia, & Goncalo, 2007; Dosi et al., 1988).

Social capital theory argues that actors maintaining a broad range of contacts in the networks have a more heterogeneous base of information and knowledge to draw on (Burt, 1982). The relationships between information flows, learning and adaptability assume that firms which are actively seeking to diversify, may be expected to be more strongly ‘plugged into’ communication and networks than firms which are content to stick to existing lines of business (Chapman et al., 2004). The benefits of a central position in inter-organisational networks has been emphasised in alliance studies (Gulati, & Gargiulo, 1999).

The literature concerned with inter-organisational networks refers to the ‘intelligence web’ that allows organisations to reduce uncertainty and identify potential collaborative opportunities residing in the network (Gulati, 1999; Powell et al., 1996). The more central a firm’s network position is, the more likely it is to have better information about a larger pool of potential partners and opportunities. In line with alliance studies in the supply chain context, central firms in a supply network possess resources, such as information, knowledge and power advantages, and higher visibility, which enhances their attractiveness to potential clients and collaborative partners. Network centrality is a direct function of organisation’s involvement and experience in business relationships located in a certain geographical area (Bellamy et al., 2014; Gulati, & Gargiulo, 1999).

There is a substantial body of literature which is based on the idea that connectedness of firms in the network generates knowledge spillovers. The firms with the larger number of network partners, benefit more from these spillovers due to increasing diversity of information and knowledge that contributes to technological capability development, which in turn leads to increased innovation output (Ahuja, 2000). The firm may enjoy the benefits of weak ties in the supply networks through its suppliers in terms of diffusion of innovative ideas and technologies. Another argument here is that firms that can navigate large networks, will be better positioned to observe more product innovations (Skilton, & Bernardes, 2015). Thus, central firms are seen to be more innovative (Tsai, 2001). Tsai (2001) found that firm-level absorptive capacity, as well as the firm's network position (i.e., firm degree centrality), leads to increased business unit innovation output.

In the resource sector and related supply chains, innovative activities have become increasingly interdependent involving different forms of inter-firm relationships from the subcontracting of specialised supplier firms to more collaborative arrangements as alliances and partnerships (Figueiredo & Piana, 2016). Various forms of collaboration between suppliers and customers may include development of specialised components of production systems, or may engage independent suppliers of knowledge-intensive services to undertake aspects of particular innovation projects (M. Bell & Figueiredo, 2012). These interdependencies reflect the nature of learning by interaction, which involves industry downstream and upstream linkages with other firms (suppliers or customers). Basco and Calabrò (2016) claimed that small firms in the natural resource based clusters search new ideas in the close environment – customers, suppliers and competitors, when attempting to introduce new products, services or processes. Furthermore, the need to solve customer problems lead to investment in research and development, and new products and services thus increasing absorptive capacity of the METS firm.

Taking this perspective in the context of the resource sector supply chains in South Australia, it can be inferred that centrally positioned suppliers with many clients have access to more diverse sources of ideas and knowledge, which they are able to transform into innovative products and services. Therefore, the following hypotheses are postulated:

H3a *There is a positive relationship between METS firm supply networks positional embeddedness and its capability diversification.*

H3b *There is a positive relationship between METS firm supply networks positional embeddedness and its sectoral diversification.*

H1c *There is a positive relationship between METS firm supply networks positional embeddedness and its innovativeness.*

3.3.3 Relational embeddedness

The assumption behind positive relationships between METS firm relational embeddedness and its propensity to innovate and diversify is that strong ties between customers and suppliers, such as investments in complementary and specific resources can exert a positive effect on knowledge transfer and joint learning (Selnes & Sallis, 2003; Uzzi & Lancaster, 2003). When firms are linked through embedded ties, they tend to transfer more sensitive or private knowledge, and engage in exploratory learning (Charterina et al., 2016; Uzzi & Lancaster, 2003). Examples from the automotive industry supply networks show that suppliers are able to improve their capabilities in quality management, production and delivery, as well as product and process innovation by working closely with major customers who had already developed expertise in these areas (e.g., Choi & Kim, 2008; Kito, Brintrup, New, & Reed-tsochas, 2014; Luo, Baldwin, Whitney, & Magee, 2012).

In this research, relational embeddedness between supplier and customer was defined following McEvily and Marcus (2005) as an aggregate of three concepts *trust*, *fine-grained information-exchange* and *joint problem-solving.* Uzzi (1996) established trust as a precursor for fine-grain information exchange resulting in joint-problem solving. McEvily and Marcus (2005) proposed a model that relates these three components to the acquisition of competitive capabilities. They argue that both trust and information sharing create necessary conditions for joint problem solving. Information sharing increases managerial awareness about the possibilities for acquiring new capabilities through supply chain relationships, and trust facilitates the willingness of a firm to accept learning from the exchange partner new ways of doing things. In this research trust, information exchange and joint problem solving are dimensions of relational embeddedness (Figure 3.3).

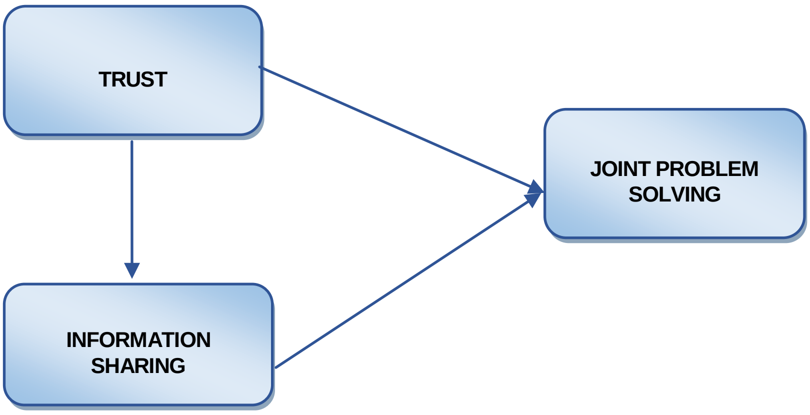

Figure 3.3 Relationships among dimensions of relational embeddedness (McEvily, & Marcus, 2005)

Each dimension and its relationships with firms innovativeness and diversification are described in the next sections.

Joint problem solving. In industrial purchasing relationships, joint problem solving or joint problem solving is defined as '…interpenetration of organisational boundaries…' (Heide & John, 1990, p. 25). The metaphor describes the integration of activities, when exchange parties share responsibilities for the tasks which are supposed to be a direct responsibility of one party. This may involve cooperation around product design, quality and cost control and delivery system, as well as long term planning (Gulati & Sytch, 2007). As the degree and scope of joint problem solving between supplier and buyer increases, the relationship moves towards an alliance. Joint problem solving also assumes joint problem solving, which refers to resolving or dealing with disagreements between exchange partners, technical issues, conflicts and unexpected complications (Uzzi, 1996, 1997).

Joint problem-solving facilitates tacit knowledge transfer between partners, stimulates learning of 'the new ways of doing things' (Zander & Kogut, 1995) through understanding the idiosyncratic capabilities and processes of the exchange parties. Since the complex knowledge underlying a firm's capabilities is often firm-specific and non-codified (Nelson & Winter, 1982; M. Polanyi, 1966), joint problem-solving is associated with experimentation, observation, and search for new solutions for product and service customisation (McEvily & Marcus, 2005). When partners are engaged in a cooperative problem-solving activity, a mutually satisfactory solution may be obtained. This may potentially lead to better performance through mutually developed process, and increasing efficiency and effectiveness of processes (G. Kumar & Banerjee, 2014).

The benefits of resolving relational and operational issues in day-to-day business 'on-the-fly', as opposed to market exit strategy has been emphasised in the embeddedness literature (Uzzi, 1996). Uzzi (1997) has emphasised the benefit of joint problem solving from a supplier perspective, since a supplier can get feedback from the client, incorporate it and improve processes, while in the case of market relationships, the loss of a customer leaves a supplier to infer the cause of the problem. Thus, joint problem solving enhances responsive learning, as well as facilitating the emergence of new ideas and their combinations. In supply chains, joint problem solving was found to positively impact the operation of firms and their innovative capability (Soosay, Hyland, & Ferrer, 2008; Soosay, & Hyland, 2004).

Drawing on the US automotive industry and its suppliers, Gulati and Sytch (2007) argue that increase in coordinated activities and a greater overlap of strategic goals leads to higher levels of value creation, which results in enhanced manufacturer performance. McEvily and Marcus (2005) have explored the effects of joint problem solving on supplier capability development among job-shop manufacturers in the US and found that joint problem solving is positively associated with an ability to acquire capabilities. Thus, it is hypothesised that:

H4a *There are positive relationships between joint-problem solving between METS firm and its customers and its capability diversification.*

H4b *There are positive relationships between joint-problem solving between METS firm and its customers and its sectoral diversification.*

H4c *There are positive relationships between joint-problem solving between METS firm and its customers and its innovativeness.*

Fine-grained information exchange. Information sharing between exchange parties is defined as 'the degree to which each party discloses information that may facilitate the other party's activities' (Heide, & Miner, 1992, p. 275). It is one of the most critical prerequisites for successful relationships between exchanging parties (Dyer & Singh, 1998). The exchange of unique fine-grained information, such as opportunities and challenges that could be anticipated in the course of procurement relationships, helps to narrow the number of options that parties consider in decision making (McEvily & Marcus, 2005).

The detail, accuracy, timeliness, and scope of information exchange were found to be a precursor for joint problem solving (McEvily & Marcus, 2005). Thus, companies that share sensitive information in a timely manner are in a better position for joint problem solving, since coordination mechanisms are easier to establish.

In the resource sector and related industries, firms transfer knowledge by passing technical specifications, coordinating engineering requirements, assuring quality control, developing components and systems, certifying suppliers, and discussing delivery time, production volumes and prices (Martinez-Fernandez, 2010; Scott-kemmis, 2013; Warrian & Mulhern, 2009).

In this process, exchange parties that share detailed and accurate information gain competitive advantage by developing their absorptive capacities by learning from the each other and building up their technological capabilities (Scott-kemmis, 2013):

H5a *There are positive relationships between the scope and quality of information exchange between METS firm and its customers and its capability diversification mediated by joint problem solving in supplier-customer relationships.*

H5b *There are positive relationships between the scope and quality of information exchange between METS firm and its customers and its sectoral diversification mediated by joint problem solving in supplier-customer relationships.*

H5c *There are positive relationships between the scope and quality of information exchange between METS firm and its customers and its innovativeness mediated by joint problem solving in supplier-customer relationships.*

Trust in the supply chain relationships. Trust in inter-organisational relationships could be defined as the expectation that partner organisations '…may be relied upon to fulfil its obligations, to behave predictably, and to act and negotiate fairly even when the possibility of opportunism is present…'(Zaheer, McEvily, & Perrone, 1998).

Being a core concept in the relational view (Dyer & Singh, 1998), social capital (Burt, 1997) and embeddedness theories (Granovetter, 1985; Uzzi, 1996, 1997), trust has been continuously discussed in the context of inter-organisational relationships (e.g., Handfield & Bechtel, 2002; Johnston, McCutcheon, Stuart, & Kerwood, 2004; Lawson et al., 2008; Narayanan & Raman, 2004; Nyaga, Whipple, & Lynch, 2010).

From the *network level perspective*, the presence of trust in inter-organisational networks facilitates the emergence of network governance, which, it has been argued, is a far more effective form of economic organisation than a market or hierarchy (Powell, 1990; Provan, & Kenis, 2008). In regional development and inter-organisational networks literature, the role of trust has been emphasised as a necessary determinant for knowledge spillovers and free communication of ideas among firms in the regional networks. Geographic proximity facilitates trust, leading to the emergence of localised knowledge and information diffusion, as well as exchange relationships based on open-ended contracts (Balland, Belso-Martínez, & Morrison, 2014; Giuliani, Maffioli, Pacheco, Pietrobelli, & Stucchi, 2013; Martin, & Sunley, 2011; Ter Wal, & Boschma, 2007).

At the supplier-customer dyad level, the literature puts emphasis on firms' practices, assuming that trust between exchange parties emerges when business relationships are aimed at maximising unique competitive advantage through access to privileged resources that could not be achieved in the course of arm's-length transactions (e.g., Dyer & Singh, 1998; Håkansson & Snehota, 1989). Trust facilitates relationship-specific investments (Dyer, & Singh, 1998), resulting in improved quality of communication between parties, and lower transaction costs between supplier and buyer firms (Sako, 1991; Zaheer et al., 1998). Within the resource-based view, trust is identified as a key antecedent of building relational capital with suppliers (Day et al., 2013). It enhances information sharing that leads to better coordination and integration, positively influencing competitive advantage of participant firms, as well as the entire supply chain (Hemmert, Kim, Kim, & Cho, 2016).

Trust and commitment in supplier-buyer relationships prevents opportunistic behaviour, thus fostering the culture of 'mutual reliance', acting as a security guarantee in highly interdependent relationships between a supplier and buyer, especially in risky situations. Trusting relationships reduce the need for contractual safeguards, thus reducing associated costs (e.g. Provan, 1993). Furthermore, trust encourages parties to exercise less defensive behaviour and accept more influence from their partners (Day et al., 2013), be more open to new ideas and experimentation, thus becoming more flexible and innovative (Kim et al., 2015). In summary, the presence of trust in supplier-buyer relationships contributes to cost reduction through reducing relational uncertainty, enhances the value of transactions through better synchronisation and coordination, and encourages learning and experimentation leading to innovations and acquisition of new capabilities (Zaheer et al., 1998).

Relationships between trust and scope and quality of information exchange in supplier-customer relationships. In the recent supply chain literature, the role of trust in facilitating information exchange among supply chain partners has been emphasised (e.g., Birasnav, Mittal, & Loughlin, 2015; Huong

Tran, Childerhouse, & Deakins, 2016; Kristijan Mirkovski, Paul Benjamin Lowry, & Bo Feng, 2016; L. Wu, C.-H. Chuang, & C.-H. Hsu, 2014). Inter-organisational trust relates to information exchange, since trust allows the exchange parties to accept information from their partners as trustworthy. In this case, trust acts as an information filter, since naturally, more importance is placed on the advice of people who are reliable (McEvily & Marcus, 2005).

At the same time, trust allows organisations to be more open, and not withhold essential and critical information, since they are interested in the well-being of each other. The evidence from the literature is that trust is an underlying mechanism which allows information exchange to happen (e.g.Chapman et al., 2004; MacKinnon et al., 2004; McEvily & Marcus, 2005). With a lack of trust, suppliers would not disclose sensitive information about prices, ways of doing things and be afraid that it might be shared with competitors.

Thus, in the context of the SA resource industry, supply networks' high level of trust between supplier – a METS firm – and a client – a mining company or a higher tier supplier – positively impacts the scope and quality of information exchange, which in turn contributes to supplier learning leading to increased innovativeness and capability development. Therefore, it is proposed that:

H6a *There are positive relationships between trust in supplier-customer relationships and METS firm capability diversification mediated by the scope and quality of information exchange and joint problem solving between METS firm and its customers.*

H6b *There are positive relationships between trust in supplier-customer relationships and METS firm sectoral diversification mediated by the scope and quality of information exchange and joint problem solving between METS firm and its customers.*

H6c *There are positive relationships between trust in supplier-customer relationships and METS firm innovativeness mediated by the scope and quality of information exchange and joint problem solving between METS firm and its customers.*

Relationships between trust and joint problem solving. In terms of problem solving, trust facilitates discovery of mutually satisfactory solutions and decreases opportunistic behaviour. It facilitates parties to apply a joint effort to solve the problem collectively, even beyond officially established areas of responsibility (McEvily & Marcus, 2005).

In the resource-related industries context trust between suppliers and customers is not always easily identified. The authors comment on the problems small suppliers face when they work collaboratively on customer problems, which are related to the lack of protection of intellectual property. For example, Warrian and Mulhern (2009) investigating mining and heavy manufacturing clusters in Canada point out to the intellectual property breaches from the customer side, when the customers pass Canadian suppliers' experience to Asian companies to get cost advantages. In the oil, & gas industry in Aberdeen (Chapman et al., 2004) found that credibility as a localised asset generated through trust and collaboration among local firms does not contribute to sectoral diversification of local suppliers, but rather provides support for geographical expansion through industry networks.

In the context of SA resource industry supply networks it is hypothesised that high level of trust between supplier – a METS firm – and a client – a mining company or a higher tier supplier – positively impacts the possibility of effective joint problem solving, which in turn contributes to supplier learning, innovativeness and capability development. Thus, it is proposed that:

H7a *Trust between METS firm and its customers positively impacts METS firm capability diversification through the mediation effect of joint problem solving.*

H7b *Trust between METS firm and its customers positively impacts METS firm sectoral diversification through the mediation effect of joint problem solving.*

H7c *Trust between METS firm and its customers positively impacts METS firm innovativeness through the mediation effect of joint problem solving.*

3.4 Moderating variables

Formal network governance mechanisms specific to the resource sector affecting METS firms and the opportunities in the resource supply chain were identified in the literature concerned with the resource extractive regions and clusters and exploratory interviews with the SA resource industry stakeholders. The most important mentioned in the literature and by SA interviewees were certification and the role of getting work directly from the mining company and the role of industry associations. From the network governance perspective these factors act as formal mechanisms of regional supply network governance in the South Australian resource industry. The moderating effect of METS company size was added due to the diversity of METS company sizes in the sample.

3.4.1 Moderating effect of company size

The influence of company size on innovative performance and diversification, as well as inter-firm and within firm processes and relationships, has been long documented.

The RBV perspective argues that possession of an excess of fungible resources is a pre-condition for diversification. In accordance with this view, consolidated literature since the seminal book of (Chandler, 1990), has documented a positive relationship between firm size, considered as a proxy of the amount of available internal resources, and diversification using samples, including large firms.

Colombo, Piva, and Rossi-Lamastra (2014) note that very small firms are usually highly diversified since they often adopt customer-centred, consultancy-oriented business models. Small firms may develop a new product to satisfy customer need and this could result in entry into a new-to-the-firm product line. Thus, the firm progressively broadens its product portfolio.

Company size influences the positional embeddedness of a firm. It is logical to assume that the larger firms have more clients and are thus more centrally positioned in regional production networks. Furthermore, larger companies usually have better systems in place to win tenders put by resource companies and have a high probability of being positioned close to major ‘hubs’ in the regional production network. It is therefore proposed that:

H8 *The size of the METS firm moderates relationships among model variables.*

3.4.2 Moderating effect of tier position in the regional supply network

Proximity to sophisticated customers is one of the major pillars identified by Porter (Porter, 1998) that stimulates local capability development in clusters. Positive relationships between direct communication of local suppliers and MNCs have been acknowledged by scholars (Javorcik & Spatareanu, 2009). However, in the resource sector in developing countries, this assumption has been challenged (Atienza et al., 2016). In the Australian context, collaboration with customers around their problem has been acknowledged as a mechanism of supplier capability development and innovativeness (Martinez-Fernandez, 2010; Scott-kemmis, 2013).

Proximity to mining companies and tier one suppliers in the resource industry supply chain is an indirect sign that the supplier has all the systems in place to deal with big clients (Atienza et al., 2016). Certification is very important for METS suppliers to successfully bid for tenders and win work in the resource sector (Atienza et al., 2016). The compliance of METS company processes to ISO is one of the key elements to be selected as a supplier to a mining project. In addition, industry specific certifications are important to prove firm credibility.

Thus, a METS company has more opportunities to offer its services to major mining companies and EPCM providers if it has all the systems in place. From the perspective of supply network governance, resource supply chain structure and standards define the opportunity space for the suppliers. It is therefore proposed that:

> ***H9*** *The position of METS firm in the tiered structure of resource supply chain moderates relationships among model variables.*

3.4.3 Moderating effect of the industry associations membership

From the supply network governance perspective, industry associations act as a network coordination body. The literature portrays the benefits of membership in industry associations for SMEs to be inconclusive. Although some scholars find it useful for building relationships within the industry (e.g. Boehe, 2013), others consider it of no value (MacKinnon et al., 2004). On one side, membership in associations allows an SME to form horizontal interfirm relationships (e.g., Gulati, 2007; Lavie, 2006), provides access to referrals and additional information resources (Boehe, 2013). Furthermore, an industry association acts as a local network hub, making members reachable to each other.

In the case of Canadian resource sector Wolfe (2008, p. 28) reports: '…the most successful clusters among the case studies have developed highly effective local associations that promote interaction and networking among the various members of the cluster, as well as advocating for local, regional and even national policy interventions that work to the benefit of cluster members…'. However, other works claim that these benefits are not necessarily valued by firms themselves. For example, Chapman et al. (2004) and MacKinnon et al. (2004), studying suppliers to the Aberdeen oil and gas sector, report on mixed attitudes of SMEs towards association membership.

In the Australian resource sector the role and place of industry associations were reported to provide opportunities for local METS to connect with potential customers, find supply chain partners with complementary capabilities, develop capabilities and access overseas markets (e.g., Scott-Kemmis, 2012). It is therefore proposed that:

> ***H10*** *The industry association membership of a METS firm moderates all postulated relationships among variables.*

3.5 Chapter summary

The chapter provides an overview of the conceptual framework and the rationale for choosing variables of interest, their inter-relationships and hypotheses developed. The conceptual model is founded upon the regional resilience, network governance and embeddedness literature and includes moderation variables specific to the resource industry. The model examines relationships between *METS firms adaptability strategies* – capability and sectoral diversification and innovativeness, and *relational* and *positional embeddedness* of a firm.

The choice of the *dependent variables* – METS firm *capability* and *sectoral diversification* and METS firm *innovativeness* was informed by regional resilience literature, which claims that innovation and diversification at the firm level underpin the resilience of resource extractive regions and clusters. The choice of *independent variables – positional* and *relational embeddedness* was informed by network governance literature, which discusses the influence of regional networks' structure and governance mechanisms on the capability development and innovativeness of local suppliers to the resource extractive industry.

The *absorptive capacity* being an internal property of a METS firm was added as a mediator between *positional* and *relational embeddedness* and firms *diversification* and *innovativeness* since it has been known as an essential determinant of development of firms innovative capabilities. The choice of the *moderator variables – position of METS firm in the tier structure*, *membership in the industry associations* was based on the literature concerned with the development of local supplier capabilities in the resource extractive regions and the analysis of exploratory interviews with SA resource industry stakeholders.

The conceptual model includes variables from three levels of abstraction. METS firm innovativeness and diversification, as well as absorptive capacity, are firm level variables. Relational embeddedness is a supplier-customer dyad-level variable, which reflects the nature of relationships between buyer and supplier, and the positional embeddedness is a network level variable, which characterises the position of the METS firm within the regional supply network.

The framework conveys the major argument of this thesis that regional resilience, built upon regional firms' adaptability strategies – diversification and innovativeness – is a product of not only local firms' internal capabilities, but also effectiveness of the regional supply network structure and relationships. The summary of the hypotheses to be tested is presented in the Table 3.1.

Table 3.1 Hypotheses summary

	Hypothesis number and description
H1a	There is a positive relationship between METS firm capability diversification and sectoral diversification
H1b	There is a positive relationship between METS firm capability diversification and innovativeness.
H1c	There is a positive relationship between METS firm sectoral diversification and innovativeness
H2a	There is a positive relationship between METS firm absorptive capacity and capability diversification.
H2b	There is a positive relationship between METS firm absorptive capacity and sectoral diversification.
H2c	There is a positive relationship between METS firm absorptive capacity and innovativeness
H3a	There is a positive relationship between METS firm supply networks positional embeddedness and its capability diversification.
H3b	There is a positive relationship between METS firm supply networks positional embeddedness and its sectoral diversification
H3c	There is a positive relationship between METS firm supply networks positional embeddedness and its innovativeness.
H4a	There are positive relationships between joint-problem solving between METS firm and its customers and its capability diversification
H4b	There are positive relationships between joint-problem solving between METS firm and its customers and its sectoral diversification
H4c	There are positive relationships between joint-problem solving and METS firm innovativeness
H5a	There are positive relationships between the scope and quality of information exchange between METS firm and its customers and its capability diversification mediated by joint problem solving in supplier-customer relationships
H5b	There are positive relationships positive relationships between the scope and quality of information exchange between METS firm and its customers and its sectoral diversification mediated by joint problem solving in supplier-customer relationships.
H5c	There are positive relationships between the scope and quality of information exchange between METS firm and its customers and its innovativeness mediated by joint problem solving in supplier-customer relationships.
H6a	There are positive relationships between trust in supplier-customer relationships and METS firm capability diversification mediated by the scope and quality of information exchange and joint problem solving between METS firm and its customers.
H6b	There are positive relationships between trust in supplier-customer relationships and METS firm sectoral diversification mediated by the scope and quality of information exchange and joint problem solving between METS firm and its customers.
H6c	There are positive relationships between trust in supplier-customer relationships and METS firm innovativeness mediated by the scope and quality of information exchange and joint problem solving between METS firm and its customers.
H7a	Trust between METS firm and its customers positively impacts METS firm capability diversification through the mediation effect of joint problem solving.
H7b	Trust between METS firm and its customers positively impacts METS firm sectoral diversification through the mediation effect of joint problem solving.
H7c	Trust between METS firm and its customers positively impacts METS firm innovativeness through the mediation effect of joint problem solving.
H8	The size of the METS firm moderates relationships among model variables.
H9	The position of METS firm in the tiered structure of resource supply chain moderates relationships among model variables.
H10	The industry association membership of a METS firm moderates postulated relationships among variables.

Chapter 4

Research design

4.1 Introduction

This chapter describes the research design of this study, including the development of the proposed conceptual framework that guided this research and was outlined in Chapter 3. Each section in the chapter explains the decisions made during the planning of the research approach, including the overall research design, methods and procedures applied to collect and analyse the data; the theoretical and practical aspects of the conceptual framework and its relationship with the pragmatist research paradigm and a mixed-methods research design; the methods and procedures performed to collect and analyse the data; as well as the issues related to the validity and reliability of the research findings (see Figure 4.1).

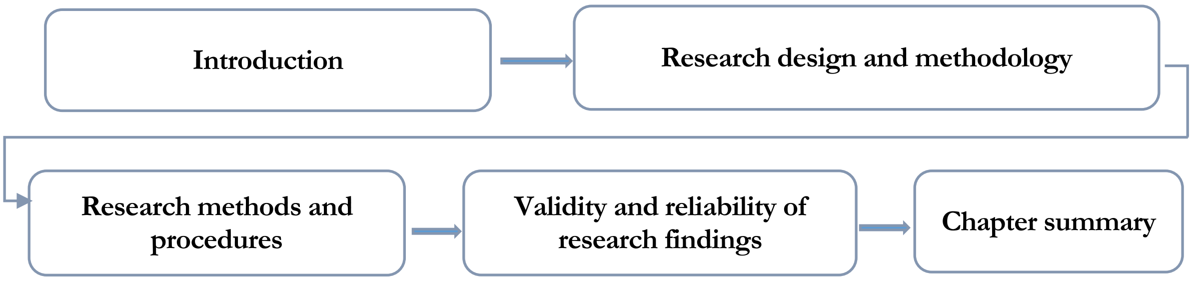

Figure 4.1 Chapter 4 structure

4.2 Research design and methodology

The philosophical and theoretical underpinning of the methodology of the current research needed to be consistent with the nature of the research problem and theoretical background. The need to address a practical problem was the starting point for this research, and led to the identification of the gap in the literature calling for pragmatic knowledge and a methodology suitable for finding and analysing appropriate data. Regional resilience, interorganisational networks and network governance literature stress the need for recognition of the mechanism operating at micro and meso-levels to understand the processes leading to regional resilience. Following this line of thought, a multi-layered conceptual framework was developed which called for the *mixed-methods research design* that included both quantitative and qualitative methods.

4.2.1 Development of the conceptual framework

As a result of the literature review (Chapter 2) and various exploratory interviews with SA resource sector stakeholders, including supply chain managers of mining companies and EPCM providers, government officials, industry association leaders and METS firms' owners and general managers, the conceptual framework was developed (Chapter 3), which guided data collection and analysis to answer the research questions.

The conceptual framework was built upon previous empirical studies dedicated to the development of the resource extractive regions and clusters and the theoretical foundations of regional resilience, network governance and network embeddedness literature. The combination of theoretical insights that underpinned the conceptual framework allowed the catalysers of the regional capability development of South Australian METS sector to be regarded in a new light.

The conceptual framework framed the investigation of the direct and indirect effects of the METS firms' positions in the regional supply network (network level), the nature of relationships with other firms in the network (supplier-client dyad level) and firm absorptive capacity (firm level) on firm adaptability strategies – their innovativeness and diversification (firm level).

Although the unit of analysis was individual METS firms, variables and relationships included in the conceptual framework reflect three levels of abstraction – firm, supplier-buyer dyad and supply network level. Moreover, the conceptual model was conceived and is explained in the context of important moderating effects, i.e., the resource supply chain tier structure and the industry association membership, which represent the context inherent to the resource sector of South Australia.

The relationships between constructs, 'mapped' against levels of abstraction, are shown in Figure 4.2.

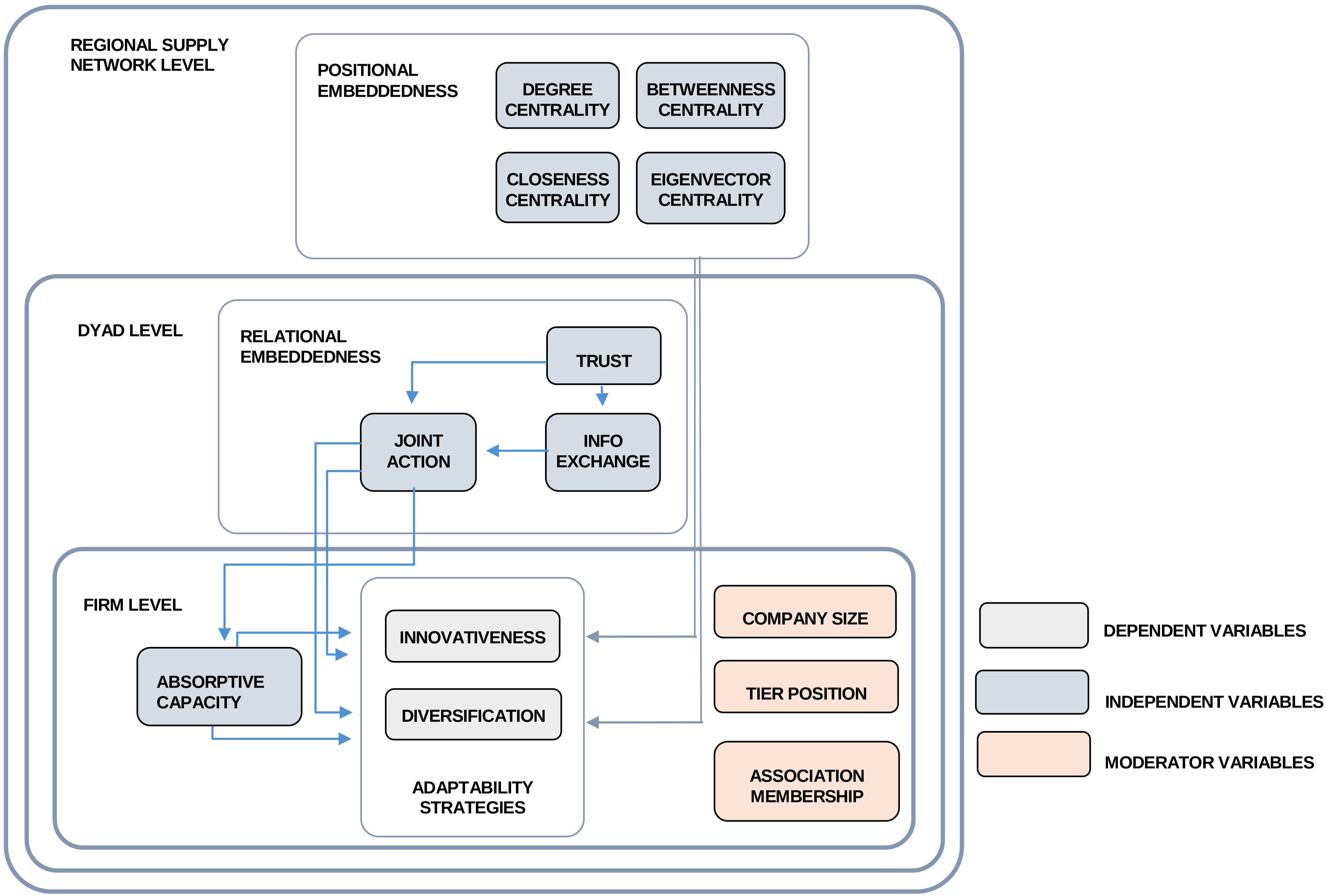

Figure 4.2 The multi-level conceptual framework: constituent variables represent three levels of abstraction (firm level, dyad level, and network level)

Approach to the research. According to Patton (1990), there was no best method for research investigation. Saunders and Lewis (2009, p. 6) point out that:

> *Business and management research not only needs to provide findings that advance knowledge and understanding, it also needs to address business issues and practical managerial problems.… (p. 6)*

Creswell (2013) suggested considering three factors when selecting how to approach the research:

- the nature of the research problem
- the personal experiences of the researcher
- and the audience for whom the report will be written.

In the current research, the nature of the research question and these perspectives determined the selection of the research approach.

Firstly, the overarching question of this PhD research involved understanding of the micro and meso-level mechanisms of adaptation and resilience of the resource extractive regions. Regional resilience literature highlights the fact that '…resilience epistemologies are predicated on a view of the world as a moving target and thus may ultimately require a science that is by necessity localised and qualitative…' (Evans, 2011, p. 233, in Bristow, & Healy, 2014b).

> *The ontology of change, place and context becomes unescapable…In complex social systems, human action is part of the control parameter set, but critically it always operates in context…(Bristow, & Healy, 2014b, p. 933)*

Secondly, the research problem was based on a practical problem currently topical in a South Australian resource industry experiencing decline due to a global downturn in commodity prices and weaker demand. A priority for the South Australian government, therefore, is building regional resilience in the state's resource extractive regions by incentivising effective regional resource and energy supply chains and supporting the local METS sector by enhancing collaboration and clusters development. The supply chain structure and collaborative relationships are important factors in maintaining industrial viability in times of downturn, allowing METS firms to pursue adaptability strategies, including innovation and diversification.

Thirdly, the resource sector was a focus of the research due to the previous experience and professional background of the researcher. Before commitment to the current research, the researcher was involved in strategic and operational management consultation and research in the resource extractive sector. The knowledge and understanding of the resource industry structure and context contributed to the selection of the research problem and approach.

Fourthly, current research was conducted in collaboration and with the assistance of the resource industry associations and the SA government. The researcher was assisted in collecting quantitative and qualitative data through engagement with the resource sector suppliers at industry conferences and networking events, and participating in programs, seminars and workshops for METS companies. Furthermore, access to multiple secondary sources and confidential information was possible. This allowed the collection of rich data, including observations, industry association databases, survey results and interviews and secondary sources, including industry databases and reports.

The above reasons encouraged the researcher to adopt a *pragmatist* research paradigm, which offered freedom to the researcher in the selection of which ontology, epistemology, axiology and methodology to apply to the research question. Pragmatism is suitable for investigation of a phenomenon in a natural context with a partnership between researcher and practitioners (Bryman & Braun, 2012).

Pragmatist research paradigm – ontology, epistemology and methodology. Pragmatism focuses on practical applied research, relaxes the need for the selection of a solely deductive or inductive approach and advocates for a mixed methods research design. Pragmatist research philosophy is concerned with solutions to problems – what works (Patton, 1990). In this view, the problem is most important, rather than methods, and the researcher can use all approaches to understand the problem. (Creswell, 2013, p. 14) outlined the key features of pragmatist knowledge that suit this research:

> *Pragmatism is not committed to any one system of philosophy and reality. This applies to mixed methods research in that assumptions when they engage in their research…Individual researchers have a freedom of choice. They are free to choose the methods, techniques, and procedures of research that best meet their needs and purposes…*

> *Truth is what works at the time: it is not based in a strict dualism between the mind and reality completely independent of the mind. Thus, in mixed methods research, investigators use both quantitative and qualitative data because they work to provide the best understanding of a research problem…*
>
> *Pragmatist researchers look to the what and how to research based on its intended consequences – where they want to go with it… (p. 14)*

The ontology – the view of reality and being – associated with the pragmatist research paradigm assumes that the researcher adopts external, multiple views of the observed phenomena to answer the research question. The epistemology, which defines what is claimed to constitute acceptable knowledge for the researcher adopting a pragmatist view, suggests that:

> *Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data…. (Saunders & Lewis, 2009, p. 119)*

This research was concerned with understanding how the regional supply network structure and relationships in the resource industry in South Australia, i.e., network governance, impact METS firms' adaptability strategies during economic downturns in commodity demand and prices. The exploratory nature of the study, the complexity of the problem, including unclear boundaries between the phenomena and the environment, called for a flexible research approach allowing multiple sources and methods to be utilised.

There was a need to understand the problem from multiple perspectives and to find out 'what is happening; to seek new insights; to ask questions and to assess phenomena in a new light' (Robson, 2002, p. 59), as well as test hypotheses using the traditional positivist approach. Such a need for quantitative testing of the hypothesised relationships based on the literature review and the analysis of the interviews with the resource supply network participants called for the adoption of both inductive and deductive reasoning. Testing hypothesised relationships in a positivist tradition was followed with in-depth interviews, which provided deeper meanings and insights, leading to the adoption of the *mixed methods* research design, compatible with pragmatist research philosophy.

4.2.2 Mixed methods research design

Due to the problem centred nature of the research, the mixed-methods design was adopted, with the assumption that collecting diverse types of data best provides on understanding of a research problem (Creswell, 2013). Mixed methods allowed multi-level analysis, highlighting relationships and interactions at different levels and dimensions of the studied phenomena in three levels of abstraction. Furthermore, the results obtained using one method helped inform the other method and enabled triangulation of the findings. The mixed method research design allowed the researcher to '…simultaneously collect both quantitative and qualitative data, merge the data and use the results to understand a research problem…' (Creswell, 2013, p. 514).

Quantitative methods underpinned by positivist knowledge were applied to test hypothesised relationships between firms' positional and relational embeddedness in the regional supply network and METS firms' adaptability strategies, while qualitative analysis of the interviews and secondary sources elicited deeper insights from multiple stakeholders into the problem of resilience in the SA resource extractive regions. The quantitative investigation was also informed by exploratory interviews with industry stakeholders that informed the development of the conceptual framework.

Qualitative and quantitative data in the main study were collected simultaneously and the information integrated to be interpreted. Following the concurrent mixed methods research design path, the research proceeded through the stages outlined in Figure 4.3.

Research site selection. The case of the South Australian resource sector as a basis for this research was selected for several reasons. (The importance of building resilient resource extractive regions in the South Australian context through the development of the local METS sector was outlined in Chapter 1 – Introduction).

Firstly, the METS sector makes a significant contribution to exports and the gross state product (GSP) in South Australia, with the largest open-pit mine, Olympic Dam, operated by BHP Billiton, one of the leading world operators. The South Australian economy is significantly affected by large-scale mining projects, being the key source of technology and services suppliers. The METS is ranked 17th in terms of its contribution to South Australia's gross state product and 19th in terms of taxes (Department of State Development, 2015).

Secondly, the development of efficient and competitive local supply chains in the mining sector is one of the top priorities for the South Australian government. The METS sector presently contributes $2.4 billion to the GSP of South Australia. It further employs 17,830 full-time employees (FTE).

Finally, the uniqueness was determined by large-scale transformation and restructuring of the South Australian regional supply chains, which took place in the mining sector because of a global downturn in commodity prices.

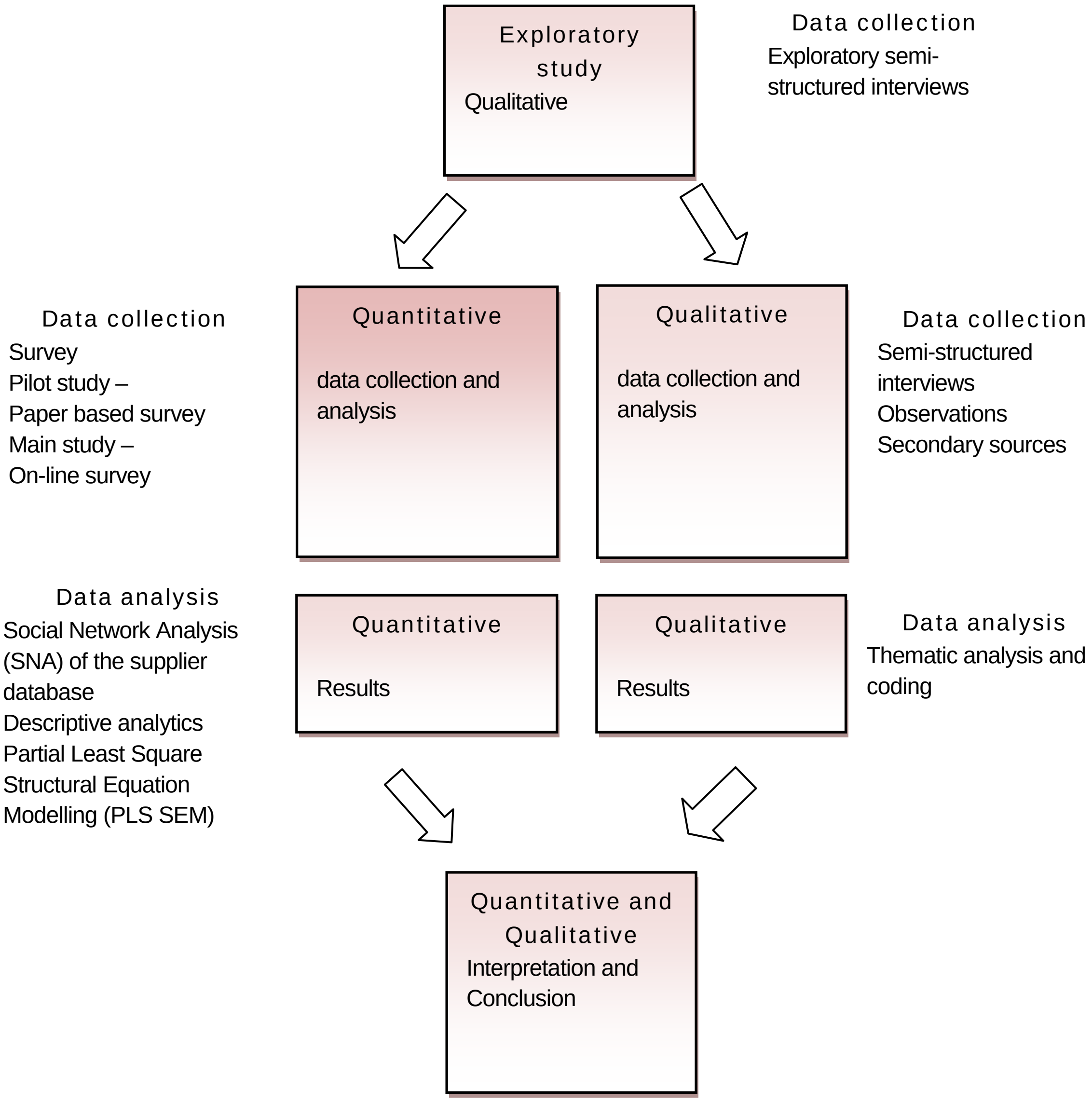

Figure 4.3 Mixed-method research design with the data collection and analysis

Participant selection. The conceptual framework that guided this research was concerned with understanding how regional resilience at meso-level is impacted by micro-level relationships between the supply network structure, the nature of supplier buyer relationships and METS firm diversification and innovation in the context of a downturn in commodity prices. The complexity of the research problem determined the major criteria for the sample selection.

At the initial stage, *exploratory qualitative interviews* were set up with the key stakeholders in the supply chain using a snowball sampling technique. The researcher sought to get insight into the mining operators, industry associations, METS companies and government in relation to the issue of capability upgrade, diversification and innovation in local firms operating within the supply network of the South Australian resource sector, as well as their relationships with customers, suppliers and other organisations.

In the *quantitative part of the study*, the population of the companies to be surveyed was identified through membership of industry associations and commercial organisations operating in the SA resource sector. The databases of the Industry Capability Network (ICN), South Australian Chamber of Mines and Energy (SACOME), Global Maintenance Upper Spencer Gulf (GMUSG), Upper Spencer Gulf Common Purpose Group (USG CPG) were utilised. These organisations collect data about South Australian companies operating in a range of sectors, including the resource sector. Additionally, through close collaboration with resource sector associations, the contact details of South Australian companies participating in development programs, events and conferences were obtained.

METS companies selected for this study were selected based on the following criteria:

- The company had received income from the resource sector over the last three years.
- The company could have foreign, Australian or South Australian ownership, but must operate in South Australia.

The population of firms surveyed and interviewed is represented by small, medium and large businesses supplying the mining sector in South Australia.

According to the Australian Bureau of Statistics (ABS), small businesses tend to have the following management or organisational characteristics:

- independent ownership and operations
- close control by owners/managers who also contribute most, if not all the operating capital
- principal decision-making by the owners/managers.

For this research, small business was defined as a business employing less than 20 people.

For the *qualitative data collection*, the METS companies were selected using purposeful sampling (Newman, 2006). Information-rich cases, from which the researcher could learn about the most important issues relevant to the study, were selected for the in-depth interviews (Patton, 1990).

A summary of the organisations that took part in the study is shown in Table 4.1.

Table 4.1 Companies/organisations interviewed or surveyed

Company/Organisation	Stage one Interview only	Interview, & Survey	Survey only
Government	9		
Industry Associations	5		
Mining Companies	3		
EPCM/ EPC providers	4		
Research and Consulting Services	5		
METS firms		26	156

4.2.3 Demographic profile of the participants

Company size. Table 4.2 and Figure 4.4 summarise the demographic profile of the sample. In terms of company size, 46.15% of the respondent companies were small businesses with less than 20 full time employees (FTE); 37.18% were medium size companies with the number of FTE ranging from 20 to 200; and 16.67% represented large companies with more than 200 FTE. Thus, the spectrum of the respondents cut across the range of large companies, as well as small and medium size enterprises (SMEs).

Table 4.2 Company size[3]

	Number of companies	Percentage, % (N=156)
Small (1-20 FTE)	72	46.15
Medium (21-200 FTE)	58	37.18
Large (200+ FTE)	26	16.67
Total	156	100

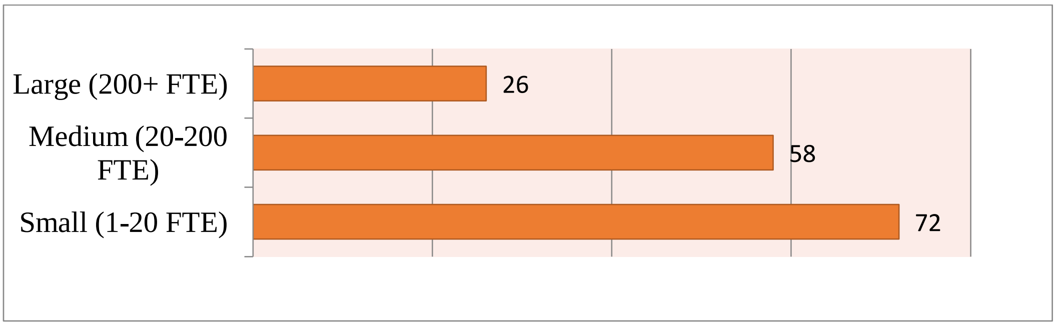

Figure 4.4 Breakdown by company size

Table 4.3 and Figure 4.5 depict the fact that out of 147 companies that disclosed their turnover in aggregate; 62% were SMEs with turnovers of less than $10 million. The rest, 38%, had a turnover of $10 million and higher.

Table 4.3 Annual turnover, AUD

Turnover range, AUD	Number of companies	Percentage, % (N=156)
Have not disclosed	9	6
$0 - $499,999	25	17
$500,000 - $0.99m	12	8
$1m - $1.99m	10	7
$2m - $4.99m	21	14
$5m- $9.99m	20	13
$10m - $19.99m	16	11
$20m+	43	29

[3] Classified according to ABS (http://www.abs.gov.au/ausstats/abs@.nsf/mf/1321.0)

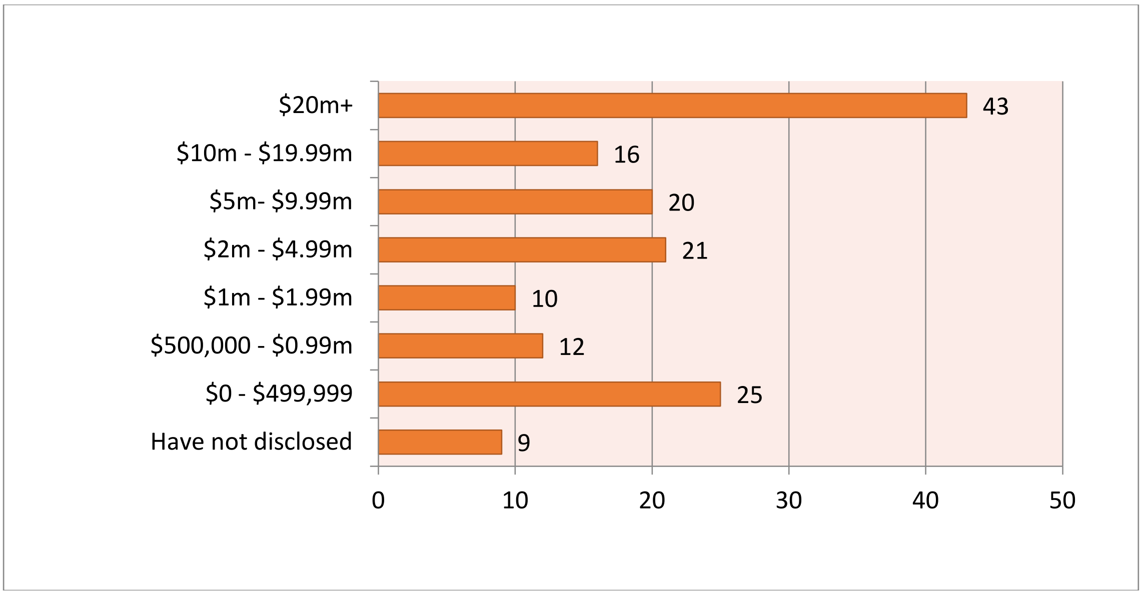

Figure 4.5 Breakdown by company turnover

Table 4.5 and Figure 4.6 show that out of 148 companies that responded, the majority – 56.76% – had been operating for less than 20 years; 38.51% had been operating in the industry from 21 to 100 years; and the oldest companies established in the industry for more than 100 years were 4.73%.

Table 4.5 Company age

Years of operation	Number of companies	Percentage, % (N=156)
1-20	80	56.76
21-100	56	38.51
100+	7	4.73

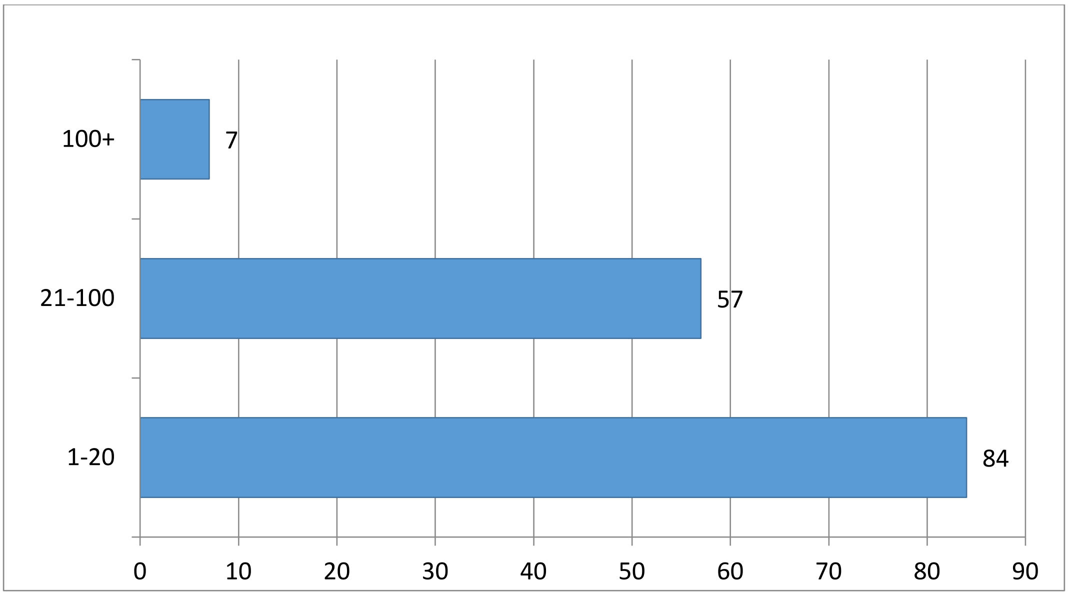

Figure 4.6 Breakdown by company age

Company head office location by state. In terms of head office location, Figure 4.7 shows that out of 123 companies with head offices in SA, the majority – 61% – were in Adelaide; 9% in the Upper Spencer Gulf region (Whyalla, Port Augusta and Port Pirie); and the rest, 30%, had their offices in other regional areas of South Australia.

Table 4.6 and Figure 4.7 demonstrate that 83% of companies have head offices in SA; 5.4 % in NSW; 4.7% in Vic; 3.4% in WA; 2.7% in Qld; and 1% in the NT.

Table 4.6 Head office location by state

	Number of companies	Percentage, % (N=156)
SA	123	83.1
NSW	8	5.4
VIC	7	4.7
QLD	4	2.7
NT	1	0.7
WA	5	3.4

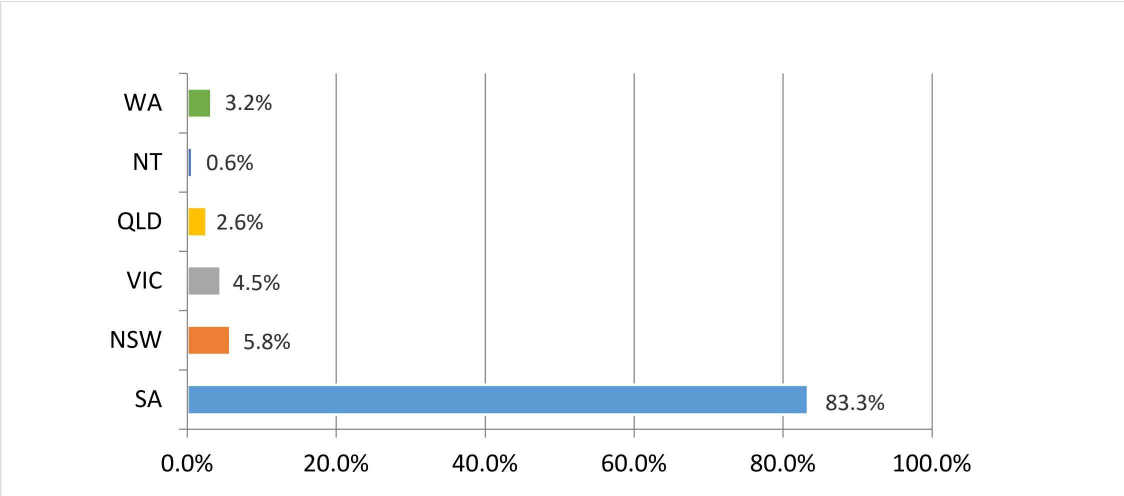

Figure 4.7 Head-office location

Head office location in South Australia. Table 4.7 and Figure 4.8 show that out of 123 companies with head offices in SA, the majority – 61% – were in Adelaide; 9% in the Upper Spencer Gulf region (Whyalla, Port Augusta and Port Pirie); and the rest, 30%, had their offices in other regional areas of South Australia.

Table 4.7 Head office location, SA

	Number of companies	Percentage, % (N=156)
Adelaide	95	60.90
USG	16	10.26
Remote SA	20	12.82
Other	25	16.03
Total	156	100

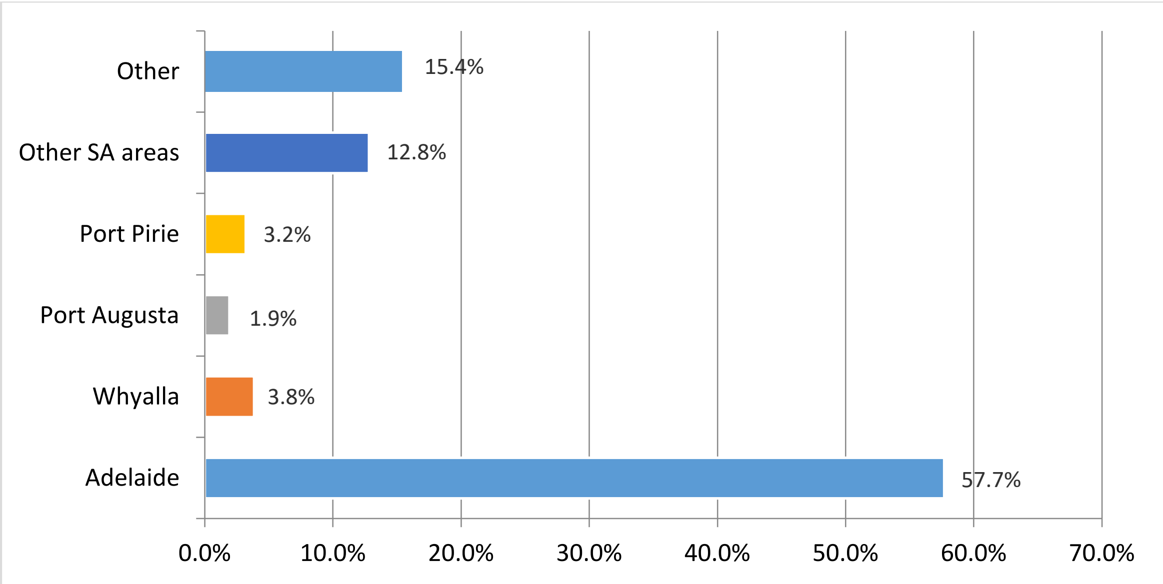

Figure 4.8 Head office location, SA

Designation of the respondents. Breakdown by the designation of the respondents is shown in Figure 4.9 and Table 4.8. Among the respondents, senior managers (i.e., those with the designation of Chairman, Principal, Directors, CEO and CFO) constituted 32.69% of the respondents. Managers (General Manager and managers) represented 44.87% of the respondents. The rest 22.44% were represented by such positions as Partner, Principal Consultant, Licensee, Business Development Specialist, Program Leader, Business Lead, Project Engineer, Principal Lawyer.

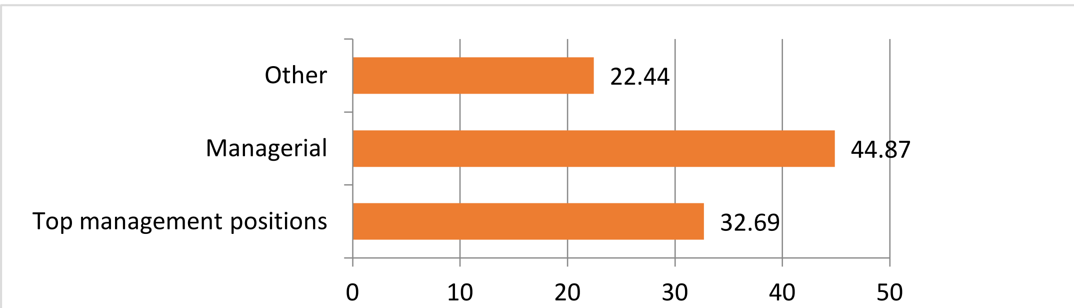

Figure 4.9 Designation of respondents

Table 4.8 Designation of respondents

Position	Number of companies	Percentage,% (N=156)
Head of company (Chairman, Director, CEO)	51	32.69
Senior management	70	44.87
Other	35	22.44
Total	156	100

METS core business activities. The core business activity for the majority of SA METS that responded to the survey (32.1%) was mining related services (geological, construction, engineering, electrical). Figure 4.10 and Table 4.9 depict participating companies grouped by their core business activities.

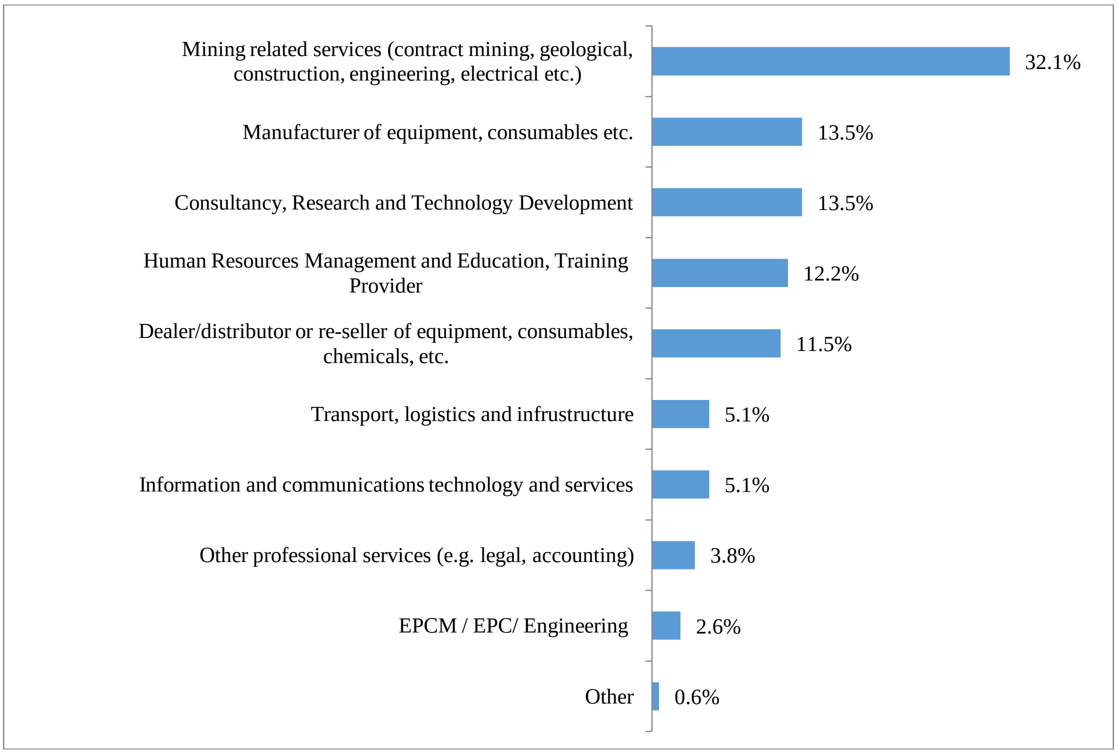

Figure 4.10 Breakdown by METS core business activity

Table 4.9 Breakdown by METS core business activity

Core Business	Number of companies	Percentage, % (N=156)
mining related services (geological, construction, engineering, electrical)	50	32.1
consultancy, research and technology development	21	13.5
manufacturer of equipment, consumables	21	13.5
human resources management and education, training provider	19	12.2
dealer/distributor or re-seller of equipment, consumables, chemicals	18	11.5
information and communications technology and services	8	5.1
transport, logistics and infrastructure	8	5.1
other professional services (e.g., legal, accounting)	6	3.8
EPCM / EPC/ engineering	4	2.6
Other	1	0.6

The capability diversification was calculated as a sum of capabilities that the company had identified. Table 4.10 and Figure 4.11 show that the majority of companies were highly specialised, having only one (30.8%), two (17.3%) or three (21.8%) major capabilities.

Table 4.10 Number of capabilities per METS company

Number of capabilities	Number of companies	Percentage,% (N=156)
1	48	30.8
2	27	17.3
3	34	21.8
4	19	12.2
5	10	6.4
6	6	3.8
7	5	3.2
8	3	1.9
9	2	1.3
11	1	0.6
13	1	0.6

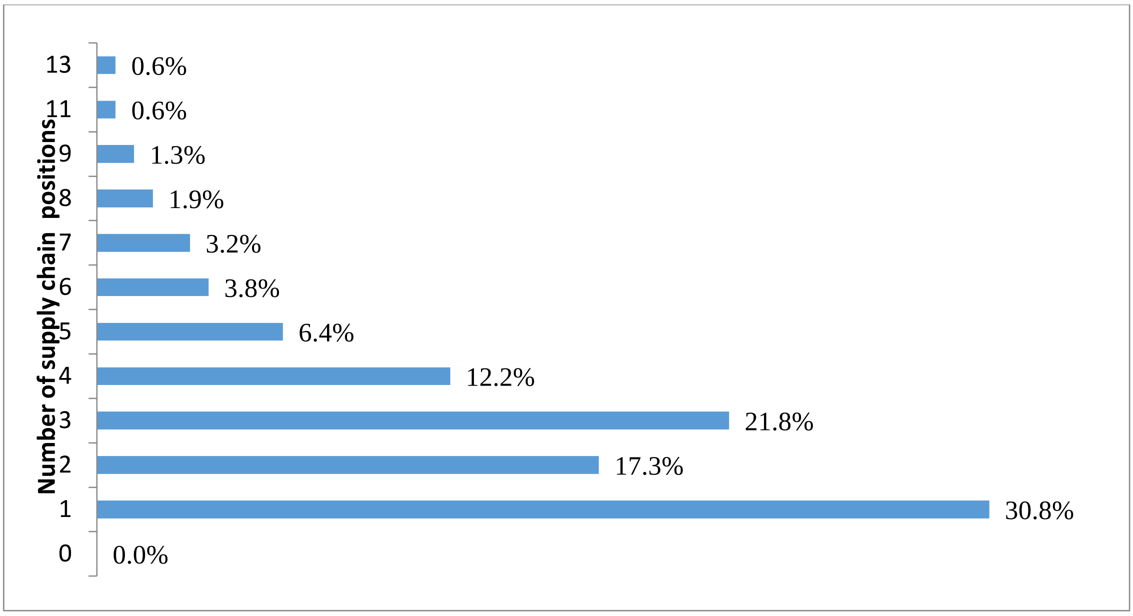

Figure 4.11 Number of capabilities per METS company

Table 4.11 and Figure 4.12 demonstrate that the majority of the participants in the study identified engineering (76.5%) and technical capabilities, as well as consultancy services (both equalling 77.9%) as core capabilities. Equipment/product supply and hire (45.6%) and Construction (43.0%) were two other more common capabilities.

Table 4.11 SA METS capabilities

Capabilities	Number of companies	Percentage, %(N=156)
Technical and consulting services	58	77.9%
Engineering	57	76.5%
Equipment/product supply, & hire	34	45.6%
Construction	32	43.0%
Electrical	29	38.9%
Other	29	38.9%
Transport, & logistics	22	29.5%
Education, & skills	21	28.2%
Environmental services	20	26.8%
Industrial Services	20	26.8%
Research and technology development	18	24.2%
Business, legal and finance	17	22.8%
Recruitment, & labour hire	13	17.4%
Civil construction	13	17.4%
Mining services	12	16.1%
Manufacturing	10	13.4%
Exploration services	7	9.4%
Accommodation	3	4.0%

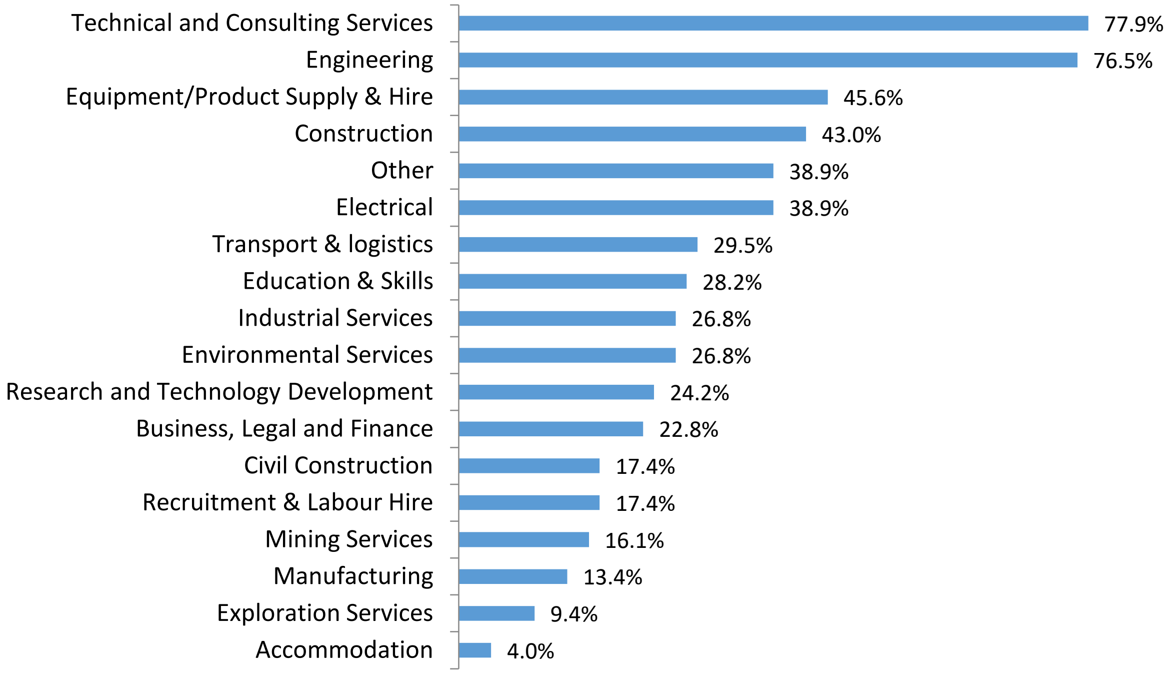

Figure 4.12 METS capabilities

The respondents were also asked to identify the sectors in which they operated. As per Table 4.12 and Figure 4.13, respondents identified resource (79.2%) and the oil and gas sectors (57.7%). The other top five sectors were manufacturing (56.4%), construction (51.7%), defence and security (45%), energy (41.6%) and water (34.2%).

Table 4.12 SA METS operating in various industry sectors

Sector	Number of companies	Percentage,% (N=156)
Mining, & Resource	118	79.2%
Oil, & Gas	86	57.7%
Manufacturing	84	56.4%
Construction	77	51.7%
Defence, & Security	67	45.0%
Energy	62	41.6%
Water	51	34.2%
Transport	44	29.5%
Food, & beverage	41	27.5%
Automotive	31	20.8%
Education, & Training	28	18.8%
Other	21	14.1%

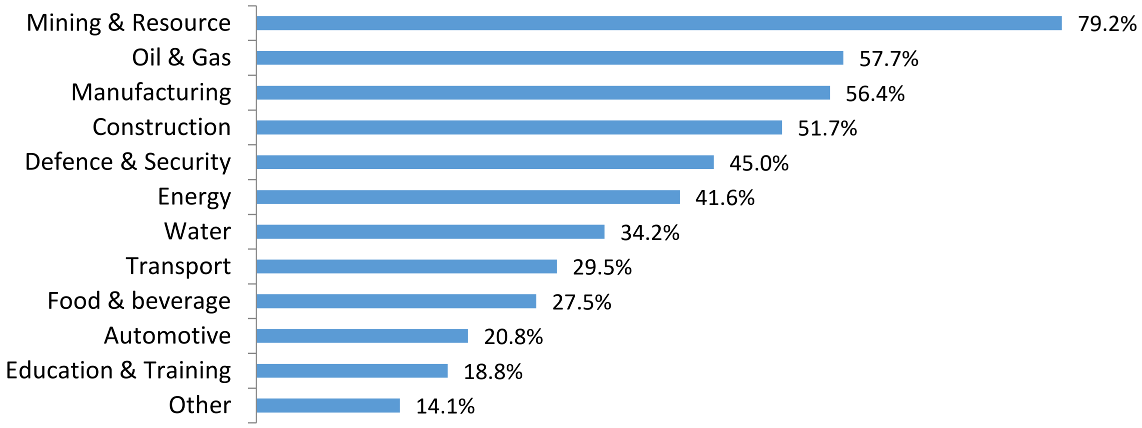

Figure 4.13 The percentage of SA METS operating in various industry sectors in the sample

Position in the resource and energy supply chain. As indicated in Table 4.13 and Figure 4.14, 42.3% of the participants operated as equipment, technology or services providers working directly with a mining company, followed by Tier 2 suppliers or sub-contractors to Tier 1 suppliers at 38.9%. Tier 3 participants were principally sub-contractors to a sub-contractor(s) with 29.5%. Sub-contractors to OEM constituted 22.1% and Tier 1 contractors to mining companies represented 16.1% of the total participants.

Table 4.13 Position of SA METS in the resource and energy supply chain

Role in the resource and energy supply chain	Number of companies	Percentage, % (N=156)
Equipment, technology or services provider working directly with a mining company	62	41.6
Sub-contractor to Tier 1(s)	58	38.9
Sub-contractor to a sub-contractor(s)	44	29.5
Sub-contractor to an OEM(s)	33	22.1
Tier 1 contractor to mining projects	24	16.1
Other	24	16.1
Sub-contractor to an OEM sub-contractor(s)	18	12.1
Original Equipment Manufacturer (OEM)	12	8.1
Contract mining	11	7.4
Pre-commercial R&D provider	10	6.7

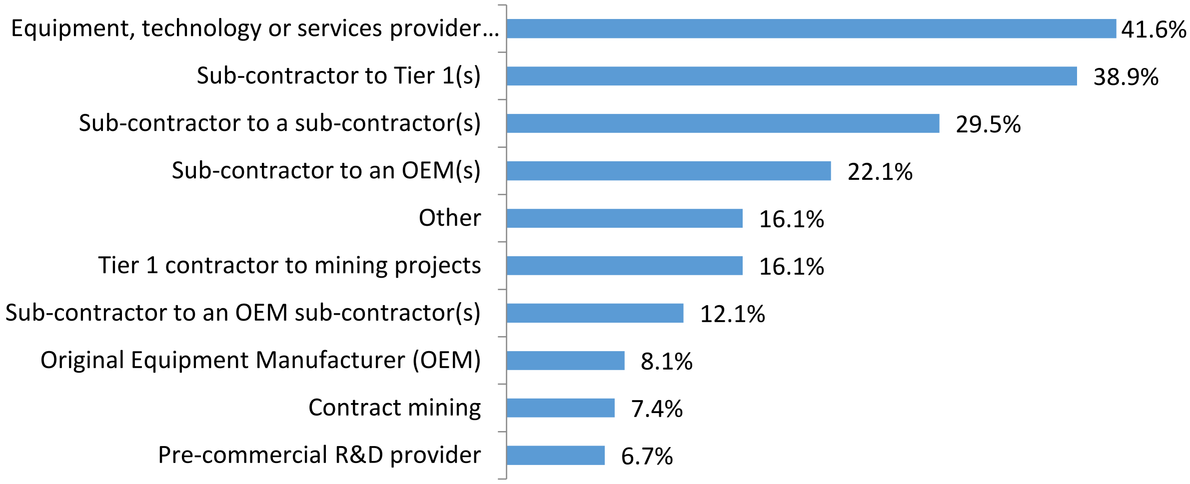

Figure 4.14 Position of SA METS in the resource and energy supply chain

Certification. Companies were asked to identify compliance to various certification standards. As per Figure 4.15 and Table 4.14 in terms of international standards certification, more than half of the respondent companies, 51%, were ISO 9001:2008 certified; 24.2% were ISO 14001:2004 certified; and 12.8% were ISO 31000:2009 certified. Fewer respondents complied with Australian and New Zealand Occupational Health and Safety standards. 21.5% were certified according to AS/NZS 4801 OHS and 11.4% to OHSAS 18000 OHS. 26.9% of respondent companies held different types of certification. Other industry specific standards included ISO 9100 Aerospace, AS9100C; Achilles; NATA (National Association of Testing Authorities); and other.

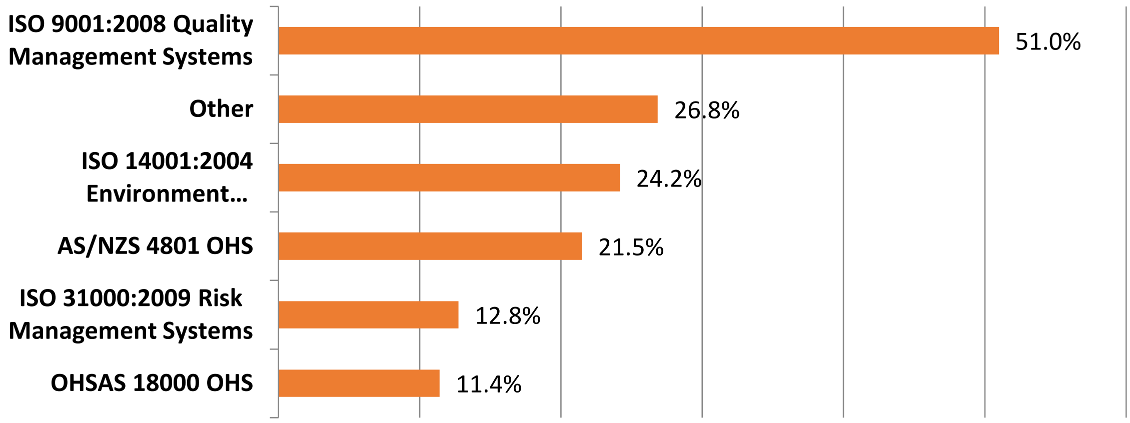

Figure 4.15 SA METS certification

Table 4.14 SA METS certification

	Number of companies	Percentage of total (N=156)
ISO 9001:2008 Quality Management Systems	76	51.0
Other	40	26.9
ISO 14001:2004 Environment Management Systems	36	24.2
AS/NZS 4801 OHS	32	21.5
ISO 31000:2009 Risk Management Systems	19	12.8
OHSAS 18000 OHS	17	11.4

4.2.4 Ethical considerations

This research was approved by the University of Adelaide Human Research Ethics Committee as low risk research. The committee endorsed the approach and data collection instruments for this research (see Appendix A1).

The consent forms and participant information sheets were prepared and signed by participants (see Appendix A2). The permission of the participants to record interviews was asked.

During data analysis stage, care was taken by the researcher to assure that the respondents, the company names would not be identifiable in any subsequent analysis and reporting. Once the final draft of the report was written, the digital recordings of the interviews were destroyed. The confidentiality agreement was signed with the Industry Capability Network, an organisation that provided access to supplier database. The ethical issue of confidentiality was dealt with through the following procedures:

- Confidentiality was maintained at all times.
- Participation in the research was voluntary.
- Any audio or video-taped sessions were carried out only with the prior approval of the participants.
- Both quantitative and qualitative data were analysed solely by the researcher.

4.3 Research methods and procedures

The overall procedure of data collection is outlined in Figure 4.16. Data collection took place from November 2014 to May 2016 including exploratory phase, pilot and main quantitative studies and qualitative study. Figure 4.16 illustrates the procedures and methods of data collection and analysis.

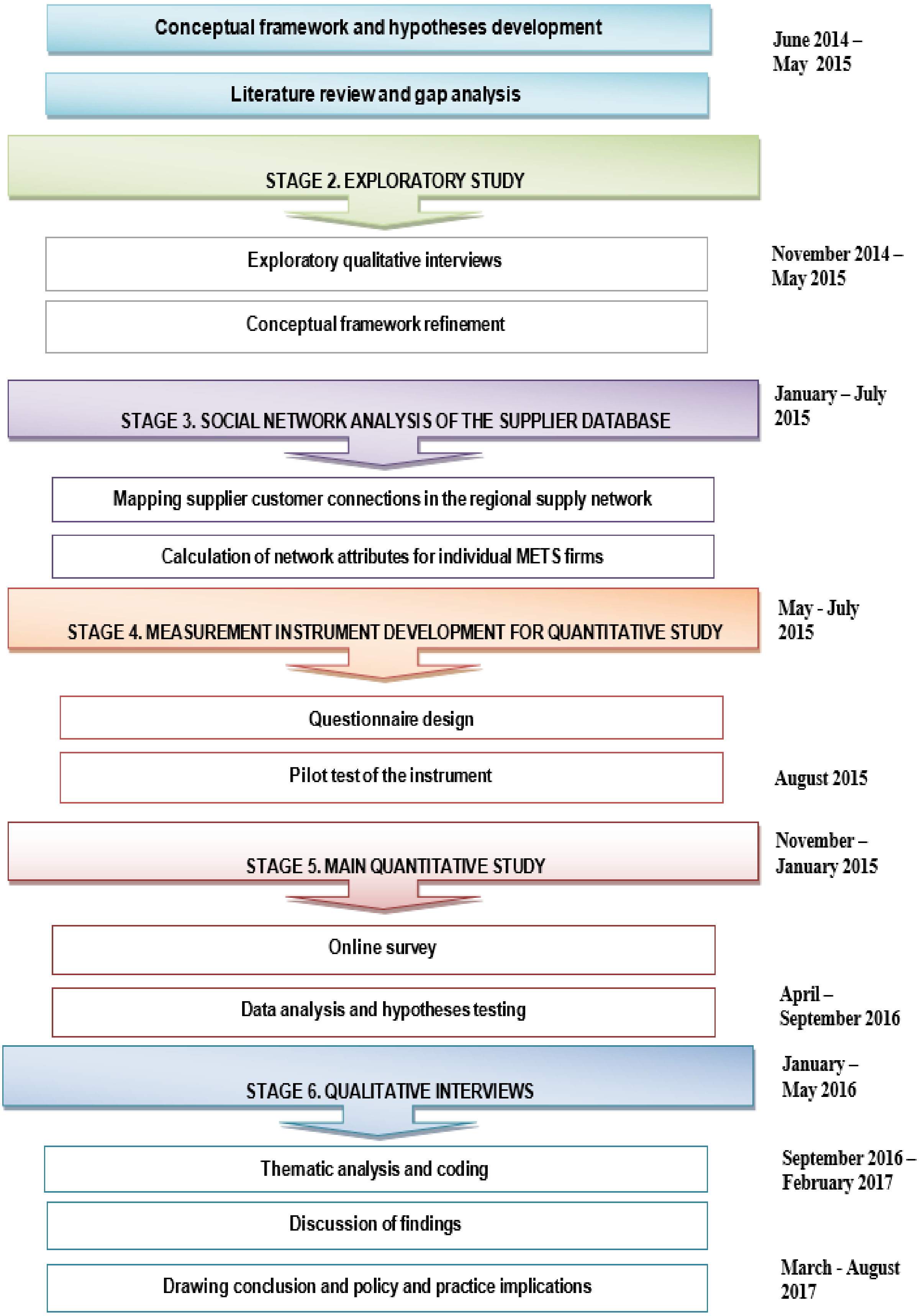

Figure 4.16 Research design procedures

4.3.1 Data collection

Exploratory phase (November 2014 – May 2015). Qualitative interviews with the key SA resource industry stakeholders were conducted to inform the development of the conceptual framework which guided data collection for the quantitative study. 26 interviews were conducted, including nine with state government officials who were involved in resource supply chain development programs, five with the leaders of resource related industry associations at the Federal and state level, three with major resource extracting and processing companies, three with Tier 1 suppliers to resource companies – EPC and EPCM providers – one with Tier 2 contractors, two with senior university academics involved in collaborative projects in the government and resource sector, five with research and consultancy agencies involved in projects related to building the supplier base and innovative capabilities in the South Australian resource sector.

Social network analysis of the supplier database (January – July 2015). To *measure positional embeddedness,* also known as *network centrality,* supplier-buyer relationships in the SA resource industry were mapped to reconstruct the regional supply network structure and calculate METS firms' *degree*, *betweenness, closeness* and *eigenvector centrality*. To reconstruct the network of supply chain relationships within the resource sector in South Australia, the Industry Capability Network (ICN) database was utilised[4].

For the current study, the South Australian branch of ICN was approached with the request to provide information about the subset of companies that supply the resource sector and operate in South Australia. The information for 503 companies and their clients in SA during the period 2010 to 2016 was extracted.

Quantitative study (May 2015 – July 2016). The quantitative study included paper based and online survey conducted with the SA METS companies. At the time of commencement of the quantitative data collection in November 2014 – May 2016, there was no official data on the overall number of METS companies in SA. In 2017, however, according to the SA government, there were more than 650 METS companies operating in the field (Development).

[4] Industry Capability Network (ICN) is an independent organisation financially supported by Australian, New Zealand, state and territory governments. The primary objective of ICN is to provide local suppliers with the opportunities in different sectors by informing them about upcoming tenders as well as assisting project managers of big projects to find local suppliers. The ICN database contains information about 70,000 suppliers across Australia.

The mailing list for the main study included 368 companies of the estimated 650 METS (approximately 57%). These companies were invited (see Appendix A3). A total of 172 companies responded, and, after checking for completeness, 156 were accepted, which is a response rate of 42% of the distributed questionnaires and 24% of the METS population.

After collecting qualitative data through interviews, quantitative data collection proceeded in two stages – a limited pilot study (N=32) followed by a larger main study (N=156) – and involved a paper-based, as well as online survey of METS companies operating in the SA resource industry supply chains.

Qualitative study (January – May 2016). The final task during the period of data gathering was to conduct qualitative interviews with 24 METS companies as a follow-up to the quantitative survey in order to get in-depth insight into the METS' strategies and supply chain relationships during a downturn in the SA resource sector. Out of 156 companies, 24 agreed to an interview, which would allow a more 'open range of experiences' to be shared with the researcher (Patton, 1990). In-depth semi-structured interviews were conducted in firms of different sizes, turnover, levels of diversification and resource sector involvement.

4.3.2 Data analysis

Overview of the data analysis methods used in this study. The quantitative data collected through the survey and measures of positional embeddedness of firms in the regional supply network were calculated using social network analysis (SNA), and hypotheses testing was performed by means of structural equation modelling (SEM), while qualitative data were interpreted using thematic analysis and coding. Several software packages were utilised to analyse the data. The *Smart PLS* software package was used to test research hypotheses. The IBM *SPSS 21* statistics software analysis tool was used to perform descriptive analysis of the data. *UCINET 6.365* (Borgatti, Everett, and Freeman, 2002) software was used to calculate company attributes (degree and eigenvector centrality) in the resource supply network. *NVivo 11* was used to perform thematic analysis of the qualitative interviews.

The next sections provide a description of data collection and analysis.

Partial least square structural equation modelling (PLS-SEM). Quantitative data collection and analysis were undertaken in a traditional positivist way, with the objective of testing the proposed conceptual framework. A path *analysis* using partial least square structural equation modelling was applied to analyse the relationships among selected variables affecting METS firm performance (Joseph F. Hair, Hult, Ringle, & Sarstedt, 2014).

Structural equation modelling (SEM) as a multivariate analysis technique combines confirmatory factor analysis (CFA) and multiple regression and allows for simultaneous investigation of a series of interdependent and dependent relationships amongst multiple variables. Furthermore, SEM not only models multiple dependent variables simultaneously, but is also able to handle non-normal data and estimates the direct and indirect effects of exogenous latent constructs on endogenous (Joseph F. Hair et al., 2014).

SEM allows for assessing latent variables at the observation level (measurement model) and the testing of relationships between latent variables on the theoretical level (structural model) (Bollen, 1989). A multi-group SEM analysis, using the moderator as the grouping variable and comparing the ‘main’ effects postulated in the conceptual model across groups can also be performed. However, the drawback of conducting subgroup analysis is loss of statistical power and information in the grouping variable (Sarstedt, Henseler, & Ringle, 2011).

Two SEM methods have been well developed in the literature: covariance-based (CB-SEM) and variance-based partial least square techniques (PLS SEM, Joseph F. Hair, Sarstedt, Pieper, & Ringle, 2012). CB-SEM is aimed at estimating model parameters in a way that the difference between the estimated and sample covariance matrices is minimised, while PLS-SEM maximises the explained variance of the endogenous latent variables by estimating partial model relationships in an iterative sequence of ordinary least squares (OLS) regressions. Researchers consider these two approaches to SEM to be complementary, rather than competing (Joseph F. Hair et al., 2012). Scholars stress that application of a particular method should be based on *research objective, data characteristics,* and *model set-up* (e.g., Fornell & Bookstein, 1982; Gefen, Straub, & Rigdon, 2011; Reinartz, Haenlein, & Henseler, 2009).

In this research, partial least square structural equation modelling was used for several reasons (Joseph F. Hair et al., 2014, p. 19). Firstly, PLS-SEM focuses on prediction rather than explanation and is useful for studies on the sources of competitive advantage and success drivers, and the objective of this research was to identify the drivers of innovation and diversification of resource sector suppliers based on their integration into the regional supply network and the nature of supplier buyer relationships.

Secondly, the structural model includes mediation and indirect effects, which does not allow using 'first-generation analysis techniques', such as regression and ANOVA. Thirdly, the sample size is small and data are non-normally distributed. Finally, due to the novel combination of variables and introduction of new variables in the conceptual framework, the model is rather more exploratory than explanatory. PLS SEM is more suitable for exploratory research than CB-SEM, which is more applicable in testing existing theories (Joseph F. Hair et al., 2012).

PLS-SEM was originally developed by Wold (1975a) and further extended by Lohmoeller (1989). It was created as an alternative to CB-SEM with relaxed demands on sample size, data normality assumptions, and specification of relationships (Joseph F. Hair et al., 2012). An important characteristic of PLS-SEM is that it estimates latent variable scores as exact linear combinations of their associated manifest variables (Fornell & Bookstein, 1982). The scores thus capture the variance that is useful for explaining the endogenous latent variable(s). Estimating models via a series of OLS regressions implies that PLS-SEM relaxes the assumption of multivariate normality needed for maximum likelihood–based SEM estimation (Fornell & Bookstein, 1982; Lohmoeller, 1989; Wold, 1975a).

The reasons for choosing PLS-SEM over CB-SEM often relate to *data characteristics*, such as the analysis *of non-normal data*, *small sample sizes*, and the *formative measurement of latent variables*. As PLS-SEM is based on a series of OLS regressions, it has minimum demands regarding sample size and generally achieves high levels of statistical power (Reinartz et al., 2009). PLS-SEM is considered to be a distribution-free 'soft modeling approach', which is suitable for applications where strong assumptions cannot be fully met (Joseph F. Hair et al., 2012). The ability to handle structural models with formative and reflective outer model modes is an important issue for SEM. While CB-SEM is applicable for formative outer model specifications only under certain conditions, PLS-SEM can almost unrestrictedly handle both reflective and formative measures (e.g.Wynne W. Chin, 1998). Furthermore, PLS-SEM is not constrained by identification concerns, even if models become complex, a situation that typically restricts CB-SEM usage (Joseph F. Hair et al., 2012).

The following disadvantages must be mentioned. Firstly, there is the lack of global optimisation criteria and, as a result, no measures for overall model fit. Secondly, since no constraints have been imposed on the distribution, inferential frameworks could not be applied. This forces researchers to use non-parametric evaluation criteria and resampling procedures to evaluate model adequacy. Thirdly, there is a concern about unbiased parameter estimation and consistency, since least squares estimators do not control the effects of one part of the model's errors to another. This is referred to as PLS-SEM bias (Wynne W Chin, 2010; Joe F. Hair, Sarstedt, Ringle, & Mena, 2012).

The increasing popularity of PLS-SEM in strategic management, marketing and management research has been proved over recent years (Joe F. Hair et al., 2012), which makes it suitable for the purposes of this study. Since the model includes latent variables, measured through the application of scales based on the previous literature – absorptive capacity and relational embeddedness variables – confirmatory factor analysis (CFA) was conducted to confirm that a set of measurable variables reflected the latent constructs in the current research setting (Schumacher & Lomax, 1996).

Social network analysis (SNA). Social network analysis (SNA) has gained attention as a tool for investigating a broad range of complex phenomena. It is a valuable lens with which to analyse relationships in organisational theory and behaviour, strategic management, business studies and sociology. Applications of SNA in interorganisational studies involve the investigation of the structural and relational aspects of inter-firm alliances, joint ventures and supply chains (Provan, Fish, & Sydow, 2007). Recently SNA has also been applied to studies of supply chains and networks (Balland, Belso-Martínez, & Morrison, 2014; Giuliani, Maffioli, Pacheco, Pietrobelli, & Stucchi, 2013; Hearnshaw, & Wilson, 2013; Kim, Choi, Yan, & Dooley, 2011; Ramos, Roseira, Brito, Henneberg, & Naudé, 2013).

Formal measures of network characteristics have been developed to construct testable models, thus making it possible to incorporate a network-based perspective in the studies on regional competitiveness. The relationships between the position of firms in inter-organisational networks and their business performance have been extensively studied (Borgatti, & Li, 2009; Capó-Vicedo et al., 2011; Giuliani, 2013; Giuliani et al., 2013; Kim, Lee, Choe, & Seo, 2014; Kim et al., 2011; West, 2014).

According to Borgatti and Li (2009), SNA concepts are particularly suitable for studying how patterns of inter-firm relationships in supply networks translate to competitive advantages through management of materials movement and diffusion of information. Autry and Griffis (2008) applied the concept of social capital, framed as part of social network theory, to the supply chain context. However, researchers claim that the theoretical framework that relates social network theory to supply network dynamics and the comprehensive application of SNA to studying supply networks is still lacking.

Scholars also highlight the fact that most of the research applying SNA in the supply chain context, analyses egocentric networks, i.e., the relationships of one focal actor with other actors (Borgatti, Everett, and Freeman, 2002). However, there are fewer studies that adopt a whole network approach to estimate firm centrality in regional networks (Sloane, O'Reilly, & Reilly, 2013), which is considered to be time and resource consuming. In the current research, a whole network approach was adopted.

To measure *positional embeddedness* of a METS company in the regional resource industry supply network, methods and procedures of social network analysis have been applied (Borgatti, Everett, & Johnson, 2013; Borgatti & Li, 2009). Firstly, the data about METS companies, their clients and suppliers were collected from industry databases and the survey. Then, it was compiled into an adjacency matrix to reconstruct the connections within the SA regional supply network (see Appendix B). Then *UCINET 6.365* software was used to calculate the network attributes of the companies that completed the survey. Finally, these attributes were used to measure the centrality construct in the conceptual framework along with other variables collected through the survey questionnaire and analysed with the application of the appropriate statistical techniques.

Thematic analysis and coding of qualitative data. Thematic analysis is a widely-used method of describing and interpreting a qualitative data set in great detail and identifying patterns or themes (Braun & Clarke, 2006). Epistemologically, thematic analysis in the current research is a part of the critical realism method (Bryman & Braun, 2012). It allows making sense of participants' experiences and understanding of the current structure and dynamics of relationships in the resource related supply networks in the context of South Australian economy at a point of time.

The qualitative data collected through interviews from 26 METS companies, was transcribed, identified, reduced, coded and categorised. The audio recordings of interviews were transcribed by a third party organisation to be prepared for analysis by the researcher. A comprehensive thematic analysis of the interview data was performed using *NVivo* software (Bryman & Braun, 2012). The data were classified according to descriptive codes, such as *supply chain relationships, diversification strategies, embeddedness, role of associations, relationships with clients, certification and accreditation issues, macro-level socio-economic factors*. Once coded, the data were analysed for emerging themes or patterns (Miles, Huberman, & Saldana, 1984). Since the study was informed by the conceptual framework, the *a priori* themes and concepts were matched with the data.

Qualitative data collection was conducted until the saturation point was reached. The entire data set was analysed at the semantic level to identify repeated patterns of meanings (Bryman, & Braun, 2012). A theme-building approach was utilised using the following steps. Firstly, the interview transcriptions were read thoroughly to identify key concepts, topics and recognise repeating patterns. Then the *Nvivo* 11 software was utilised to code the data and assign phrases and paragraphs to themes and subthemes. Words and phrases that typified a theme were highlighted to produce a table with themes and subthemes, quotes and confirming cases. Lastly, key phrases and patterns were documented, and the links between themes and concepts drawn to interpret the response patterns according to theme.

To free the data from bias in the interpretation process, another scholar was engaged to validate the data analysis. Two researchers independently performed the analysis to identify key ideas and subthemes that arose, and to identify areas where there was no agreement on a specific subtheme. After analysis had been completed, both analysts compared the notes and compiled the final result, thus addressing the validation issue (Pope, Ziebland, & Mays, 2000). Some themes were reorganised and additional links were incorporated to reach the agreement on themes and the links drawn.

4.4 Validity and reliability of the research findings

Validity and reliability are always central concerns of a research study. This concern was addressed in several ways. Firstly, the current research utilised a mixed methodology approach, which includes both qualitative and quantitative stages, which is an accepted method of data triangulation to enhance validity (Jick, 1979).

Secondly, for the quantitative part of the assessment of the study, face, content, and construct validity tests were performed. *Face validity* was ensured through involvement of industry experts to review the questionnaire and interview questions design. *Content validity* for latent constructs in the model was ensured by utilising measurement instruments from previous research and by checking through the pilot study. *Construct validity* was evaluated by application of CFA.

Reliability of the measurement model was ensured through evaluation of *indicator reliability* (squared standardised outer loadings), *internal consistency reliability* (composite reliability), *convergent validity* (average variance extracted, AVE), and *discriminant validity* (Fornell-Larcker criterion, cross-loadings) (Joseph F. Hair et al., 2012). This is discussed in more detail in Chapter 5.

Causality issue. Since the data was collected at one point of time, it does not satisfy the requirement of temporal ordering for the estimation of causal relationships between variables in the conceptual model. Thus, the causality was inferred and established based on previous research and qualitative interview data.

As for the *qualitative part of the study*, validity and reliability of the sources was ensured through assessment of trustworthiness of the interview data by drawing on secondary sources and industry reports. Validation of the thematic analysis was ensured by involving an independent scholar in the process of data coding followed by comparison and aggregation of the results obtained by two analysts.

The procedures implemented to address validity and reliability issues of quantitative and qualitative findings are described in detail in the Chapter 5 – Quantitative study and Chapter 6 – Qualitative study.

4.5 Chapter summary

Chapter 4 outlines the research design, including the theoretical and philosophical underpinning of the conceptual framework development and the approach to research as well as methods of the data collection and analysis.

Pragmatist research and mixed methods research design was considered to be appropriate given the applied nature of the research and complexity of the research problem, which requires understanding the phenomena from multiple perspectives and at the same time based on an external view of reality, corresponding to positivist traditions.

Mixed methods research design adopted in this study allowed the use of both inductive and deductive logic, combining the strengths of both methods. The positivist deductive quantitative study allowed for statistical testing of the relationships between selected constructs and for making inferences, and the inductive qualitative part allowed for contextualising, enriching and triangulating quantitative findings.

The rationale behind the choice of the research site and participant selection was also covered. The research site was selected based on considerations of relevance to the research problem, access to data and industry needs.

The data collection methods and procedures were also described. Initially, exploratory interviews were conducted, followed by a quantitative data collection procedure – paper-based and online survey – were undertaken as part of the pilot and main studies and finalised by in-depth interviews with selected METS firms to enrich quantitative findings.

The analysis techniques utilised in this study were selected with the reference to the nature of the research problem with the reference to previous research. In the quantitative part of the research, path analysis was applied to create the conceptual framework for investigating interrelationships between selected variables influencing METS firm innovation and diversification. Social network analysis was applied to identify a firm's position in the resource industry regional supply network. In the qualitative part, thematic analysis of the qualitative interview data was undertaken.

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Chapter 5

Quantitative study

5.1 Introduction

Chapter 5 provides a detailed description of the stages of the main quantitative study undertaken to test relationships postulated in the conceptual framework presented in Chapter 3.

The conceptual framework guided data collection, and determined selection of data analysis techniques. The quantitative study was conducted using the general framework of structural equation modelling (SEM) (Joe F. Hair et al., 2012). The major stages of analysis involved: specification of the structural model and the measurement model, data collection and examination, descriptive analysis, assessment of the measurement model, assessment of the structural model, multi-group analysis and test of moderation effects, and results interpretation (see Figure 5.1).

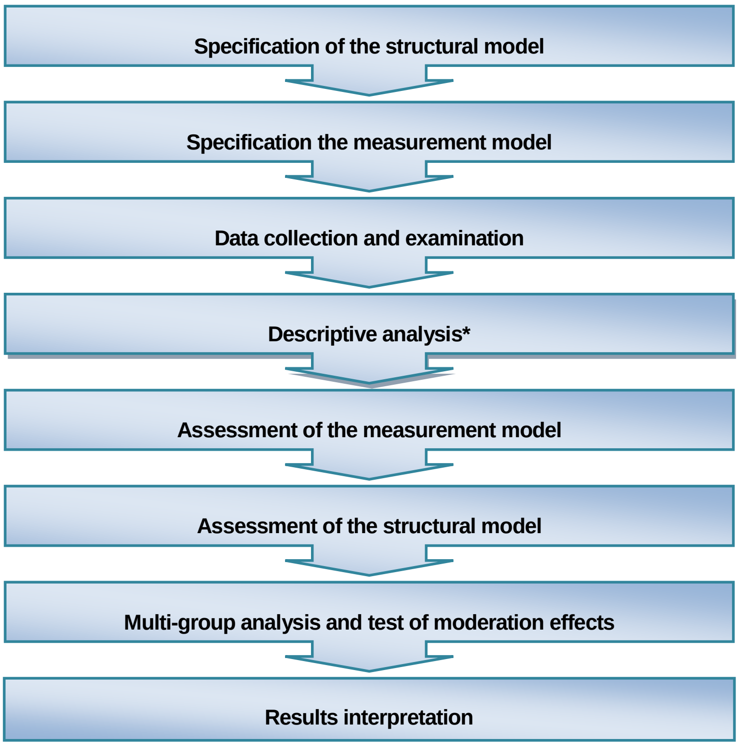

Figure 5.1 A typical procedure for PLS-SEM data analysis followed in the current research (adapted from Hair et.al., 2014). *The results of the descriptive analysis of the sample were presented earlier in the Chapter 4 – Research design, Section – Participant selection.

5.2 Specification of the structural model

The structural model, also known as a 'path model', is the first step in SEM. The structural model is based on theory and logic and visually illustrates the relationships between variables included in the model (Joseph F. Hair et al., 2014). The structural model in this study, based on the conceptual framework outlined in Chapter 3, is demonstrated in Figure 5.2. The hypothesised relationships among variables and constructs in the model were explained and summarised in Chapter 3.

The exogenous variables in the conceptual framework were *trust* and *network centrality* variables, and the endogenous included *absorptive capacity, information exchange, joint problem solving, sectoral and capability diversification, and innovativeness* (see Table 5.1).

Table 5.1 Summary of variables in the structural model, including mediation paths and moderators

Variable	Variable name	Variable type
Exogenous		
CENT_D	degree centrality in the regional supply network	latent, continuous
CENT_CL	closeness centrality in the regional supply network	single item, continuous
CENT_B	betweenness centrality in the regional supply network	single item, continuous
CENT_E	eigenvector centrality in the regional supply network	single item, continuous
TRUST	trust	latent, ordinal
Endogenous		
JA	joint problem-solving	latent, ordinal
IE	information exchange	latent, ordinal
ABS_CAP	absorptive capacity	latent, ordinal
SECT_DIV	sectoral diversification	single item, continuous
CAP_DIV	capability diversification	single item, continuous
INN	innovativeness	single item, continuous
Moderators		
SIZE	company size	categorical (nominal)
TIER	position in resource supply chain tier structure	categorical (nominal)
MEMB	membership in associations	categorical (nominal)

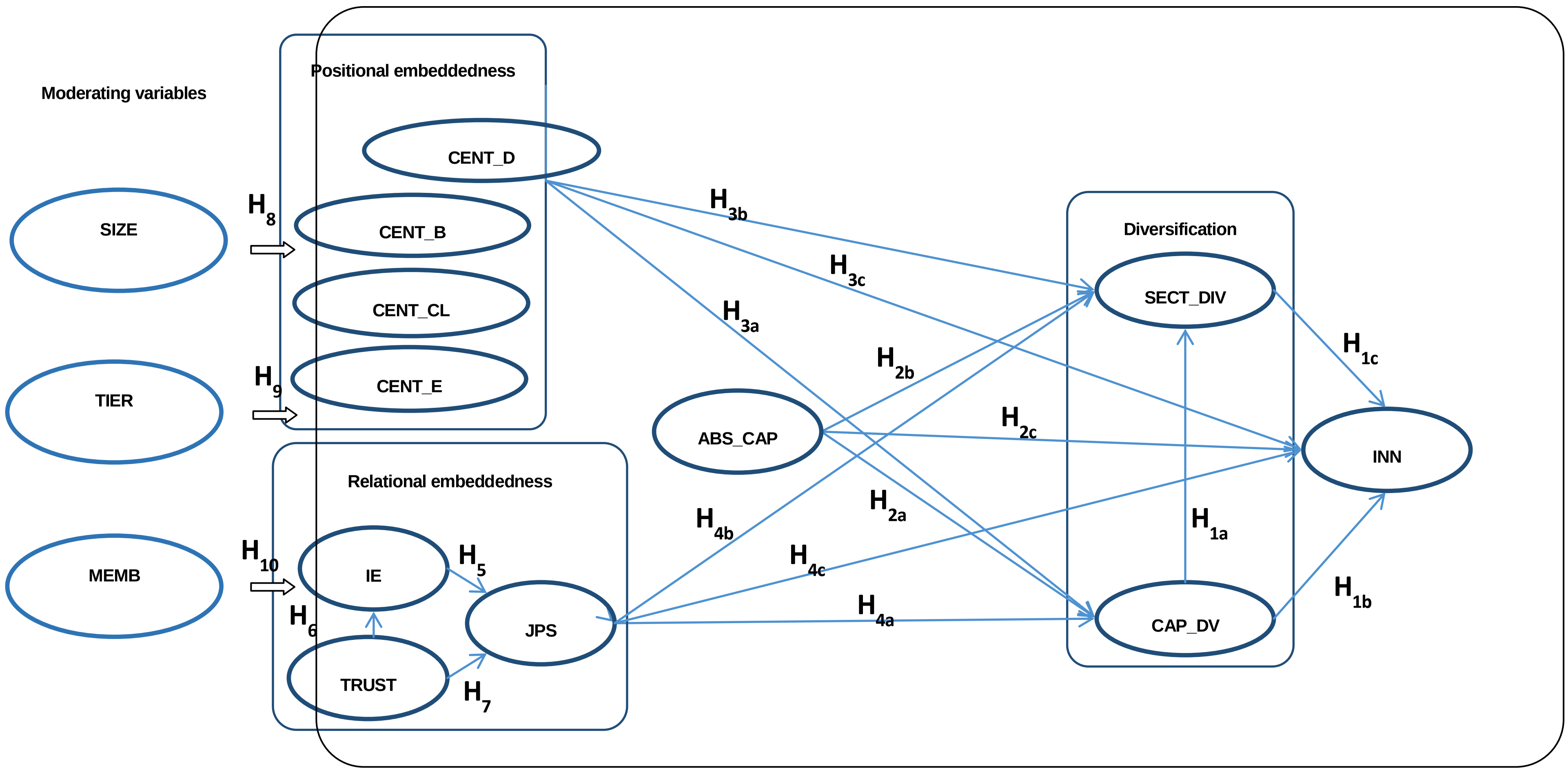

Figure 5.2 Structural model based on the conceptual framework. Model variables: INN – innovativeness, CAP_D – capability diversification, SECT_D – sectoral diversification, ABS_C – Absorptive Capacity, CENT_DB – degree and betweenness centrality, CENT_CL – closeness centrality, CENT_E – Eigenvector centrality, IE – fine-grained information exchange, JPS – joint problem solving

5.3 Specification of the measurement model

To specify variables in the conceptual framework, the following procedures were undertaken (see Figure 5.3).

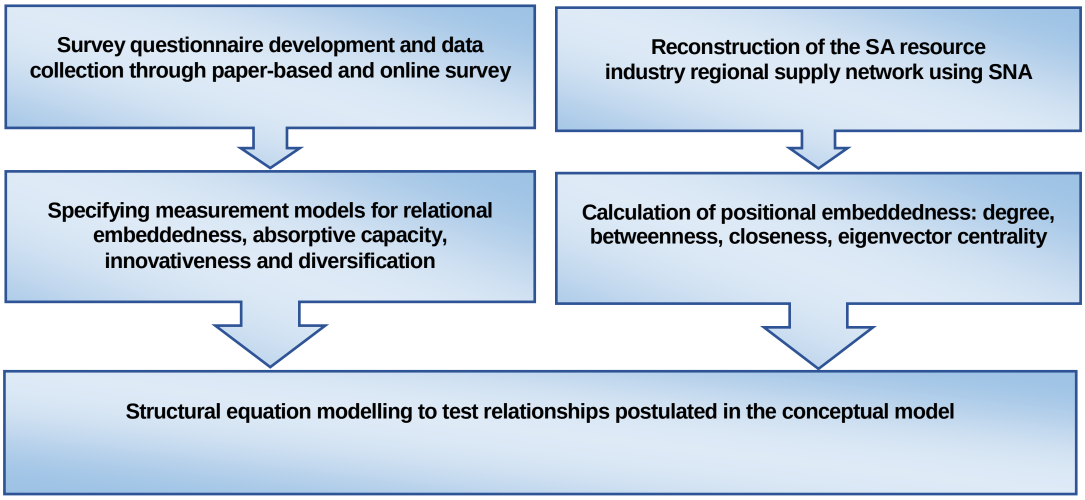

Figure 5.3 Procedures implemented to measure variables and constructs in the conceptual model

To measure constructs of *relational embeddedness*, *absorptive capacity*, *innovativeness* and *diversification* and collect demographic information about research participants, a questionnaire was developed. The survey instrument was an adaptation of multi-item measurement scales identified in the academic and industry related literature to represent the latent constructs and observed variables included in the conceptual framework. The measurement scales and indicators used in the questionnaire to measure the variables *innovativeness, network centrality variables, absorptive capacity, trust, information exchange, joint problem solving* were developed with reference to previous research. Two measures of METS firm *diversification* – *capability diversification* and *sectoral diversification* – were calculated as the number of services provided by a METS firm and the number of industry sectors in which the firm operated.

To measure the *positional embeddedness* of a METS firm in the regional resource and energy supply network, a social network analysis of supplier-buyer relationships in South Australia was also conducted, using the dataset obtained from the Industry Capability Network (ICN) database and following procedures described in the previous research (e.g. Borgatti & Li, 2009; Kito et al., 2014).

5.3.1 Operationalisation of the dependent variables

The dependent variables in this research were METS firm diversification and innovativeness. The decisions made to operationalise these variables are described below.

METS firm capability and sectoral diversification. The literature on firm diversification offers methods for evaluating how successful a firm is in extending product or service lines and entering new sectors and markets. However, most sources consider corporate diversification, while fewer works can be found related to small firm diversification.

Over decades, scholars have developed and refined measures of *corporate diversification* (Jacquemin & Berry, 1979). Gort (1962) introduced the ratio of the firm's sales in the firm's primary industry to the firm's total sales as one measure of corporate diversification. Another measure is *Herfindahl's index of industrial concentration*, which is calculated as the sum of the squared shares of each product's contribution to the firm's total output. The *inverted Herfindahl index* was employed in several empirical studies to estimate the effect of diversification in knowledge intensive industries. However, scholars argue that there is no general model to assess small firm diversification, and therefore, it is appropriate to choose a particular index that performs best empirically (Jacquemin & Berry, 1979).

From the literature on small firm diversification, scholars acknowledge that a practical way would be to measure SME diversification through the number of activities the firm undertakes in different sectors (Santarelli & Tran, 2013). Some scholars (e.g.Maurizio, John, & Carlo, 2015) evaluate small firm diversification as the number of services provided by a SME to its clients. Geographic diversification is often measured by the number of export markets (Cieślik, Kaciak, & Welsh, 2012; Wheeler, Ibeh, & Dimitratos, 2008). Based on these statements, supplier the diversification was operationalised with two dimensions: *capability diversification* and *sectoral diversification*.

Capability diversification was measured by calculating the number of capabilities a firm could offer to its clients and *sectoral diversification* as the number of industry sectors to which the firm supplied its services. To operationalise *capability diversification*, the small firm diversification literature was examined initially. The Standard Industrial Classification (SIC) or North American Industry Classification System (NAICS) are commonly used by frameworks to classify firm core capabilities (e.g.Hitt, Hoskisson, & Ireland, 1994; Montgomery, 1982; Qian, 2002). Since these frameworks are not in use in Australia, an attempt to use the Australia and New Zealand Industry Code (ANZSIC) classification was made (Trewin, 2006). However, upon examining the ANZSIC framework and having consulted with industry and government experts, ANZSIC codes were found to be of limited use in representing SA METS firms' capabilities. Given the fact that there was no SIC code classification available to assign to METS services, in this study calculation of inverted the Herfindahl index was not possible. Other ways of calculating the breadth of services using the Herfindahl index were developed by scholars (e.g. Garcia-Vega, 2006; Han, Kuruzovich, & Ravichandran, 2013), but calculating these required data on firms sales, which was not possible to collect in the current research.

Thus, to analyse the breadth of capability diversification of METS firms, the methodological approach to match and compare information acquired from industry-specific reports and expert interviews with previous studies of METS firms' capabilities, was adopted. National and state resource industry associations have developed their own classification frameworks to assess the capabilities of their members. These classifications naturally overlap, but the most comprehensive ones were those developed by ICN and the Austmine associations at the national level and they were used in this study. The researcher developed a list of the most common capabilities for South Australian firms supplying to the resource sector based on SACOME and GMUSG member's capabilities classifications. This decision was made because the population of firms surveyed was drawn, namely from the members of these associations.

The list of capabilities was compared with ICN and Austmine capability classifications and compared with the previous industry studies (Ritter, 2004; Scott-kemmis, 2013). Furthermore, the capability list was validated by a group of three industry experts, including association leaders and a mining company procurement manager to agree on the number of available options. As a result, 18 services were identified to be the most relevant for the population on METS firms in the current research (see Table 5.2). Furthermore, the option 'other' was included in the questionnaire. In response to a multiple-choice question, the respondents had to indicate, whether a particular service was provided by the firm.

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Table 5.2 Measurement model of *dependent* variables

Variable name	Description	Source	Questionnaire items		Scale	Indicators
DEPENDENT VARIABLES						
Capability diversification	The number of services (capabilities) METS firm supplying	Maurizio, John, & Carlo, 2015, Scott-Kemmiss, 2012	What are your company's capabilities? Please select all that apply. • Manufacturing • Engineering • Construction • Transport, & logistics • Equipment/Product Supply, & Hire • Electrical • Business, Legal and Finance • Education, & Skills • Environmental Services • Exploration Services	• Accommodation • Mining Services • Technical and Consulting Services • Research and Technology Development • Recruitment, & Labour Hire • Civil Construction • Industrial Services • Other	Continuous Sum of selected choices 1.18	CAP_DIV
Sectoral diversification	The number of industries the METS company operates	Chapman, 2004, Santarelli, & Tran 2013	Please identify the industry sectors the company operates in. Select all that apply: • Mining, & Resource • Defence, & Security • Oil, & Gas • Construction • Manufacturing	• Energy • Automotive • Education, & Training • Water • Transport • Food, & beverage • Other	Continuous Sum of selected choices 1.12	SECT_DIV
Innovativeness	The number of new products and services METS firm introduces over the last 3 years	OECD (2005), (Katila & Ahuja, 2002), Belso-Martinez, & Molina-Morales, 2013; Dougherty, & Dunne, 2011	Please identify the number of the new to firm products and services the company introduced during the last 3 years?		Continuous	INN

The *sectoral diversification* was operationalised through the number of sectors the firm identified that it supplies products/services to. The list consisting of 12 sectors that represent common markets for SA METS was compiled from the industry associations' reports and validated through the interviews with the industry experts (see Table 5.2). The variables, *capability diversification* and *sectoral diversification*, were calculated by summing up the number of capabilities and sectors identified by the responding companies.

METS firm innovativeness. METS innovativeness was measured by the number of *new products/services introduction* adopted (Belso-Martinez, & Molina-Morales, 2013; Dougherty, & Dunne, 2011; Katila, & Ahuja, 2002). The number of products/markets developed during a certain period is a common non-financial performance measure (Warren, 2008, p. 1115). A *new product/service introduction* was defined as any change in a product's design.

Given that the limited R&D activities conducted by the lower tier suppliers in the SA resource sector result in low innovation rates amongst resource sector suppliers, the 'new-to-firm' rather than the 'new-to-market' product or service was considered as innovative. METS companies, whose core capabilities are dealer and distributor activities, could have identified the number of new products they bought from OEMs to be re-sold as 'new-to-firm'. These types of responses were double-checked with the companies and amended accordingly to obtain the actual measure.

5.3.2 Operationalisation of independent variables

The indicators commonly used in previous research to represent regional supply network connectedness are *degree centrality*, *betweenness centrality*, *closeness centrality* and *eigenvector centrality*. Some scholars have combined networks metrics to obtain a more multifaceted representation of centrality. For example, Lechner and Leyronas (2012) used a two-item measure composed from eigenvector centrality and two-step reachability to examine firm connectedness within a regional network.

Positional embeddedness. In this study, four common network measures were adopted to evaluate the supplier position in a regional supply network: *degree centrality*, *betweenness centrality*, *closeness centrality* and *eigenvector centrality*. The *degree centrality* captures the number of the direct connections a firm has in the supply network; *betweenness centrality* measures the extent to which the firm is located in the shortest path between pairs of other firms in the network; *closeness centrality* identifies how close the node is to all other actors in the network; and *the eigenvector centrality* reflects the importance of the firm tiers in the regional supply network, in terms of proximity to the key players in the network.

The procedure of calculation of these metrics is outlined in Table 5.3. To reconstruct the network of supply relationships within the resource sector in South Australia, the Industry Capability Network (ICN) database was consulted. The data collection and analysis took place from January to July 2015. The dataset was employed to identify METS firms and their supply links with other companies operating in the mining sector within the SA region.

Table 5.3 Network attributes and procedures to calculate

Measure	Definition in strategic management literature
Degree centrality	The number of direct ties an actor has. 'Nodes with more ties will have more information and, to the extent that information has an impact on things like performance, better performance…' (Borgatti & Li, 2009)
Betweenness centrality	'…Betweenness centrality measures the centrality of a focal firm in a network, and is calculated as the fraction of shortest paths between other companies that pass through the focal firm. Betweenness measures influence a focal firm has over the information through the network…' (Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van den Oord, 2008) '…nodes that lie along many short paths between others (a property known as betweenness centrality) are structurally important nodes that are well positioned to (a) control and possibly filter or color information flows, and (b) become over-burdened bottlenecks that slow the network down…'(Borgatti & Li, 2009)
Closeness centrality	The sum of graph-theoretic distances from all other nodes, where the distance from a node to another is defined as the length (in links) of the shortest path from one to the other (Borgatti, 2005). In other words, it measures how close a node is to all the other actors in the network. (Borgatti, 1995). Taking perspective of information flows, circulating in the network, the nodes with low closeness scores are seen to be well-positioned to get access to novel information as well as spread information quicker than others (Marsden, 2002).
Eigenvector centrality or Bonacich power centrality	'…A node that is connected to nodes that are themselves well connected should be considered more central than a node that is connected to an equal number of less connected nodes… Suppose firm A's customers have many customers of their own, and those customers have many customers and so on. Firm A's actions potentially affect a great number of other firms downstream. In contrast, if firm B's ten customers do not have many customers of their own, B's actions could have much less effect on the system as a whole…' (Borgatti & Li, 2009, p. 10)

Records of 503 companies operating in South Australia during the period 2010 to 2016 were extracted from the dataset, and the information then categorised according to the following criteria:

- companies identified as suppliers to ‘mining’ and ‘oil, & gas’ industries
- companies operating in South Australia (regardless of ownership)
- four key attributes:
  - the company name
  - the industry sectors to which the company supplies services or products
  - geographical location of operations
  - a list of client firms to which the company supplies products or services.

The resulting dataset contained 2,455 firms with a total of 6,683 supply chain connections. The firms included Tier 1 suppliers (those who supply directly to mining companies, including EPC/EPCM providers), Tier 2 suppliers (those that do not directly supply to mining companies but do supply any of the Tier 1 suppliers) and Tier 3 suppliers (those that supply any of the Tier 2 suppliers, but neither the mining companies nor the Tier 1 suppliers). See Appendix B Figure 1 for a full network visualisation and Appendix Table 1 for network statistics.

To check the accuracy of the existing information in the dataset, the names of METS company clients in the database and in the survey answers were thoroughly compared for each company that participated in the survey (N=156). Only minor inconsistencies were found. The interview data confirmed the long-term nature of buyer-supplier relationships in the region, which proved the relative stability of the regional supply networks structure. The database was also checked for inconsistencies, duplicates and spelling errors in company names.

Social network analysis (SNA). SNA was used to reconstruct the structure of the regional supply network in South Australia. Whole network studies, which are difficult in the supply chain field (Borgatti & Li, 2009), are nevertheless considered effective. In his research, a procedure similar to that described in (Bellamy et al., 2014; Kito et al., 2014) was applied. The *whole network approach* allows for calculating a METS firm’s *positional embeddedness* in the regional supply network, including metrics such as *degree*, *betweenness*, *closeness* and *eigenvector* centrality.

Information about the companies and their clients served as the basis for the creation of a simple undirected binary *adjacency matrix* to reconstruct the resource supply network of the South Australian resource extractive industry. An undirected matrix reflects the existence of inter-organisational relationships and, hence, information and knowledge flows, while a directed graph would have reflected the flow of goods and power (Kim et al., 2011).

The adjacency matrix was a simple square matrix with as many rows and columns as there were ‘network actors’ in the dataset. The scores in the cells of the matrix indicate whether the tie between each pair of companies is present or absent. The cell contains a ‘1’ if the supply chain connection between two companies is present and ‘0’ otherwise (Borgatti et al., 2013). The matrix was non-directed, since the supply network was regarded as a conduit of information and knowledge exchange, which is bidirectional as opposed to materials and finance flow. Only the presence or absence of the supply chain connection between two companies mattered (see Table 5.4).

Table 5.4 An example of adjacency matrix used to reconstruct the regional supply network in the South Australian resource extractive sector

Suppliers/Clients	Client 1	Client 2	Client 3	…	Client N
METS 1	1	0	0		0
METS 2	1	0	1		0
METS 3	0	0	0		1
…					
METS M	0	1	1		0

The network attributes for each node were calculated by using *UCINET* 6.365 software (Borgatti, Everett, and Freeman, 2002). The *degree, betweenness, closeness* and *eigenvector centrality* were calculated and extracted for the companies that responded to the survey (N=156).

Relational embeddedness. The embeddedness construct and its effects on a firm’s performance was identified in an ethnographic study performed by Brian Uzzi drawing on the example of US apparel firms (Uzzi, 1996). The key features of ‘embedded ties’ as opposed to ‘arms-length ties’ that allowed for creating network effects in the apparel industry economy were trust, fine-grained information exchange and joint-problem solving (Uzzi, 1996). In this research, scales to measure *trust*, *joint problem solving* and *information exchange* constructs were adopted from Gulati and Sytch (2007), who studied the effects of joint-dependence between suppliers and manufacturers in the US manufacturing industry. The authors proved the mediating effect of joint problem-solving and quality and scope of information exchange on manufacturing performance.

The embeddedness construct incorporates three sub-constructs – *joint problem solving*, *fine-grained information exchange* and *trust*. To operationalise relational embeddedness, the constructs *joint problem solving, information exchange, trust,* and the measurement scale proposed by Gulati and Sytch (2007) were adopted. The scale was originally developed to explore joint dependence in supplier-buyer relationships in the US manufacturing sector. The scale adopted from Gulati and Sytch (2007) was discussed with the industry experts at the face-validity phase and was found to adequately reflect the issues in supplier-buyer relationships in the context of South Australian resource related industries.

The *joint problem-solving* construct was represented by ten survey items that reflect the degree of the supplier's involvement in various operational aspects of product development and service improvement, as well as the degree of joint problem solving and the adaptability of partners in the relationship (see Table 5.5).

The *information exchange* construct reflects the scope and quality of information circulated between a supplier and their customer in the course of relationships. Ten items were measured using a 7 point Likert scale (anchored at each end by 1 – not at all exchanged …7 – exchanged very frequently): the scope of information exchanged, including quality, inventory, schedule and delivery, detailed cost, marketing, long-term volume projections, manufacturing process, proprietary technical, design, and production capacity information; and three items were measured using a 7 point Likert scale (anchored at each end by 1 – very poor … 7 – excellent): quality of information exchange, including accuracy, detail and timeliness (see Table 5.5).

The *trust* construct was operationalised through six items measured using a 7 point Likert scale (anchored by 1 – strongly disagree… 7 – strongly agree), including features such as the equal position of a supplier in negotiations, the presence of opportunistic behaviour in exchange relationships and reliance on partners while sharing confidential information (Table 5.5).

Absorptive capacity. Based on previous research (e.g., Balland, Belso-Martínez, & Morrison, 2014; Broekel, & Boschma, 2012; Molina-Morales, & Expósito-Langa, 2012) and interviews with industry experts, six questions were developed from the literature to measure firm absorptive capacity. These included:

- the percentage of turnover of a firm attributed to new, dramatically improved products/services introduced in the last three years
- the percentage of spending on research and development (R&D)
- the percentage of R&D employees
- the percentage of employees with a university degree
- the percentage of qualified technicians.

Each item was measured on an 11-point scale ranging from 0 to 100.

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Table 5.5 Independent variables

Variable name	Description	Source	Questionnaire items	Scale	Indicators
INDEPENDENT VARIABLES					
Positional embeddedness					
Degree centrality	Number of direct connections in the regional supply network.	(Borgatti & Li, 2009)	----	Continuous	PE_DEGREE
Betweenness centrality	Closeness centrality in the regional supply network			Continuous	PE_CLOSENESS
Closeness centrality	Betweenness centrality in the regional supply network			Continuous	PE_BETWEENNES S
Eigenvector cent	Eigenvector centrality in the regional supply network			Continuous	PE_EIGENVECTOR
Relational embeddedness					
Joint problem-solving	Level of joint problem-solving in buyer-supplier relationships	(Gulati & Sytch, 2007; McEvily & Marcus, 2005; Uzzi, 1996)	I. Please identify to what extent your company is usually involved in the customers decision-making process regarding the following issues (if relevant)? 1 Initial design of the product/service 2 Cost control 3 Product/service modification 4 Production process 5 Subcontracting 6 Forecasting commodity requirements 7 Quality improvement	Likert scale: 1 not at all involved 2 very little 3 a little 4 a moderate amount 5 a lot 6 quite a lot 7 involved to a great extent	RE_JPS_1 RE_JPS_2 RE_JPS_3 RE_JPS_4 RE_JPS_5 RE_JPS_6 RE_JPS_7

Variable name	Description	Source	Questionnaire items	Scale	Indicators
INDEPENDENT VARIABLES					
			II. Do you agree with the following statements? 1 Company is engaged in ongoing discussion with the clients to jointly improve both their operations and ours 2 Both parties, supplier and customer, can make adjustments in the relationships to deal with changing circumstances 3 Problems that arise in the course of relationships are treated by parties as joint rather than individual responsibilities	N/A 1 strongly disagree 2 disagree 3 slightly disagree 4 neither agree nor disagree 5 slightly agree 6 agree 7 strongly agree	RE_JPS_8 RE_JPS_9 RE_JPS_10
Information exchange	Scope and quality of information exchange in buyer-supplier relationships	(Gulati & Sytch, 2007; McEvily & Marcus, 2005; Uzzi, 1996)	I. Please identify the kinds and frequency of information that your company exchanges with the clients 1 Quality information 2 Inventory information 3 Schedule and delivery information	Likert scale: 1 not at all exchanged 7 exchanged very frequently	RE_IE_1 RE_IE_2 RE_IE_3 RE_IE_4 RE_IE_5 RE_IE_6

Variable name	Description	Source	Questionnaire items	Scale	Indicators
INDEPENDENT VARIABLES					
			4 Detailed cost information 5 Marketing information 6 Long-term volume projections 7 Manufacturing process information 8 Proprietary technical information 9 Design information 10 Production capacity		RE_IE_7 RE_IE_8 RE_IE_9 RE_IE_10
			II. Please characterise the information exchange between your company and your clients 1 Accuracy of information received 2 Detail of information received 3 Timeliness of information received	N/A Likert scale: 1 very poor … 7 excellent	RE_IE_11 RE_IE_12 RE_IE_13
Trust	Level of trust in buyer-supplier relationships	(Gulati & Sytch, 2007; McEvily & Marcus, 2005; Uzzi, 1996)	Please identify to what extent you agree with the following statements in regard to relationships with your clients/suppliers: 1 Company is even handed in negotiations 2 Company customers/suppliers may use opportunities that arise to profit at its	Likert scale: 1 strongly disagree 2 disagree 3 slightly disagree 4 neither agree nor disagree 5 slightly agree 6 agree 7 strongly agree	RE_T_1 RE_T_2 RE_T_3 RE_T_4 RE_T_5 RE_T_6

Variable name	Description	Source	Questionnaire items	Scale	Indicators
INDEPENDENT VARIABLES					
			expense (inverted) 3 You cannot rely on customers/suppliers to keep promises made to you (inverted) 4 You hesitant to transact with customers suppliers when specifications are vague (inverted) 5 You trust your customers/ suppliers to treat you fairly 6 You trust that proprietary information is kept confidential		
Absorptive capacity	Firm's ability to recognise, assimilate, leverage, and deploy the available external knowledge	(P. P.-a. Balland, Belso-Martínez, & Morrison, 2014; Broekel & Boschma, 2012; E Giuliani, 2013; Molina-Morales & Expósito-Langa, 2012)	1 The percentage of turnover of a firm attributed to new, dramatically improved products/services introduced in the last 3 years 2 The percentage of spending on research and development (R&D) 3 The percentage of R&D employees 4 The percentage of employees with a university degree 5 The percentage of qualified technicians	Continuous 0-100%	PER_TO_NEWPR AC_RDSPEND AC_RDEMP AC_UNIGRAD AC_QUALTECH

5.3.3 Operationalisation of the moderator variables

Company size. To test the moderating role of company size on METS firm innovativeness and diversification, two groups were identified: Group 1 – small businesses with full time employees (FTE) less than 20 and Group 2 – medium and large enterprises with more than 20 employees.

Tier position in the resource supply chain. To evaluate the effect of proximity to major clients in the resource supply chain, the binary moderator variable TIER was introduced. The questionnaire asked the METS firm to indicate its position in the resource supply chain (see Table 5.6). The firms were segregated into two groups. Group 1 consisted of companies that worked directly with the resource companies or EPCM providers (Tier 1 suppliers in the resource supply chain). Group 2 consisted of companies that sub-contracted to Tier 1 or lower in the supply chain.

Association membership. To create a moderating variable measuring membership in industry associations, the respondents were asked to identify the industry specific bodies of which they are members. The number of industry associations of which the company was a member was then calculated and the mean identified to split the sample into two groups.

Table 5.6 Operationalising the moderator variables

Variable name	Description	Source	Questionnaire items	Scale Indicators	
MODERATOR VARIABLES					
Company size	The number of FTE employees		How many „full time equivalent' (FTE) employees did your company have in Australia on 1 July 2015?	Categorical: 1 less than 20 FTE (small) 2 more than 20 FTE (medium and large)	COMP_ SIZE
Tier	Position in resource sector supply network: does supply directly to resource company or through contractors	(Atienza et al., 2016; Inemek & Matthyssens, 2013)	Where does your company operate in the resource supply chain? • Contract mining • Tier 1 contractor to mining projects • Subcontractor to Tier 1(s) • Subcontractor to a subcontractor(s) • Original equipment manufacturer (OEM) • Subcontractor to an OEM(s) • Subcontractor to an OEM subcontractor(s) • Equipment, technology or services provider working directly with a mining company • Precommercial R&D provider • Other	Categorical: 1 TIER 1 2 OTHER TIERS	TIER
Associations	Membership in industry associations	(Atienza et al., 2016; Boehe, 2013)	Please identify industry associations/related organisations that you are member of and evaluate them according to their relative value to your company (acquiring new clients, finding opportunities for collaboration, getting valuable information)?	Categorical: 1 non-member 2 member	AS_ MEMB

5.4 Data collection and examination

Before launching the pilot study, the survey questionnaire was reviewed by three resource industry experts with the aim of assessing its readability and clarity (see Appendix C1). Furthermore, two academic experts have reviewed the survey for representativeness, content validity, and face validity. Based on the feedback from both practitioners and academics, 6 questions were deleted from the survey, and 15 rephrased. In addition, the industry experts helped to generate fixed-choice answers for several questions and made suggestions on measurement scales to tailor them to the context of the South Australian resource sector.

5.4.1 Data collection: Survey – a pilot study

The pilot study was conducted at the 12th Annual Resource Conference in Port Augusta, South Australia in August 2015. This conference was chosen as it was one of the most popular local conferences with high participation rates of companies operating in the South Australian resource sector. For the pilot study, the questionnaire was distributed among 110 conference participants with 32 responses obtained, producing a response rate of 16%. The data collected were analysed to improve the content and appearance of the survey instrument for the main study.

The descriptive analysis of the data obtained from the pilot study revealed the need for the elimination of 5 redundant questions and questions with responses with low variability. For example, most of the METS companies reported zero patents (trademarks) introduced over the last three years. This was not surprising given the information obtained from the preliminary interviews. Such homogenous responses did not allow for the forming of a variable and were eliminated from analysis. Some question scales were re-considered based on participant feedback. Questions that appeared to be not fully understood by participants and had low response rates were eliminated from the questionnaire.

The exploratory factor analysis undertaken for the constructs *trust*, *information exchange*, *joint problem-solving* and *absorptive capacity*, showed adequate reliability of the measurement instrument, and it was retained for the main study with no changes, particularly, given the small size of the pilot study sample.

5.4.2 Data collection: Survey – the main study

The survey questionnaire contained five sections (Appendix C2):

Section A	Supply chain structure includes questions regarding the position of the supplier in the resource supply chain and its direct partners,
Section B	Innovations includes questions about new product development and firm absorptive capacity,
Section C	Supplier-buyer relationships contains questions about trust, information exchange and joint problem-solving among supply chain participants,
Section D	Supply chain collaboration includes questions about supplier collaboration and,
Section E	Institutions for collaboration - industry associations
Section F	General information include questions about the demographic profile of the company and respondent.

The use of a self-completion online questionnaire was dictated by time and cost, given the amount of information needed over a short period of time (Newby et al., 2003). An online survey is very easy to manage, since it could be sent out to many participants and they can take the survey when they have time. To administer the online survey, the invitation to participate was sent by email, with a direct link to the survey. The *Qualtrics* survey platform was used to collect responses on-line.

The mailing list was compiled from the industry associations' databases (ICN, SACOME, and GMUSG) and lists of mining related conferences and industry events. Several measures were taken to maximise the response rate for the survey (Fowler, 1993) by having the government of South Australia endorse and fund the project with the support of four resource industry associations, as well as adopting standard good practice.

- Industry Capability Network (ICN)
- Global Maintenance Upper Spencer Gulf Resource Industry Cluster (GMUSG)
- South Australian Chamber of Mines and Energy (SACOME)
- Austmine
- Resource and Engineering Skills Alliance (RESA)
- most socially active mining companies operating in the region, including BHP Billiton and OZ Minerals

- advertising the project through industry events and conferences (SACOME industry briefings, GMUSG Conferences 2015, 2016)
- conducting multiple follow-ups with non-respondents.

368 METS firms were invited to participate in the survey. 172 companies agreed to participate and 156 fully completed the questionnaire, resulting in a response rate of 42%.

Sample representativeness check and non-response bias. Due to small sample size, the Kolmogorov-Smirnov test was applied to assess sample representativeness. To assure that the respondents were representative of the population of suppliers to the resource and energy sector in South Australia, the *mean firm size* and the *mean firm sales* of the respondents were compared with the population (e.g.Caceres, Guzman, & Rekowski, 2011). The difference was not significant. The South Australian Chamber of Mines and Energy (SACOME) reports were used to confirm that the respondent firms were representative of the resource sector service providers regarding data on total revenues and number of employees.

The non-response bias was examined by comparing the characteristics of the companies from which responses had been received against those from which no response were received for the same two characteristics – *firm size* (number of full-time employees in 2015) and *firm turnover* (turnover in 2015). No significant differences were identified between the categories of respondents and non-respondents on either *firm sales* or *firm size*. Thus, it was concluded that the sample was representative of the firms supplying to the resource sector of South Australia between November 2015 and January 2016.

PLS-SEM requirements of sample size. The obtained sample size was checked against the minimum requirements of partial least square structural equation modelling (Joseph F. Hair et al., 2014). Barclay, Higgins, and Thompson (1995) proposed a rule of thumb for the rough estimation of the minimum sample size, which takes into consideration model complexity. It postulates that the minimum sample size should be ten times the number of path relationships directed at a particular construct or the number of formative indicators per construct. Since the current model does not contain formative constructs, the largest number of paths directed to an endogenous construct in the saturated model was six. Thus, the minimum sample size should not be less than 60. However, this rule of thumb does not take into account effect size, reliability, the number of indicators, and other factors that affect statistical power (Joe F. Hair et al., 2012).

Another estimation, proposed in (Joseph F. Hair et al., 2014, p. 21), takes into consideration the model complexity and sample size assuming the commonly used statistical power of 80% to identify the minimum R^2 values of 0.1, 0.25, 0.50 and 0.75 in the endogenous constructs in the structural model for significance levels of 1%, 5% and 10%. According to this estimation, for a model with the maximum six arrows pointing to the construct to detect R^2 as small as 0.1, a commonly used 5% significance level, a minimum of 157 (R^2=0.1) cases in the sample is required. Thus, the sample size of 156 marginally meets the minimum requirements for the data analysis.

5.4.3 Data treatment

The data analysis involved examination of the sample characteristics. Preliminary analysis included data screening, handling missing values and checking whether data met normality assumptions followed by descriptive and inferential statistical analysis to test research hypotheses.

The first step of data screening was a search for abnormalities and unusual data cases. These included *suspicious response patterns*, such as 'straight lining' in Likert scale type questions, when the respondent keeps selecting the same option (Joseph F. Hair et al., 2014). The *inconsistencies in answers to inverted questions* as well as *indirectly related questions* were also reviewed. Consistency of answers was further checked by comparing the answers to indirectly related questions.

The *trust* construct was the only one in the conceptual model that involved three inverted questions. The responses to the negatively worded items of the *trust* construct were measured using a 7 point Likert scale: *Company customers may use opportunities that arise to profit at its expense; You cannot rely on customers to keep promises made to you; You are hesitant to transact with customers when specifications are vague* were inversely recoded.

Missing data. To handle missing data, the following approaches proposed in the literature were adopted:

- casewise deletion for cases with the amount of missing data exceeding 15% (Joseph F. Hair et al., 2014)

- Little's missing completely at random (MCAR) test to find patterns of missing data (Ho, 2008)
- mean value replacement for the indicators with the less than 5% of missing data (Joseph F. Hair et al., 2014).

During data screening, the rule of thumb was that if the amount of missing data exceeded 15%, the observation was removed from the file (Joseph F. Hair et al., 2014).

Out of 172 cases obtained from the online survey, only 156 valid cases were retained. Furthermore, the remaining cases were screened to identify whether the percentage of missing values per indicator exceeded the 5% level. In the case where there was less than 5% of missing values per indicator, mean replacement was considered to be an appropriate technique (Joseph F. Hair et al., 2014; Ho, 2008).

The highest level of missing values per indicator was 3%, so the expectation-maximisation algorithm (EMA) was applied to treat the missing values. Then, Little's missing completely at random (MCAR) test was undertaken to test the null hypothesis, where missing values in the dataset were missing completely at random. The results were not statistically significant (Chi-square = 1458.147, sig. = .124), so the null hypothesis that values were missing completely at random was not rejected.

Testing for outliers and normality. PLS-SEM modelling applied in this study was referred to as a 'soft modeling' approach as opposed to a 'hard modeling' CB-SEM technique. PLS-SEM modelling applies mild statistical assumptions to variable properties and does not impose any requirements on the distribution or measurement scale of indicators. Univariate normality is not needed for least squares estimates of regression parameters to be meaningful. The only requirement is that the systematic portion of all linear OLS regressions must be equal to the conditional expectation of the dependent variables (Wold, 1975a). However, it is still recommended that researchers should examine PLS-SEM results carefully when distributions deviate substantially from normal (Joseph F. Hair et al., 2014).

To test whether the empirical data fits a normal distribution, such techniques as Kolmogorov-Smirnov and Shapiro-Wilks tests for normality, examination of trimmed mean, skewedness and kurtosis values, are applied (Tabachnick & Fidell, 2007). Skewedness relates to the symmetry of distribution and kurtosis to the distribution 'peakiness'. According to Morgan and Griego (1998), if values of skewedness and kurtosis do not exceed 5.5, then the distribution is not significantly different from normal. Curran, West, and Finch (1996) recommend that the values of skewedness should not exceed 2, and for kurtosis should not exceed 7. Furthermore, Lomax and Schumacker (2012) proposed a rule of thumb that both skewedness and kurtosis should not exceed +/-1.

The descriptive statistics of all variables (i.e., mean, standard deviation, skewness, and kurtosis) were assessed (Appendix D Table 1). The distribution of most variables was significantly positively skewed, with the Kolmogorov-Smirnov statistic yielding $p<0.00$, indicating a non-normal distribution across variables (see Appendix D Table 2).

Variables company size, the number of new products/services introduced, closeness and betweenness centrality were positively skewed. In regard to the company size and the number of new products/services introduced, due to the nature of the research question and small population of firms under investigation, listwise deletion was considered undesirable. Companies of a certain size and those producing a number of new products and services beyond two standard deviations were retained.

According to Graybill (1976, p. 213), in situations where normality assumptions are seriously violated, several options could be applied.

- Violation of the assumptions could be ignored.
- A valid procedure that considers the new assumption could be applied.
- A new model that reflects all important aspects of the original model and satisfies all the assumptions could be designed (this includes data transformation and filtering).
- A distribution-free procedure that is insensitive to normality assumptions violations could be applied.

Scholars argue that most researchers opt for the third option (e.g., Sakia, 1992). Among the most popular transformations applied to non-normally distributed data is the Box-Cox transformation below (Box & Cox, 1964).

$$y_i^{(\lambda)} = \begin{cases} y_i^{\lambda};\ \lambda \neq 0 \\ \log y_i\ ;\ \lambda = 0 \end{cases} \tag{1}$$

This family incorporates traditional transformations including log-transformation when λ =0. Despite the fact that the transformation rarely simultaneously fulfills the basic assumptions of linearity, normality and homoscedasticity as originally suggested by Box and Cox (1964), it has been widely used in the empirical testing of functional relationships in various disciplines, especially in econometrics (Sakia, 1992). However, it has also been noted that log-transformed data causes difficulty in interpreting model estimates and does not facilitate inferences concerning the original data (Feng, Wang, Lu, Chen, & He, 2014).

Log-transformation (λ =0) was applied to two variables: *new product/service* and *company size,* since all these variables are natural numbers. Given that the *new products/services* variable contains zeros and the logarithm of 0 is undefined, the distribution was anchored at 1.00 (Osborne, 2010) by adding a const=1 to the logarithm argument. Thus, the transformation for the indicator *number of products/services introduced* took the form for non-normally distributed variable with zeros:

$$y_i = \log(y_i + 1) \tag{2}$$

And for *company size* and *company age* (non-normally distributed variables without zero):

$$y_i = \log(y_i) \tag{3}$$

Since almost all variables failed to meet normality conditions, remedial steps were undertaken for further statistical analysis as a part of the PLS-SEM procedure. These steps are based on ordinary least square (OLS) regression estimation and incorporate the Bollen-Stain bootstrapping technique as a commonly accepted method for analysing non-normally distributed data (Joseph F. Hair et al., 2012). The requirement is that for all variables the skewedness and kurtosis should be lower than 2 and 7 respectively (Curran et al., 1996), which was met by the dataset.

In regard to *closeness* and *betweenness centrality,* due to severe violation of the normality assumptions, these variables were deleted from the model. Furthermore, EFA revealed high multicollinearity between *betweenness centrality* and *degree centrality*. Thus, only *degree centrality* and *eigenvector centrality* were retained in the model.

5.5 Assessment of the measurement model

Measurement model evaluation involved exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA is mostly used to determine the total number of variables required to measure a construct (Worthington & Whittaker, 2006). EFA was performed to identify whether the measured variables could reflect the latent constructs specified, based on the previous research and empirical findings in the proposed structural model. EFA was conducted using *SPSS*. CFA was undertaken using *SmartPLS* to evaluate the relationships between observed indicators and the underlying latent constructs that the indicators were intended to measure prior to testing the hypothesised relationships. Hierarchical component modelling (HCM) was applied to reduce the number of relationships in the model and the collinearity issues between constructs (Joseph F. Hair et al., 2014).

5.5.1 Exploratory factor analysis

EFA was performed for all latent constructs and measured variables, including *convergent validity*, *discriminant validity* and *internal consistency* of scales.

Factor loadings were examined for each construct to establish *convergent validity*. Regardless of the sample size, loadings greater than 0.5 and averaging out to greater than 0.7 for each factor were considered to be appropriate (Sheridan & Ong, 2011).

Discriminant validity, which reflects the extent to which the factors are distinct from each other, was evaluated by examining whether scale variables were loaded significantly on one factor. For an item that loads on more than one factor, cross-loading should differ by more than 0.2. In addition, correlation between factors should not exceed 0.7, otherwise shared variance could be expected (Sheridan & Ong, 2011).

The *internal consistency* of the scales was evaluated by Cronbach's alpha coefficients, which should be above 0.60 (Pallant, 2007).

A unidimensionality check was performed for each latent factor as is advised when measured variables are connected to a latent variable in a reflective model. A factor is considered unidimensional, if the first eigenvalue of the block is greater than 1 and the second eigenvalue is smaller than 1. A block is also considered as unidimensional when Cronbach's alpha and composite reliability (Dillon – Goldstein's ρ) are larger than 0.7 (Tenenhaus, Vinzi, Chatelin, & Lauro, 2005).

Since the tests of normality identified a significant difference ($p < 0.00$) in the variance of each item in the model from a normal distribution (see Appendix D Table 1), principal axis factoring was utilised for EFA as proposed by Fabrigar, Wegener, MacCallum, and Strahan (1999). Furthermore, following a suggestion of Costello and Osborne (2011), *oblique rotation* (i.e., Promax) was applied to render a more accurate factor solution, assuming inter-correlation between factors.

Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) statistics allowed the evaluation of the factorability of items (Tabachnick, & Fidell, 2007). The former has to be large and significant while the latter must be greater than 0.6. Following Tabachnick and Fidell (2007) recommendation that the minimum loading of an item should be 0.32, the *SPSS* function 'suppress small coefficients' was applied. Item communalities were considered high if all were 0.8 or greater, but more common magnitudes in the social sciences are low to moderate communalities of 0.40 to 0.70 (Costello, & Osborne, 2011).

The following criteria were applied to interpret the results of the EFA:

- a Kaiser-Meyer-Olkin (KMO) of 0.6 or above (Tabachnick, & Fidell, 2007)
- a Bartlett's test of sphericity with $p<0.05$ (Tabachnick, & Fidell, 2007)
- eigenvalues above 1.00 (Pallant, 2007)
- communalities 0.30 or above (Pallant, 2007)
- item loadings from 0.33 to 0.70 or higher (Costello, & Osborne, 2011; Tabachnick, & Fidell, 2007).

The correlation table of all the indicators and variables is provided in the Appendix E Table 1.

The pattern matrix (see Appendix F Table 1), as a result of EFA performed using *SPSS*, was used to inform decisions made about items to be retained or removed from the constructs in the measurement model. Despite some cross-loadings in the pattern matrix, distinct factors were evident.

The EFA yielded 12 factors satisfying Kaiser's criterion. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (0.729), and Bartlett's test of sphericity ($p<0.00$) showed that the majority of items exhibited acceptable factorability (see Appendix F Table 2). However, a number of items did not load uniquely on one factor (e.g., *detailed cost information, joint-problem solving_quality improvement,* *joint-problem solving _production process*). Four items (e.g., *capability diversification, university graduates, information exchange_forecasting commodity requirements, marketing information, centrality_eigenvector*) did not yield loadings beyond 0.32.

The *joint problem-solving* construct measurement model adopted from Gulati and Sytch (2007) was segregated into three factors with two items cross-loading between them. The correlations between three factors (1 and 8, 1 and 11) comprising joint problem-solving constructs were *.370* and *.314* respectively.

All items comprising the *trust* construct loaded uniquely (with 9% of variance explained) on one factor, except the item 'you are hesitant to transact when specifications are vague'. This item loaded on the same factor as the 'long-term volume projections' item from the *information exchange* construct, exhibiting correlation with the factor 5. The first factor explained 17.7% of variance, 8 (3.3%) and 11 (2.8%).

The *information exchange* construct (Gulati & Sytch, 2007) also loaded on three distinct factors (3rd (7.8%) variance explained, 4th (5.5%), 5th (4.9%), except the item 'long-term volume projections', which loaded negatively (-0.345) on a separate factor.

The *positional embeddedness* construct yielded one factor solution represented by *degree* and *betweenness centrality* (6^{th} factor with 4.2% of variance explained). Eigenvector centrality with current EFA settings did not show an acceptable loading.

Company size and *company turnover* loaded on 7th factor with 3.8% of variance explained. These items were logically expected to be highly correlated.

Items reflecting the *absorptive capacity* construct exhibited reasonable convergence by loading jointly on the 9^{th} factor, which explained a further 3.3% of variance. Item 'the number of university graduates' did not load on any factor, while the item 'the number of qualified technicians' loaded separately on 13th factor.

Interestingly, *sector diversification* and *innovativeness* loaded on the 10th factor with 9% of variance explained, possibly due to the high correlation between these two variables. *Capability diversification* did not yield a high enough loading on one of the identifiable factors to be shown in the run of EFA. However, with a different EFA setting, it showed acceptable loading on a separate factor.

5.5.2 Selection of the measurement model types for *absorptive capacity* and *positional embeddedness* constructs

PLS unlike SB-SEM allows for usage of not only *reflective* but also *formative* measurement models for latent constructs. *Reflective measurement models* have a long tradition in social research of being based on classical test theory. PLS assumes that the measures represent the effects of the underlying construct. A set of indicators called ‘scale’ is highly inter-correlated, and individual items comprising a scale are interchangeable.

Conversely, *formative measurement models* assume that the indicators (formative indexes) cause the construct. Each formative index captures a specific aspect of the construct, and hence the breadth of construct domain coverage becomes very important. Models using formative measures are likely to have difficulties in terms of model identification and interpretation (Diamantopoulos & Winklhofer, 2001).

The types of measurement models for latent constructs *absorptive capacity*, *positional embeddedness*, *joint problem-solving*, *trust* and *information exchange* in this study were identified based on theoretical and empirical considerations (Coltmana, Devinneyb, Midgleyc, & Venaikd, 2008; Joseph F. Hair et al., 2014). From a theoretical perspective, the nature of the construct, the direction of causality between the indicators and the latent construct (causal priority), and the characteristics of the indicators used to measure the construct were considered.

Empirically, item intercorrelation, indicator relationships with construct antecedents and consequences should be evaluated.

Based on theoretical considerations, the reflective scales for constructs *joint problem solving*, *trust* and *information exchange* were adopted (Gulati & Sytch, 2007), which had shown high convergence with the previous findings. The *absorptive capacity* and *positional embeddedness* constructs showed a lower level of convergent validity, so two ways were considered to improve it: a formative measurement model with all items, or the deletion of the items with low loadings while retaining the reflective measurement mode. The models were tested with both methods and the second option was selected.

5.5.3 Confirmatory factor analysis

Confirmatory factor analysis (CFA) was performed using *SPSS* and *SmartPLS* to refine the measurement model for the created constructs and validate the constructs borrowed from the literature. Assessment of reflective measurement models in *SmartPLS* involves determining *indicator reliability* (squared standardised outer loadings), *internal consistency reliability* (composite reliability), *convergent validity* (average variance extracted, AVE), and *discriminant validity* (Fornell-Larcker criterion, cross-loadings) (Hair, Ringle, & Sarstedt, 2011; Henseler, Ringle, & Sinkovics, 2009). *Internal consistency reliability* is commonly measured through Cronbach's alpha.

However, Cronbach's alpha implies that all indicators are equally reliable, and efforts to maximise it can seriously compromise reliability (Raykov, 2007). In contrast, *composite reliability* does not maintain this assumption, making it more suitable for PLS-SEM, which prioritises indicators according to their individual reliability. *Convergent validity* is commonly reported as average variance explained (AVE). Discriminant validity is commonly assessed by comparing the constructs' AVE with the inter-construct correlations (Fornell, & Bookstein, 1982; Fornell, & Larcker, 1981). Another approach is assessment of cross-loadings, as a more liberal criterion Hair et al., 2012).

PLS-SEM is sometimes seen as software for exploratory rather than confirmatory factor analysis (Wold, 1975b). The argument is that PLS lacks goodness-of-fit criteria for selecting the optimum confirmatory models. The literature, however, reveals more confirmatory than exploratory uses of PLS modelling (Garson, 2014).

Internal consistency reliability is commonly assessed through estimation of Cronbach's alpha, based on inter-correlations of the observed indicator variables (DeVellis, 2003). Several works find it more desirable to have a 0.70 Cronbach's alpha coefficient. However, 0.60 is also considered acceptable (Pallant, 2007). Recently, however, criticism has been growing of this measure, since it assumes equal outer loadings on the construct. Moreover, Cronbach's alpha is sensitive to the number of items in the scale and generally underestimates internal consistency reliability.

Composite reliability (ρ_c) does not have these limitations. This measure takes into account outer loadings and is calculated as:

$$\rho_c = \frac{\left(\sum_i l_i\right)^2}{\left(\sum_i l_i\right)^2 + \sum_i \mathrm{var}(e_i)}, \tag{4}$$

Composite reliability varies between 0 and 1 and is generally interpreted in the same way as Cronbach's alpha. In exploratory research, composite reliability values from 0.60 to 0.70 are acceptable. However, at more advanced stages, values must be between 0.70 and 0.90 (Hair et al., 2014).

Convergent validity is the extent to which a measure correlates positively with alternative measures of the same construct. This characteristic is also called *indicator reliability*. To establish convergent validity, the outer loadings of the indicators should be considered, as well as the AVE.

High and statistically significant loadings on a construct indicate that the measurement indicators have much in common. However, since even a significant outer loading could still be fairly weak, a common rule of thumb is that the (standardised) outer loadings should be 0.708 or higher (Hair et al., 2014). For instance, Tabachnick and Fidell (2007) recommend 0.32 for minimum loading of an item. Item communalities are considered high if all are 0.8 or greater, but more common magnitudes in the social sciences are low to moderate communalities of 0.40 to 0.70 (Costello, & Osborne, 2011).

Indicator reliability or *communality* is calculated as the square root of a standardised indicator's outer loading and represents how much variation is explained by the construct and describes the variance extracted from the item. The square root of a standardised indicator's outer loading should be greater than 0.5 to establish convergent validity. *The percentage of explained variance* accounted for by each factor was also examined while identifying meaningful factors (Worthington, & Whittaker, 2006). Convergent validity on the construct level is established as the grand mean value of AVE. According to the same logic as applied to the individual indicator construct, AVE should be greater than 0.5.

Discriminant validity is the extent to which a construct is truly distinct from other constructs by empirical standards. Establishing discriminant validity implies that a construct is unique and captures phenomena not represented by other constructs in the model. Two methods can be applied to test discriminant validity.

The first one is the examination of cross-loadings, the second is the Fornell-Lacker criterion. In the case of cross-loadings estimation, indicator loadings on the associated construct should be greater than all of its loadings on other constructs. If a variable loads on multiple factors, then cross-loadings should be different by 0.2 (Sheridan & Ong, 2011). The *Fornell-Lacker criterion* is the more conservative approach to the estimation of discriminant validity. It checks whether the square root of each construct's average variance extracted is greater than its highest correlation with any other construct (Joseph F. Hair et al., 2014). The factor correlation matrix also has to be examined. Correlations between factors should not exceed 0.7, since a correlation greater than 0.7 indicates a majority of shared variance (Sheridan & Ong, 2011).

CFA performed using *SPSS* showed high inter-correlations between items measuring constructs, thus the reflective mode of measurement was retained. The items that showed cross-loadings and unacceptable loadings were deleted from the measurement models.

Joint-problem solving. CFA was performed in the *SPSS* statistical package to evaluate the measurement model for the *joint problem-solving* construct. In line with the findings of Gulati and Sytch (2007), the construct yielded a two component solution as shown in Appendix G Table 1. The decision was made to retain the second factor in the model, as opposed to Gulati and Sytch (2007). Items *sub-contracting* and *forecasting commodity requirements* loaded on a separate factor at the EFA stage (see Appendix G Table 1) and showed low loadings <0.7 at the CFA stage. This was not surprising, since the number of respondents who participated in the structured interview mentioned that these items were irrelevant for their businesses. Thus, these items were removed from the construct.

The measurement model for the *joint problem-solving* construct is presented in the Appendix G Tables 3-6, with a KMO of 0.850 and Bartlett's test of sphericity ($p<0.00$) (Appendix G Table 3), with 66.85% of the variance explained and a scale reliability of Cronbach's alpha of 0.851 (Appendix G Table 6).

The final two factor model was also tested in *SmartPLS* to establish that the model met the evaluation criteria outlined in *6.3.7: indicator reliability*, *internal consistency reliability*, *convergent validity*, and *discriminant validity*. All the parameter values met the requirements, as shown in Table 5.5.

The correlation between factor 1 and factor 2 of the *joint problem-solving* construct measurement model was high and significant 0.445 (see Appendix G Table 5). When CFA factors are highly correlated, higher order factors might be hypothesised. To simplify the structural model assessment, it was logical to create one higher order factor for *joint problem solving*. PLS-SEM offers a method for creating higher order constructs, which require an equal number of indicators in each of the combined factors (Joseph F. Hair et al., 2014). Given that factor 1 was composed of five items and factor 2 of three items, an alternative approach was applied. *Composite scores* were created for each factor to aggregate several indicators. Composite *weighted regression scores* were calculated in *SPSS* for each of the two factors. The results of a composite measurement model testing for the *joint problem-solving* construct in *SmartPLS* are shown in Tables 5.7 and 5.8.

Table 5.7 Summary of the two-factor reflective measurement model evaluation in Smart PLS for *joint problem solving* construct

Latent variable		Indica-tors	Loadings	Indicator reliability	Chronbach's alpha	Composite reliability	AVE	Discriminant validity
Joint problem-solving	Factor 1	JA_1	0.856	0.733	0.868	0.919	0.791	Yes
		JA_2	0.828	0.686				
		JA_3	0.841	0.707				
		JA_4	0.811	0.658				
		JA_7	0.789	0.623				
	Factor 2	JA_8	0.886	0.785	0.877	0.921	0.701	Yes
		JA_9	0.897	0.805				
		JA_10	0.885	0.783				

Table 5.8 Joint problem-solving construct reflective measurement model evaluation in smart PLS

Latent variable	Indica-tors	Loadings	Indicator Reliability	Chronbach's alpha	Composite Reliability	AVE	Discriminant validity
Joint problem-solving	JA_1	0.839	0.704	0.868	0.919	0.783	Yes
	JA_2	0.928	0.861				

Information exchange. Gulati and Sytch (2007) identified two factors comprising construct 'fine-grained information exchange': the *scope of information exchange* and the *quality of information exchange*. However, applied to the current dataset the CFA with the use of principal axis factoring and promax rotation (Kappa 4) for the *information exchange* construct yielded a three-factor solution as shown in Appendix G Table 7. The items with cross-loadings (*detailed cost information*) and low loadings and (*marketing information* and *long-term volume projections*) were deleted from the measurement scale.

As for the *joint problem solving* construct, the majority of the participants in the structured interviews identified low levels of *detailed cost* and *marketing information* exchange with clients, as well as irrelevance of *long term volume projection* and *production capacity information*. As a result, these items bore low loadings and cross-loadings during EFA (see Appendix F Table 1). The final measurement model after deletion of these four items, is shown in Appendix G Table 7-13, with a KMO of 0.710; Bartlett's test of sphericity was ($p<0.00$); and 72.3% of the variance was explained. The reliability of the scale was acceptable (Cronbach's alpha 0.760).

The weighted regression composite scores were created in *SPSS* software package for each of three factors comprising the *information exchange* construct. However, while being tested against the criteria, they failed to meeting reliability and validity checks (see Table 5.9).

Since the three factors representing the *information exchange* construct were formed by an equal number of items, the hierarchical component model (HCM) solution was applied (Joseph F. Hair et al., 2014, p. 230), which involved creating second-order structures in PLS-SEM. The higher order component (HOC) was created from three low-order components (LOCs) represented by factors identified in by the CFA: *scope of information exchange* (IE_SCOPE1, IE_SCOPE2) and *quality of information exchange* (IE_QUAL).

The measurement model with the HOC yielded acceptable validity and reliability parameters as shown in Table 5.10.

Table 5.9 Hierarchical model with composites for fine-grained information exchange construct

Latent variable	Indicators	Loadings	Indicator reliability	Chronbach's alpha	Composite reliability	AVE	Discriminant validity
Fine-grained information exchange	Scope 1	0.581	0.338	0.406	0.418	0.405	Yes
	Scope 2	0.642	0.412				
	Quality	0.775	0.601				

Table 5.10 Reliability and validity checks for HOC Information Exchange

HOC	LOCs	Loadings	Indicator Reliability
Fine-grained information exchange	Scope 1	0.78	0.781
	Scope 2	0.831	0.835
	Quality	0.922	0.922

Trust. The results of the EFA with the use of principal axis factoring and promax rotation (Kappa 4) performed for the *trust* construct are shown in Appendix G Table 14. Items 2 and 4 showed low loadings and were deleted from the model (see Appendix G Table 15). The measurement model with four items yielded a KMO of 0.804; Bartlett's test of sphericity was ($p<0.00$); 74.7% of the total variance was explained. The reliability of the scale was acceptable (Cronbach's alpha = 0.884) as shown in Appendix G Tables 16-17.

The summary of the *trust* construct performed in *SmartPLS*, consisting of four items, is shown in Table 5.11. The composite score was calculated for the *trust* construct in *SPSS*.

Table 5.11 Reflective measurement model for trust

Latent variable	Indicators	Loadings	Indicator reliability	Chronbach's alpha	Composite reliability	AVE	Discriminant validity
Trust	TRUST_1	0.747	0.558	0.89	0.925	0.755	Yes
	TRUST_3	0.934	0.872				
	TRUST_5	0.911	0.830				
	TRUST_6	0.872	0.760				

Absorptive capacity. The descriptive analysis performed after the pilot stage revealed that most of the respondent companies identified less than 10% of university graduates and R&D employees. These findings were in line with those of (Scott-kemmis, 2012; Warrian & Mulhern, 2009), reporting a shortage of highly educated employees in resource and resource related industries. University graduates tend to avoid resource and associated sectors in favour to ‘high-tech’ industries: IT, biotechnology and nanotechnology, for example. Since these indicators did not show enough variability, they were excluded from the measurement model.

As a result, only three indicators were used to perform EFA to measure absorptive capacity of METS firms: *R&D spending*, *percentage attributed to new products* and *percentage of qualified technicians* in the companies. Although the percentage of qualified technicians was much higher among surveyed companies (mean of 45,3%), it had a low loading (see Appendix G Table 18) and was, therefore, deleted from the measurement model.

The EFA yielded a satisfactory Kaiser-Meyer-Olkin measure of sampling adequacy (0.851) and a statistically significant Bartlett’s test of sphericity with $p<0.05$.

As a result *R&D spending* and *percentage of the company income attributed to new products* were used to create a composite score to measure the absorptive capacity of SA METS companies (Appendix G Table 19). Despite the low value of Cronbach’s alpha (0.578), composite reliability and AVE are acceptable (0.815 and 0.69 respectively). The composite *weighted regression score* was created using these two indicators. The reflective measurement model for *absorptive capacity* is shown in Table 5.12.

Table 5.12 Reflective measurement model for Absorptive capacity construct

Latent variable	Indicators	Loadings	Indicator reliability	Chronbach’s alpha	Composite reliability	AVE	Discriminant validity
Absorptive capacity	R&D spending	0.730	0.533	0.578	0.815	0.69	Yes
	Percentage of turnover attributed to new products	0.921	0.848				

Single measure constructs. Although using single measures in PLS-SEM reduces the predictive validity of the model and may increase bias in parameter estimates (overestimation of the measurement model relationships and underestimation of structural model relationships), the use of single-item measures is appropriate to represent observable characteristics (sales, quotas, profit) (Joseph F. Hair et al., 2014).

Single item measures were used to evaluate innovativeness, sectoral diversification and capability diversification, degree and eigenvector centrality.

Overall measurement model assessment. The evaluation of the measurement model for all variables included in the structural model is summarised in the Tables 5.13-5.15. To ensure convergence, the validity indicator loadings and reliabilities, composite reliabilities, and AVE were assessed. The indicator loadings and reliability were satisfactory (above 0.7 and 0.5 respectively).

The factor structure obtained as a result of CFA demonstrated acceptable loadings within factors with few cross-loadings between factors, which generally supported the convergent and discriminant validity of the measurement model. Cronbach's alpha and composite reliability were assessed to ensure construct reliability. As presented in Table 5.15, all values of Cronbach's alpha and composite reliability exceeded the recommended value of 0.7.

Table 5.13 Measurement model evaluation

Latent variable	Indicators	Loa-dings	Indicator reliability	Chronbach's alpha	Composite reliability	AVE	Discriminant validity
Joint problem-solving	JA_1	0.839	0.704	0.868	0.919	0.783	Yes
	JA_2	0.928	0.861				
Fine-grained information exchange (HOC)	Scope1	0.78	0.781	N/A	1	N/A	Yes
	Scope2	0.831	0.835				
	Quality	0.922	0.922				
Fine-grained information exchange Scope 1 (LOC)	Quality information	0.877	0.704	0.922	0.951	0.865	Yes
	Inventory information	0.86	0.674				
	Schedule and delivery information	0.853	0.706				
Fine-grained information exchange Scope 2 (LOC)	Manufacturing process information	0.839	0.769	0.780	0.872	0.695	Yes
	Proprietary technical information	0.821	0.740				
	Design information	0.84	0.728				
Fine-grained information exchange Quality (LOC)	Detail of information received	0.934	0.872	0.831	0.898	0.746	Yes
	Timeliness of information received	0.952	0.906				
	Accuracy of information received	0.904	0.817				
Trust (composite variable)	Four item composite variable	1.00	1.00	1.00	1.00	1.00	Yes
Degree centrality	Single-item variable						
Eigenvector centrality	Single-item variable						
Absorptive capacity	Two item composite variable	1.00	1.00	1.00	1.00	1.00	Yes
Capability diversification	Single-item variable						
Sector diversification	Single-item variable						
Innovativeness	Single-item variable						

Table 5.14 Indicators discriminant validity

	Absorptive capacity	Centrality Degree	Eigen-vector	Joint problem-solving	IE	IE quality	IE scope1	IE scope2	Trust	Innova-tiveness	Capability diversification	Sector diversification
Abs_capacity (composite)	**1**	-0.111	-0.201	0.166	0.072	-0.008	0.014	0.172	-0.056	0.243	-0.008	0.057
Centrality Degree	-0.083	**1**	0.314	-0.181	-0.158	-0.182	-0.1	-0.062	-0.107	0.103	0.272	0.105
Centrality Eigenvector	-0.201	0.309	**1**	-0.127	-0.088	-0.225	0.06	0.015	-0.129	0.075	0.125	0.222
Joint problem-solving 1	0.245	-0.046	-0.075	**0.869**	0.484	0.361	0.338	0.371	0.158	0.191	0.211	0.183
Joint problem-solving 2	0.06	-0.102	-0.145	**0.898**	0.652	0.567	0.457	0.392	0.291	0.033	0.183	0.153
Information Exchange_1	-0.065	-0.132	-0.195	0.479	0.721	**0.936**	0.33	0.27	0.329	-0.064	-0.016	0.004
Information Exchange_2	0.006	-0.166	-0.187	0.472	0.704	**0.953**	0.323	0.214	0.326	-0.042	-0.016	0.01
Information Exchange_3	0.039	-0.174	-0.247	0.533	0.703	**0.902**	0.331	0.215	0.277	0.059	0.027	0.041
Information Exchange_4	-0.028	-0.08	-0.008	0.39	0.66	0.392	**0.838**	0.297	0.026	-0.017	0.195	0.094
Information Exchange_5	0.043	-0.082	0.078	0.33	0.629	0.282	**0.813**	0.371	0.127	0.101	0.102	0.17
Information Exchange_6	0.02	0.044	0.083	0.413	0.629	0.203	**0.85**	0.371	0.028	0.012	0.257	0.168
Information Exchange_7	0.098	-0.119	-0.031	0.399	0.655	0.247	0.406	**0.872**	0.116	0.003	-0.056	0.087
Information Exchange_8	0.188	-0.01	-0.03	0.353	0.593	0.258	0.287	**0.883**	-0.001	0.008	0.055	0.081
Information Exchange_9	0.166	0.102	0.108	0.366	0.571	0.14	0.379	**0.838**	-0.021	0.034	0.166	0.141
Trust	-0.056	-0.137	-0.129	0.259	0.222	0.334	0.072	0.041	**1**	0.062	-0.064	0.087
New products	0.243	0.112	0.075	0.121	0.018	-0.017	0.037	0.017	0.062	**1**	0.128	0.34
Capability diversification	-0.008	0.37	0.125	0.221	0.117	-0.002	0.221	0.058	-0.064	0.128	**1**	0.322
Sector diversification	0.057	0.14	0.222	0.189	0.133	0.019	0.172	0.118	0.087	0.34	0.322	**1**

Notes: 1. Diagonals (in bold) represent square root of AVE while off diagonals represent correlations; N=156
2. Information exchange is a hierarchical construct comprised of three low order constructs – quality of information exchange, Scope1 and Scope 2 of information exchange

Table 5.15 Construct discriminant validity

	Absorp-tive capacity	Capability diversifi cation	Centrality	Eigen-vector	Info exch	IE Quality	IE Scope1	IE Scope2	Joint problem-solving	Innovative ness	Sector diversifi cation	Trust
Absorptive capacity	1											
Capability diversification	-0.008	1										
Centrality	-0.111	0.37	1									
Eigenvector	-0.201	0.125	0.309	1								
Information exchange	0.072	0.117	-0.113	-0.088								
IE Quality	-0.008	-0.002	-0.169	-0.225	0.763	**0.964**						
IE Scope1	0.014	0.221	-0.048	0.06	0.767	0.352	**0.913**					
IE Scope2	0.172	0.058	-0.016	0.015	0.703	0.251	0.414	**0.930**				
Joint problem-solving	0.166	0.221	-0.086	-0.127	0.648	0.531	0.453	0.432	**0.940**			
Innovativeness	0.243	0.128	0.112	0.075	0.018	-0.017	0.037	0.017	0.121	1		
Sector diversification	0.057	0.322	0.14	0.222	0.133	0.019	0.172	0.118	0.189	0.34	1	
Trust	-0.056	-0.064	-0.137	-0.129	0.222	0.334	0.072	0.041	0.259	0.062	0.087	1

Note: Diagonals (in bold) represent square root of AVE while off diagonals represent correlations; N=156

5.6 Assessment of the structural model

After establishing the convergent and discriminant validity of the measurement models, the structural model was examined to establish relationships amongst exogenous (independent variables) and endogenous constructs (dependent variables) as stated in the conceptual model.

5.6.1 Structural model evaluation criteria

Since the CB-SEM approach for structural model evaluation is based on the distinction between variance and covariance fit, it is not applicable in PLS-SEM. Its quality is assessed by means of variance-based, non-parametric evaluation criteria (e.g., Chin, 2010; Henseler et al., 2009).

Model fit has different meanings in the contexts of CB-SEM and PLS-SEM. Fit statistics for CB-SEM are derived from the discrepancy between the empirical and the model-implied (theoretical) covariance matrix (Bollen, 1989), while in PLS-SEM goodness-of–fit (GoF) focuses on the discrepancy between the observed (in the case of manifest variables) or approximated (in the case of latent variables) values of the dependent variables and the values predicted by the model (Henseler, & Sarstedt, 2013). GoF criteria have not been recommended for application during the evaluation of structural models in several recent critiques (Hair et al., 2014; Henseler, & Sarstedt, 2013). In SEM, it is recommended that alternative models be considered; hence, the best model can be determined by model comparison (Bollen, & Long, 1992).

The procedure for structural model assessment involves the following steps (Hair et al., 2014, p. 169):

- assessment of structural model for collinearity issues
- assessment of the significance and relevance of the structural model relationships
- assessment of levels of R^2
- assessment of the effect sizes f^2
- assessment of the predictive relevance Q^2 and the q^2 effect sizes.

The following steps include assessment of the 'model fit'. PLS-SEM does not provide a global GoF criterion; instead, heuristic criteria based on model predictive capability are reported. The key criteria in the current study were:

- significance of path coefficients (step 2)

- the level of R^2 values (step 3)
- the f^2 effect sizes (step 4)
- the predictive relevance (Q^2)
- the q^2 effect size (step 5).

PLS-SEM studies should provide information on:

- the population and sample structure
- the distribution of the data
- the conceptual model, including a description of the inner and outer models, as well as the measurement modes
- the statistical results to corroborate the subsequent interpretation and conclusions (Chin 2010).

In addition, researchers should report specific technicalities related to the software and computational options used, as well as the parameter settings of ancillary analysis procedures (Joseph F. Hair et al., 2014).

Coefficient of determination. The primary criterion for structural (inner) model assessment is the *coefficient of determination (R^2),* which represents the *amount of explained variance* of each endogenous latent variable and can be used as a measure of predictive accuracy. R^2 ranges from 0 to 1, with higher levels indicating better predictive accuracy. R^2 values of 0.75, 0.50 and 0.25 for endogenous latent variables as a rule of thumb are considered to manifest substantial, moderate, or weak relationships (Joe F Hair, Ringle, & Sarstedt, 2011; Henseler, Ringle, & Sinkovics, 2009).

However, R^2 does not allow adequate evaluation and selection of a model to explain endogenous constructs variance. Adding a non-significant construct may significantly increase the R^2 of an endogenous variable, especially when the number of cases is close to the number of exogenous latent variables. This causes a bias towards selecting models with many exogenous constructs, even slightly related to endogenous constructs. To select a model with less exogenous constructs and higher R^2, which is called *parsimonious*, the adjusted R^2 is applied. The R^2_{adj} is calculated as:

$$R^2_{adj} = 1 - (1 - R^2) \cdot \frac{n-1}{n-k-1} \tag{5.5}$$

Where n is a sample size and k is the number of exogenous latent variables used to predict an endogenous construct. The R_{adj}^2 reduces the R^2 by the number of explaining constructs and the sample size.

Effect size (f^2). A relative impact of a particular exogenous latent variable on an endogenous construct is assessed by means of the effect size f^2 (J. Cohen, 1988). f^2 evaluates the change in the R^2 value, when a specified exogenous construct is excluded from the model. The effect size is calculated as:

$$f^2 = \frac{R_{included}^2 - R_{excluded}^2}{1 - R_{included}^2}, \tag{5.6}$$

Values of f^2 *0.02*, *0.15*, and *0.35*, respectively, represent small, medium, and large effects (J. Cohen, 1988)of the exogenous latent variable.

Predictive relevance (Q^2). To evaluate the predictive relevance of the model, a *cross-validated redundancy (Q^2)* measure was applied. It was a synthesis of cross-validation and function fitting, which could be used to examine the model's predictive validity (Geisser, 1974; Stone, 1974). The Q^2 evaluates an individual construct's predictive relevance for the model by excluding selected structural model relationships and computing changes in the criterion's estimates (Joseph F. Hair et al., 2012). The values of Q^2, when larger than zero for any endogenous variable, indicate the quality of the predictive relevance of the model for this variable.

The Q^2 value is calculated through a *blindfolding procedure* for a certain omission distance D. This is a sample reuse technique that omits every *d*th data point in the endogenous construct's indicators and estimates the parameters with the remaining data points (Wynne W. Chin, 1998; Henseler et al., 2009). The omitted data points are treated as missing values by using such techniques as mean value replacement. The resulting estimates are then used to predict the omitted data points.

The difference between the true (i.e., omitted) data points and the predicted ones is then used as input for the Q^2 measure. Blindfolding is an iterative process that repeats until each data point was omitted and the model re-estimated. Thus, the blindfolding procedure can compare original values with predicted values. If predicted values are close to original values, then the model has a high predictive relevance for the endogenous construct.

The Q^2 values estimated by the blindfolding procedure are measures of the extent the path model can predict the observed values The relative impact of predictive relevance can be compared by means of the measure to the Q^2 effect size, calculated as:

$$q^2 = \frac{Q^2_{included} - Q^2_{excluded}}{1 - Q^2_{included}} \tag{5.7}$$

Q^2 values of 0.02, 0.15, and 0.35 indicate that an exogenous construct has a small, medium, or large predictive relevance for any endogenous construct.

Heterogeneity. A common assumption for SEM is that the data stems from a single population that is homogenous. However, in the real-world this assumption is unrealistic. *Observed heterogeneity* is commonly examined by considering categorical moderating variables and comparing corresponding group-specific path coefficient estimates, for example, by using multigroup comparison techniques (Sarstedt & Ringle, 2010). Other studies evaluate interaction effects by modelling (continuous) moderator variables that potentially affect the strengths or direction of specific path relationships (Joseph F. Hair et al., 2012).

PLS-SEM analyses require the use of complementary techniques for response-based segmentation to test for and deal with unobserved heterogeneity. Finite mixture partial least squares (FIMIX-PLS) (Sarstedt et al., 2011) is currently regarded to be the primary approach for the detection of latent classes in the data (Sarstedt & Ringle, 2010). The technique has received some criticism, since it imposes distributional assumptions on endogenous constructs, which runs contrary to PLS path modelling of the non-parametric character. It is still considered to be the most widely used approach in the field (Ringle, Sarstedt, & Schlittgen, 2010). The FIMIX-PLS approach allows the estimation of model parameters and observations' affiliations and simultaneously segments them (Sarstedt & Ringle, 2010). Joe F Hair et al. (2011) suggest that researchers should routinely use this technique to evaluate whether the results are distorted by unobserved heterogeneity.

To estimate the most appropriate number of segments, several models with alternating numbers of segments should be examined to select the model that minimises the value of the information criterion. Sarstedt and Ringle (2010) provide recommendations of criteria for FIMIX-PLS-PM analyses. Popular criteria include the *Akaike information criterion (AIC)*, the *modified AIC with factor 3 (AIC3)*, the *consistent AIC (CAIC)*, and the *Bayes information criterion (BIC)*. They nominate CAIC as the best information criterion, while AIC and BIC are found to overestimate or underestimate the correct number of segments.

In addition to these criteria, the *normed entropy statistic (EN)*, as proposed by Ramaswamy (1993), is a critical criterion for analysing whether segment-specific FIMIX-PLS results produce well-separated clusters. EN values of 0.50 indicate well-separated class memberships that allow meaningful *a priori* segmentation of specific PLS-PM estimations. Another indicator for selecting the number of segments is the small size of additional segments (Sarstedt & Ringle, 2010).

Mediation analysis. Significant indirect effects were discovered in the full structural model; thus a test for potential mediating effects was undertaken. Analysis draws on Joseph F. Hair et al. (2014) to answer the following questions:

- Is the *direct effect* between exogenous and endogenous variable significant when the mediator variable is excluded from the path model
- Is the *indirect effect* via the mediator variable significant after mediator was included in the path model
- How much of the direct effect does the indirect effect via the mediator absorb?

The last question is answered by calculating variance accounted for (VAF):

$$VAF = \frac{indirect\ effect}{total\ effect} \tag{5.8}$$

5.6.2 PLS procedures for assessing structural model relationships

Bootstrapping. Being a distribution-free multivariate data analysis technique, PLS-SEM does not rely on distributional assumptions. Hence, it does not initially provide t-values to evaluate the estimates' significance. A bootstrapping procedure is performed to estimate bootstrap standard errors, which are used to approximate t-values. Bootstrapping is a resampling approach that draws random samples (with replacement) from the data and uses these samples to estimate the path model multiple times with changed data samples. The recommended number of samples is 5,000 with the same number of cases as there are valid observations in the dataset (Joseph F. Hair et al., 2014, p. 162).

Consistent PLS algorithm. The issue of upward bias of parameter estimates for paths between observed variables and latent variable proxies in PLS, and downward bias of parameter estimates for paths between proxies, was acknowledged by scholars (e.g.Dijkstra & Henseler, 2015). An underestimation of path effects has the potential to negatively influence a method's ability to detect a significant effect if it indeed exists and causing a lack of statistical power. To overcome this deficiency, a consistent partial least squares (PLSc) algorithm was introduced (Dijkstra & Henseler, 2015). It corrects estimates of reflectively measured constructs using a reliability coefficient ρ_A. It overcomes traditional PLS' consistency problems when estimating common factor models in the sense that it consistently estimates the path coefficients, interconstruct correlations, and indicator loadings(Dijkstra & Henseler, 2015).

Weighting schemes. The selection of initial values for outer weights may impose changes in the outer models and/or the inner model estimates (Henseler et al., 2009). Specific parameter settings (e.g., stop criterion) and computational options (e.g., weighting scheme for determining inner model proxies) can also entail different model estimation outcomes and are sometimes inadequate in certain model configurations. For example, the centroid weighting scheme ensures the PLS-SEM algorithm's convergence (Henseler & Chin, 2010), but it should not be used for estimating higher order component models (Henseler et al., 2009). The initial values for the outer model relationships, parameter settings, computational options, and the resulting (maximum) number of iterations need to be reported (Joseph F. Hair et al., 2014).

5.6.3 Assessment of the structural model for collinearity issues

Since the PLS procedure is based on the OLS regression of each endogenous latent variable on its corresponding predecessor constructs, collinearity between predictor constructs may introduce a bias in the estimation of path coefficients (Joseph F. Hair et al., 2014, p. 169).

There are seven model subparts, where constructs *sector and capability diversification*, *innovativeness*, *joint problem-solving*, *information exchange* and *absorptive capacity* act as dependent variables. The constructs serving as predictors for each model subpart were assessed for collinearity.

To assess collinearity, the set of predictive constructs for each subpart of the structural model was assessed using tolerance and VIF values. A tolerance level below 0.20 (VIF above 5.00) in the predictor constructs is considered to be an indication of collinearity. As shown in Table 5.18, none of the variance inflation factor (VIF) values exceeds the threshold of 5. Thus, collinearity among predictor variables was not an issue in the structural model.

As per Table 5.16, at the indicator level, each reflective indicator loaded highest on the construct to which it was linked, compared to other constructs, thus ensuring discriminant validity at the indicator level. At the construct level, the compliance to the *Fornell-Larcker* criterion was examined. The difference between the square root of the AVE of each single construct and correlations with other constructs was found positive. Hence, discriminant validity was established.

As demonstrated in Table 5.15, the composite reliability was above the minimum threshold of 0.85 for all latent constructs as well (Henseler et al., 2009). Furthermore, the value of the construct variance observed by comparing the measurement error (Fornell & Bookstein, 1982) was greater than 0.50 for all constructs (Götz, Liehr-Gobbers, & Krafft, 2010), thus ensuring convergent validity.

To assess discriminant validity, the analysis was performed at the indicator level (Table 5.16).

Table 5.16 Collinearity assessment – variance inflation factor (VIF)

	Abs capacity	Capability diversification	Information exchange	Joint problem -solving	Inovative-ness	Sector diversifica-tion
Abs capacity		1.077			1.041	1.07
Capability diversification					1.352	
Sector diversification		1.125			1.145	
Degree centrality	1.108	1.26			1.288	1.25
Eigenvector centrality	1.118	1.256				1.193
Information exchange				1.052		
Joint problem-solving	1.019	1.156			1.196	1.104
Innovativeness						
Trust			1	1.052		

5.6.4 Assessment of the significance and relevance of the full structural model relationships

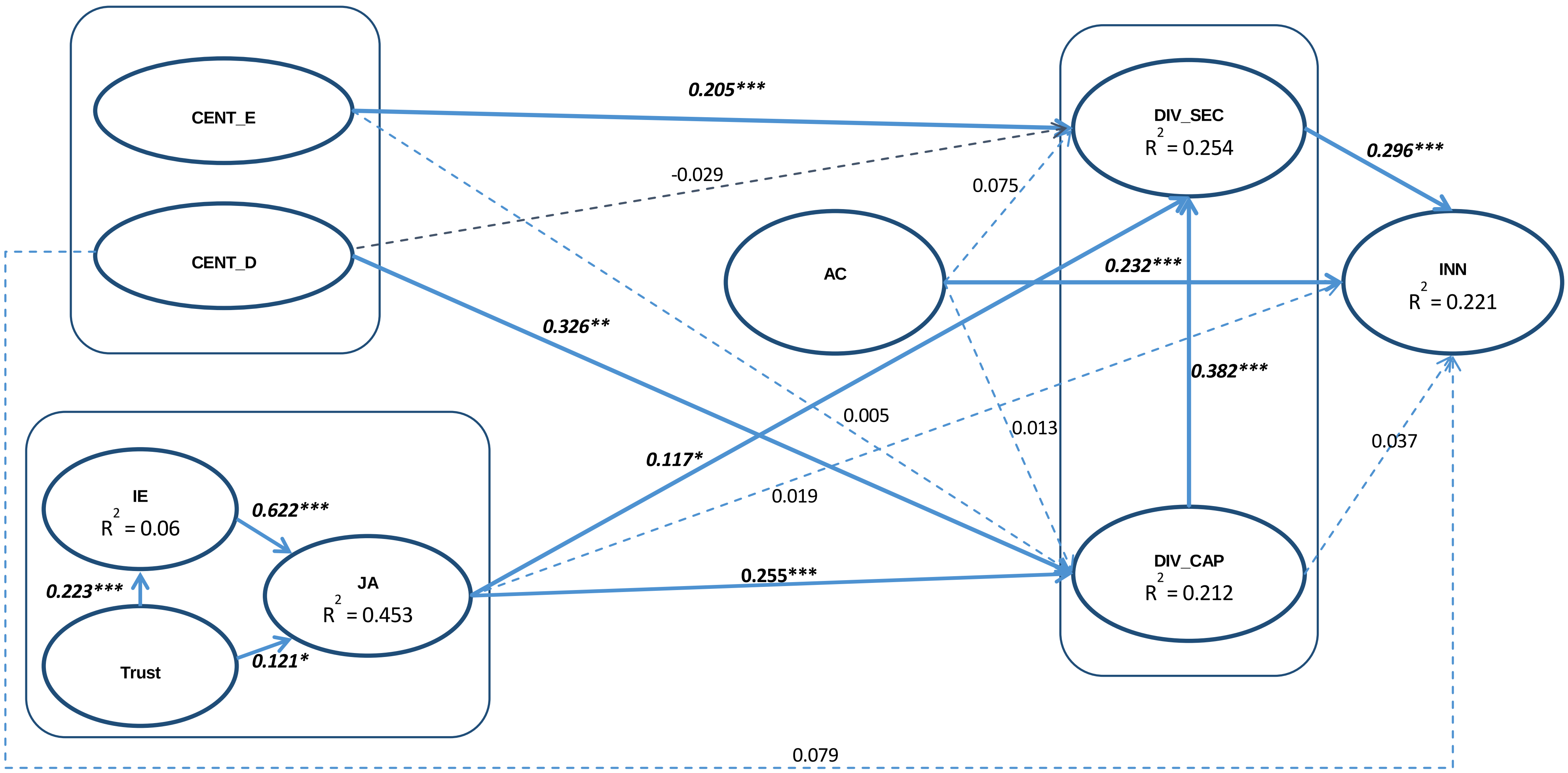
Structural model path coefficients. Standardised path coefficients ß provide evidence of a structural model's quality, and their significance should be assessed by providing t-value statistics and/or corresponding *p*-values using resampling procedures (Henseler et al., 2009). The significance of the path coefficient is evaluated through a bootstrapping procedure. The bootstrap standard error allows for calculating empirical t-values based on the original path estimate p_{ij} and the bootstrap standard error se^*_{ij}:

$$t = \frac{p_{ij}}{se^*_{ij}} \tag{5.9}$$

If the empirical *t* value is larger than a critical value, the coefficient is significant at a certain error probability (significance level). Commonly used critical *t* values for *two-tailed tests* are 1.65 (significance level= 10%), 1.96 (significance level = 5%), and 2.57 (significance level = 1%). The choice of the significance level depends on the study's objective. Since this study was exploratory in nature, a significance level of 10% was adopted (Joseph F. Hair et al., 2014). In addition, the *bootstrapping confidence interval* for a respecified probability of error can be determined. However, only the empirical *t* value, the *p* value, or the bootstrapping confidence interval needed to be reported (Joseph F. Hair et al., 2014).

An analysis of the *relative importance of the relationships* should be undertaken further to assess whether the size of the path coefficients is worth attention. Such an analysis involves the comparison of path coefficient sizes and their effects on endogenous constructs, including an assessment of *direct* and *indirect effects* via one or more *mediating constructs*. The sum of direct and indirect effects is referred to as a *total effect*. Since this research is exploratory the total effects had to be analysed (Joseph F. Hair et al., 2014).

Furthermore, to obtain the final form of the structural model, it is generally recommended that direct paths with ß<0.10 be removed because such values show a less than adequate effect in the estimation of a relationship between two variables (Tuijnman & Keeves, 1997). The primary objective of the model was to test the relationships between the positional and relational embeddedness of regional suppliers in the resource sector supply network, sectoral and capability diversification and the innovativeness of METS suppliers. In addition, the role of absorptive capacity as a mediator (moderator) between these variables was assessed. Figure 5.5 and Tables 5.17, 5.18, and 5.19 depict the values and significance of the path coefficients obtained from running the bootstrapping procedure (156 cases, 5000 samples, no sign change option). The bootstrapping revealed that 13 out of 25 hypothesised relationships were significant at ($p<0.1$), 12 at ($p<0.05$) and 8 at ($p<0.01$).



Note: N=156, 5000 samples, no sign change option

Figure 5.5 The full structural model: Bootstrapping results

Table 5.17 Path coefficients in the structural model (bootstrapping results)

	Path	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
1	ABS CAPACITY -> CAP_DIVERSIFICATION	0.013	0.016	0.075	0.172	0.864
2	ABS CAPACITY -> INNOVATIVENESS	**0.232*** **	**0.239*** **	0.07	3.307	0.001
3	ABS CAPACITY -> SECT_Diversification	0.075	0.074	0.064	1.179	0.239
4	CAP_DIVERSIFICATION -> INNOVATIVENESS	0.037	0.046	0.146	0.256	0.798
5	CAP_DIVERSIFICATION -> SECT_Diversification	**0.382*** **	**0.389*** **	0.084	4.553	0
6	CENTRALITY -> ABS CAPACITY	-0.029	-0.018	0.084	0.343	0.732
7	CENTRALITY -> CAP_DIVERSIFICATION	**0.326** **	**0.296** **	0.141	2.317	0.021
8	CENTRALITY -> INNOVATIVENESS	0.079	0.085	0.083	0.957	0.339
9	CENTRALITY -> SECT_Diversification	-0.029	-0.026	0.075	0.389	0.697
10	EIGENVECTOR -> ABS CAPACITY	**-0.179** **	**-0.183** **	0.077	2.338	0.019
11	EIGENVECTOR -> INNOVATIVENESS	0.033	0.026	0.093	0.356	0.722
12	EIGENVECTOR -> CAP_DIVERSIFICATION	0.081	0.09	0.092	0.882	0.378
13	EIGENVECTOR -> SECT_Diversification	**0.205** **	**0.198** **	0.087	2.356	0.018
14	IE -> JOINT PROBLEM-SOLVING	**0.622*** **	**0.63*** **	0.059	10.598	0
15	JOINT PROBLEM-SOLVING -> ABS CAPACITY	**0.151*** **	**0.156*** **	0.073	2.055	0.04
16	JOINT PROBLEM-SOLVING -> CAP_DIVERSIFICATION	**0.255*** **	**0.253*** **	0.069	3.718	0
17	JOINT PROBLEM-SOLVING -> INNOVATIVENESS	0.019	0.027	0.091	0.203	0.839
18	JOINT PROBLEM-SOLVING -> SECT_Diversification	**0.117* **	**0.116* **	0.067	1.731	0.083
19	SECT_Diversification -> INNOVATIVENESS	**0.296** **	**0.283** **	0.117	2.526	0.012
20	TRUST -> IE	**0.223*** **	**0.233*** **	0.079	2.819	0.005
21	TRUST -> JOINT PROBLEM-SOLVING	**0.121* **	**0.116* **	0.066	1.833	0.067

N=156. Significant paths (β>0.1, *p< 0.10. ** p<0.05, *** p<0.01) are highlighted with bold italic

Table 5.18 Indirect effects in the full structural model

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Value s
ABS CAPACITY -> INNOVATIVENESS	0.024	0.023	0.025	0.946	0.344
ABS CAPACITY -> SECT_DIVERSIFICATION	0.004	0.005	0.028	0.138	0.89
CAP_DIVERSIFICATION -> INNOVATIVENESS	0.106**	0.101**	0.044	2.412	0.016
CENTRALITY -> CAP_DIVERSIFICATION	0	0	0.006	0.08	0.936
CENTRALITY -> INNOVATIVENESS	0.107	0.11	0.074	1.444	0.149
CENTRALITY -> SECT_DIVERSIFICATION	0.123**	0.113**	0.058	2.107	0.035
EIGENVECTOR -> CAP_DIVERSIFICATION	-0.002	-0.003	0.014	0.125	0.901
EIGENVECTOR -> INNOVATIVENESS	0.024	0.024	0.045	0.526	0.599
EIGENVECTOR -> SECT_DIVERSIFICATION	0.012	0.017	0.043	0.293	0.77
IE -> ABS CAPACITY	0.086	0.088	0.047	1.83	0.067
IE -> CAP_DIVERSIFICATION	0.167***	0.167***	0.045	3.749	0
IE -> INNOVATIVENESS	0.085	0.091	0.056	1.506	0.132
IE -> SECT_DIVERSIFICATION	0.141***	0.143***	0.047	2.988	0.003
JOINT PROBLEM-SOLVING -> CAP_DIVERSIFICATION	0.001	0.001	0.012	0.124	0.901
JOINT PROBLEM-SOLVING -> INNOVATIVENESS	0.109***	0.109***	0.042	2.6	0.009
JOINT PROBLEM-SOLVING -> SECT_DIVERSIFICATION	0.11***	0.111***	0.036	3.058	0.002
TRUST -> ABS CAPACITY	0.036	0.037	0.024	1.498	0.134
TRUST -> CAP_DIVERSIFICATION	0.07	0.069	0.028	2.479	0.013
TRUST -> IE_QUAL	0.17**	0.178**	0.067	2.552	0.011
TRUST -> IE_SCOPE1	0.171***	0.176***	0.061	2.814	0.005
TRUST -> IE_SCOPE2	0.156***	0.16***	0.056	2.818	0.005
TRUST -> INNOVATIVENESS	0.035	0.038	0.028	1.278	0.201
TRUST -> JOINT PROBLEM-SOLVING	0.138***	0.145***	0.051	2.739	0.006
TRUST -> SECT_DIVERSIFICATION	0.059	0.059	0.028	2.081	0.037

N=156. Significant paths (β>0.1, *p< 0.10. ** p<0.05, *** p<0.01) are highlighted with bold italic

Table 5.19 Total effects in the structural model

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
ABS CAPACITY -> CAP_DIVERSIFICATION	0.01	0.013	0.072	0.144	0.886
ABS CAPACITY -> INNOVATIVENESS	0.261***	0.264***	0.075	3.499	0
ABS CAPACITY -> SECT_DIVERSIFICATION	0.082	0.082	0.067	1.229	0.219
CAP_DIVERSIFICATION -> INNOVATIVENESS	0.147	0.152	0.13	1.13	0.259
CAP_DIVERSIFICATION -> SECT_DIVERSIFICATION	0.37***	0.375***	0.077	4.801	0
CENTRALITY -> ABS CAPACITY	-0.048	-0.043	0.077	0.627	0.531
CENTRALITY -> CAP_DIVERSIFICATION	0.343**	0.314**	0.153	2.243	0.025
CENTRALITY -> INNOVATIVENESS	0.114*	0.118*	0.064	1.793	0.073
CENTRALITY -> SECT_DIVERSIFICATION	0.123**	0.113**	0.058	2.107	0.035
EIGENVECTOR -> ABS CAPACITY	-0.169**	-0.172**	0.078	2.178	0.029
EIGENVECTOR -> CAP_DIVERSIFICATION	0.069	0.078	0.094	0.735	0.462
EIGENVECTOR -> INNOVATIVENESS	0.057	0.053	0.101	0.563	0.573
EIGENVECTOR -> SECT_DIVERSIFICATION	0.213**	0.214**	0.083	2.574	0.01
IE -> ABS CAPACITY	0.086	0.088	0.047	1.83	0.067
IE -> CAP_DIVERSIFICATION	0.167***	0.167***	0.045	3.749	0
IE -> INNOVATIVENESS	0.085	0.091	0.056	1.506	0.132
IE -> JOINT PROBLEM-SOLVING	0.622***	0.63***	0.058	10.659	0
IE -> SECT_DIVERSIFICATION	0.141***	0.143***	0.047	2.988	0.003
JOINT PROBLEM-SOLVING -> ABS CAPACITY	0.139*	0.141*	0.075	1.844	0.065
JOINT PROBLEM-SOLVING -> CAP_DIVERSIFICATION	0.269***	0.264***	0.064	4.206	0
JOINT PROBLEM-SOLVING -> INNOVATIVENESS	0.136	0.145	0.09	1.524	0.128
JOINT PROBLEM-SOLVING -> SECT_DIVERSIFICATION	0.226***	0.227***	0.072	3.147	0.002
SECT_DIVERSIFICATION -> INNOVATIVENESS	0.286***	0.274***	0.109	2.637	0.008
TRUST -> ABS CAPACITY	0.036	0.037	0.024	1.498	0.134
TRUST -> CAP_DIVERSIFICATION	0.07	0.069	0.028	2.479	0.013
TRUST -> IE	0.223***	0.231***	0.08	2.783	0.005
TRUST -> INNOVATIVENESS	0.035	0.038	0.028	1.278	0.201
TRUST -> JOINT PROBLEM-SOLVING	0.26***	0.26***	0.081	3.192	0.001
TRUST -> SECT_DIVERSIFICATION	0.059	0.059	0.028	2.081	0.037

N=156. Significant paths (β>0.1, *p< 0.10. ** p<0.05, *** p<0.01) are highlighted with *bold italic*

Supplier innovativeness and diversification. As expected, analysis yielded significant positive relationships between *capability diversification* and *sectoral diversification* (β = *0.382***, p<0.01*), supporting H_{1a}. *Sectoral diversification* was positively related to supplier *innovativeness* (β = *0.296***, p<0.01*), confirming H_{1c}. *Capability diversification* did not yield any significant direct or indirect effects on supplier *innovativeness,* thus H_{1b} was declined.

As expected, *absorptive capacity* had a significant positive relationship with METS *innovativeness* – the number of new products/services introduced by the supplier company (β = *0.151**, p<0.05*), supporting H_{2c}. No indirect effect of *absorptive capacity* on *capability* or *sectoral diversification* was recorded, thus hypotheses H_{2a} and H_{2b} were declined.

Effects of positional embeddedness on firm innovativeness, diversification and absorptive capacity. Two variables retained in the structural model to measure positional embeddedness in the regional supply network were *degree centrality* and *eigenvector centrality*.

Effects of degree centrality on supplier diversification and innovativeness. A positive and significant relationship (β = 0.296***, p<0.01) was established between degree centrality (CENT_D) and capability diversification (DIV_CAP), thus supporting H_{3a}. The total effect of centrality on capability diversification is slightly higher (β = 0.314***, p<0.01), accounting for a non-significant mediation via absorptive capacity.

The results of mediation analysis indicated that *degree centrality* exerted a significant indirect effect on *sectoral diversification* through *capability diversification* (β = *0.123**, p<0.05*). The total effect of *degree centrality* on *innovativeness* through mediation path *capability diversification* and *sector diversification* has yielded β = *0.118*, p<0.1* (see Figure 5.6).

Eigenvector centrality and sectoral diversification. Eigenvector centrality, which quantifies the importance and influence of a firm in the network, positively and significantly correlates with *supplier sectoral diversification* (β = *0.198***, p<0.01*), supporting H_{3b}.

Effects of positional embeddedness on firm *innovativeness, diversification* and *absorptive capacity.* Analysis results indicated that *trust* between supplier and customer directly and significantly influenced the level of *fine-grained information exchange* (β = 0.223***, p<0.01), hence supporting

H_6 . H_5 was also confirmed, since *fine-grained information exchange* in turn is highly correlated with *joint problem solving* (β = 0.622***, p<0.01). In addition, as expected, *trust* between buyer and supplier positively correlates with *joint problem solving* (β = 0.121*, p<0.1), supporting H_7.

Joint problem solving – capability and sector diversification. Direct positive and significant relationships were established between joint problem solving and capability diversification (β = 0.253***, p<0.01), supporting H_{4a}. Joint problem solving also yielded a direct positive, however, less significant, effect on sectoral diversification (β = 0.116*, p<0.1), supporting H_{4b}. No significant relationship was established between joint problem-solving and supplier innovativeness, thus H_{4c} was not confirmed.

5.6.5 Analysis of mediation effects

Investigation of the indirect impact of *degree centrality* on *sectoral diversification* and *innovativeness* via mediation of *capability diversification* and *innovativeness*. Mediation analysis revealed a positive and significant indirect effect of *degree centrality* on *sectoral diversification* (β = *0.113*, p<0.1*) via the mediators *capability diversification*, and *innovativeness* via mediating variables *capability diversification* (DIV_CAP) and *sectoral diversification* (DIV_SEC) (see Figure 5.6).

According to Joseph F. Hair et al. (2014), a direct significant effect between variables is desirable in order to meaningfully interpret mediation. Further analysis revealed that the direct effect of degree c*entrality* on *innovativeness* without mediating variables *capability diversification* (DIV_CAP) and *sectoral diversification* (DIV_SEC) yielded (β = 0.125**, *p<0.05*). Although the indirect effect of *centrality* on *innovativeness* was non-significant, the total effect was (0.118*, p*<0.01*). A VAF of 0.93 suggested that the full mediation of *capability diversification* (DIV_CAP) and *sectoral diversification* (DIV_SEC) absorbs 93% of the *degree centrality* effect on *innovativeness*.

In a similar fashion, the direct relationship between *degree centrality* and *sectoral diversification* (DIV_SEC) tested without the mediator *capability diversification* was (0.156**, *p<0.05*) (see Figure 5.6). According to Joseph F. Hair et al. (2014), a VAF of 0.92 suggests that 92% of the *degree centrality* effect on *sectoral diversification* was explained by *capability diversification*.

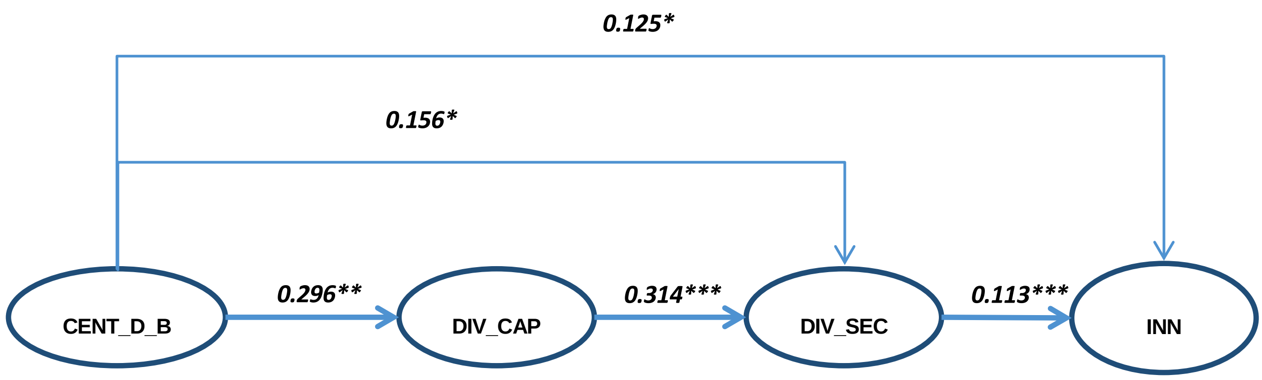


Figure 5.6 Mediation path between degree centrality (CENT_D) and firm innovativeness (INN) via capability diversification (DIV_CAP) and sectoral diversification (DIV_SEC)

Investigation of the indirect impact of information exchange on sectoral diversification and capability diversification via mediation of joint problem solving. The hypothesised relationships between fine-grained information exchange and firm capability and sectoral diversification through mediation of joint problem-solving ($H_{5a\text{-}5b}$) were supported (Figure 5.7). The indirect effect of information exchange on capability diversification yielded β = 0.167***, p<0.01 (VAF = 99%) and on sectoral diversification β = 0.143***, p<0.01 (VAF = 99%). Thus, as expected, there was a full mediation of joint problem-solving on relationships between information exchange and METS diversification. No significant direct or indirect effect of information exchange on supplier innovativeness was established.

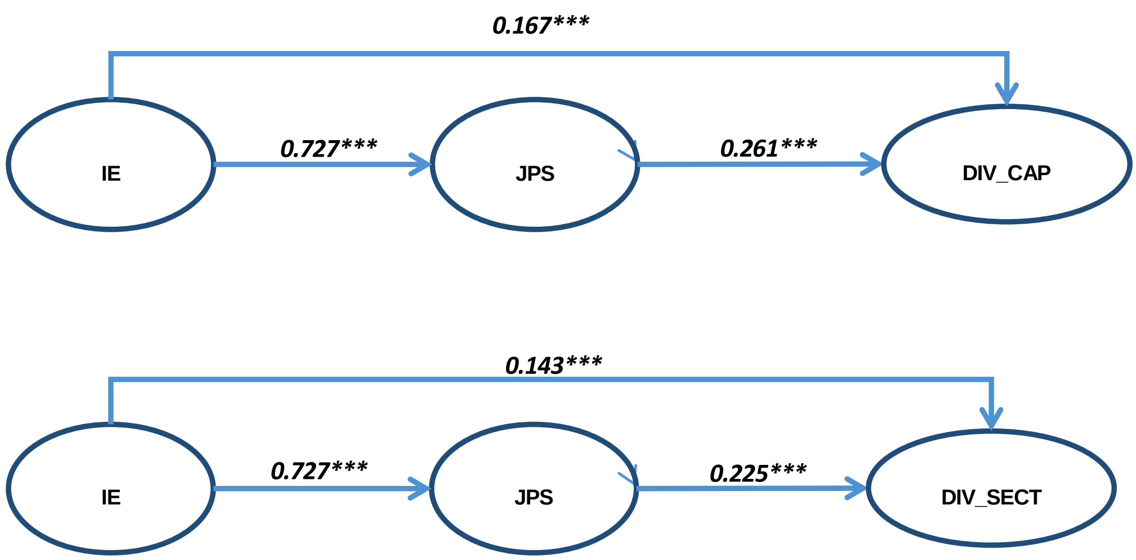


Figure 5.7 Mediation path between *information exchange* and *firm diversification* variables via *joint problem-solving*

Indirect impact of trust on diversification and innovativeness via joint problem solving. No significant relationships between *trust* and *capability* and *sectoral diversification* or *innovativeness* through the mediation of joint problem solving were established. Thus, the hypothesised mediational paths $H_{7a\text{-}7c}$ were not supported empirically.

Indirect impact of trust on joint problem solving via fine-grained information exchange. As expected, a significant indirect impact of *trust* on *joint problem solving* via *information exchange* was established (β = *0,145***, p<0.01*), while the total effect yielded 0.26. A VAF of 0.557 suggests 55.7% of partial mediation of *information exchange* between *trust* and *joint problem solving.*

The indirect impact of joint problem solving on sectoral diversification and innovativeness via capability diversification. The indirect effect of *joint problem solving* on *sectoral diversification* was positive and significant (β = *0,111***, p<0.01*) as well as totally effective *(*β = *0.227***, p<0.01).* A VAF of 0.49 suggests that 49% of the effect of *joint problem-solving* on *sectoral diversification* was explained by *capability diversification* (Figure 5.8).

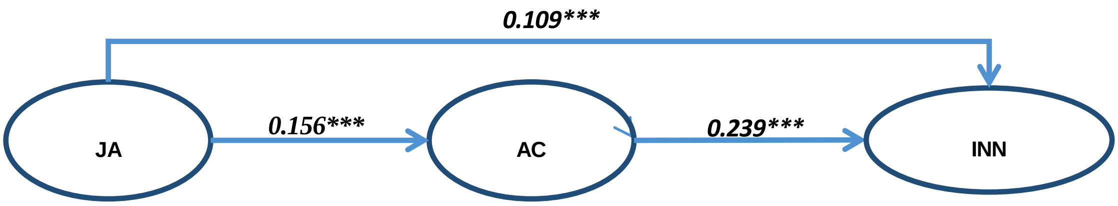


Figure 5.8. Mediation path joint problem solving on sectoral diversification and innovativeness via capability diversification

5.6.6 Evaluating explained variance (R^2) and adjusted variance explained (R^2_{adj}) of endogenous variables

The current model setup yielded relatively low predictive power in terms of explaining variance in endogenous variables (see Table 5.20. Thus, variance explained for *capability diversification* yielded (R^2 = 0.212, R^2_{adj} =0.192), for *sectoral diversification* (R^2 = 0.254, R^2_{adj} =0.23) and *innovativeness* (R^2 = 0.221, R^2_{adj} =0.191). However, considering the multitude of potential antecedents of firm diversification and innovativeness, these R^2 values could be considered rather satisfactory.

Table 5.20 Bootstrapping results for endogenous variables R^2 and R^2_{adj}

Endogenous variable	R^2			R^2_{adj}		
	Sample Mean (M)	T Statistics	P Values	Sample Mean (M)	T Statistics	P Values
CAP_DIVERSIFICATION	0.212	2.059	0.04	0.192	1.788	0.074
SECT_DIVERSIFICATION	0.254	3.365	0.001	0.23	2.91	0.004
INNOVATIVENESS	0.221	3.387	0.001	0.191	2.677	0.007
JOINT PROBLEM-SOLVING	0.453	7.014	0	0.446	6.814	0
INFORMATION EXCHANGE	0.06	1.333	0.183	0.055	1.166	0.244
ABS CAPACITY	0.079	1.734	0.083	0.061	1.214	0.225

The blindfolding procedure was carried out to evaluate the model predictive power. The omission distance of eight yielded cross-validated redundancy values for all endogenous constructs above zero (see Table 5.21).

Table 5.21 Assessment of levels of coefficient of determination R2 and cross-validated redundancy Q^2

Endogenous variable	R2	R2 adjusted	Q2
CAP_DIVERSIFICATION	0.212	0.192	0.098
SECT_DIVERSIFICATION	0.254	0.23	0.167
INNOVATIVENESS	0.221	0.191	0.092
JOINT PROBLEM-SOLVING	0.453	0.446	0.313
INFORMATION EXCHANGE	0.06	0.055	0.019
ABS CAPACITY	0.079	0.061	0.01

Given the relatively low predictive power of the model to increase the R^2 and Q^2 values of the moderation effects – multi-group analysis of the moderator variables: *company size*, *tier position in the resource supply chain* and *association membership*, as well as interaction terms, were further examined.

5.7 Analysis of moderation effects

In the current research, multi-group analysis was performed to estimate the moderating effects of *company size, tier position in the resource supply chain*, and *membership in industry associations.* In addition, interaction of the terms on the model variables were explored. The literature suggests that testing interaction effects is an approach that provides greater capacity to identify moderating effects than multigroup analysis (e.g.Joseph F. Hair et al., 2014; Qureshi & Compeau, 2009). While interaction terms are superior in their ability to identify moderating effects, multigroup analysis is appropriate for testing the strength of moderation effects in the case of nominal moderating variables.

5.7.1 Continuous moderating effects

In the current research, interaction terms were tested to examine continuous moderating effects in specific relationships between two variables in the model. All possible *two-way interaction terms* were created and tested, including *absorptive capacity* on *positional embeddedness* (*degree* and *eigenvector centrality*), *absorptive capacity* on *relational embeddedness* (*trust*, *information exchange* and *joint problem-solving*), *relational embeddedness* on *positional embeddedness,* and *capability* and *sectoral diversification* on *positional embeddedness, capability* and *sectoral diversification* on *relational embeddedness.*

To reduce inflation in path coefficients, the option *standardised* in the *interaction product generation* was selected to ensure that the indicators of the latent constructs *trust*, *information exchange,* and *joint problem-solving* were standardised. The bootstrapping procedure results revealed six significant interaction effects (p<0.1) that improved the R^2 and Q^2 estimates of endogenous variables in the baseline model (see Table 5.22).

Table 5.22 Interaction terms and their effects on endogenous variables

Interaction term	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
ABSORPTIVE CAPACITY × DEGREE CENTRALITY-> INNOVATIVENESS	0.151*	0.146	0.08	1.874	0.061
ABSORPTIVE CAPACITY × DEGREE CENTRALITY -> CAPABILITY DIVERSIFICATION	-0.256**	-0.237	0.123	2.076	0.038
ABSORPTIVE CAPACITY × EIGENVECTOR CENTRALITY -> CAPABILITY DIVERSIFICATION	0.222**	0.213	0.089	2.502	0.012
ABSORPTIVE CAPACITY × JOINT PROBLEM SOLVING-> INNOVATIVENESS	-0.162**	-0.161	0.068	2.393	0.017
CAPABILITY DIVERSIFICATION × JOINT PROBLEM SOLVING -> SECTORAL DIVERSIFICATION	0.15*	0.159	0.08	1.871	0.061
JOINT PROBLEM SOLVING × DEGREE CENTRALITY -> CAPABILITY DIVERSIFICATION	0.222**	0.203	0.096	2.296	0.022

N=156. Significant paths (β>0.1, *p< 0.10. ** p<0.05)

There was a significant positive moderating effect (*0.151*, p<0.1*) of the interaction terms *absorptive capacity* and *degree centrality*, which strengthens relationships between *degree centrality* and *innovativeness* (see Figure 5.9).

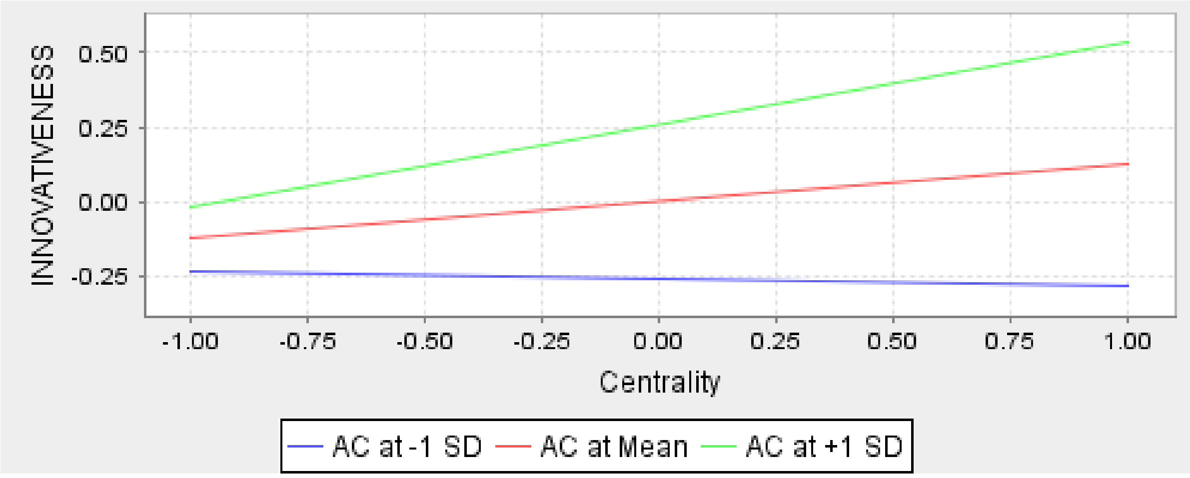


Figure 5.9 **The moderating effect of *absorptive capacity* on the relationships between *degree centrality* and *innovativeness***

The effect of *degree centrality* on supplier *capability diversification* (see Figure 5.10 was lower for companies with high *absorptive capacity* (*-0.256**, p<0.05*).

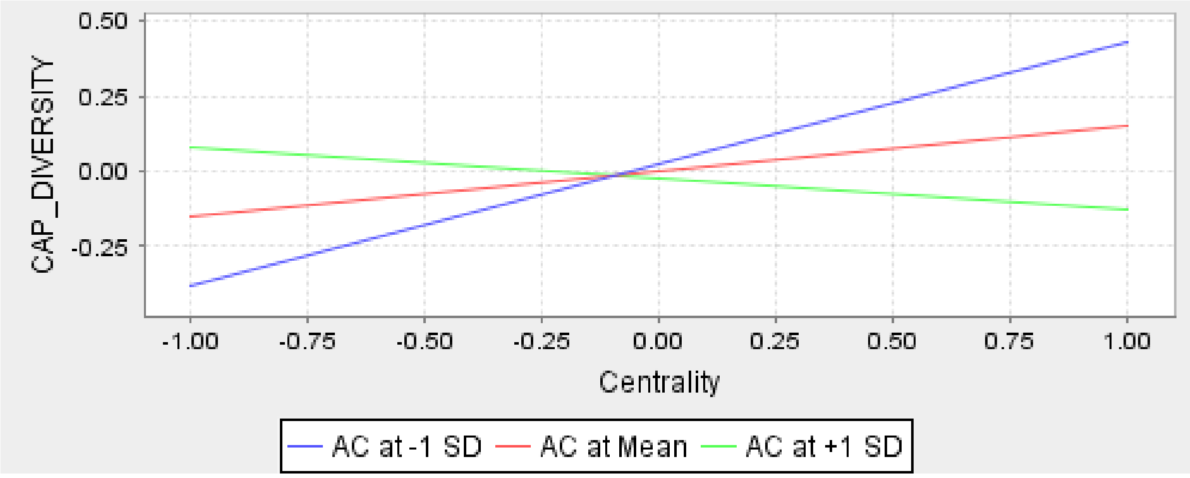


Figure 5.10 **Moderating effects of *absorptive capacity* on relationships between *centrality* and *capability diversification***

An interesting cross-over interaction effect of *absorptive capacity* and *eigenvector centrality* on *capability diversification*. While there was no direct relationship observed between *eigenvector centrality* and *capability diversification* (*0.05*) as well as *absorptive capacity* and *capability diversification (0.013)*, their combination produced a significant positive effect on *capability diversification* (*0.222***, p<0.05, see Figure 5.11).

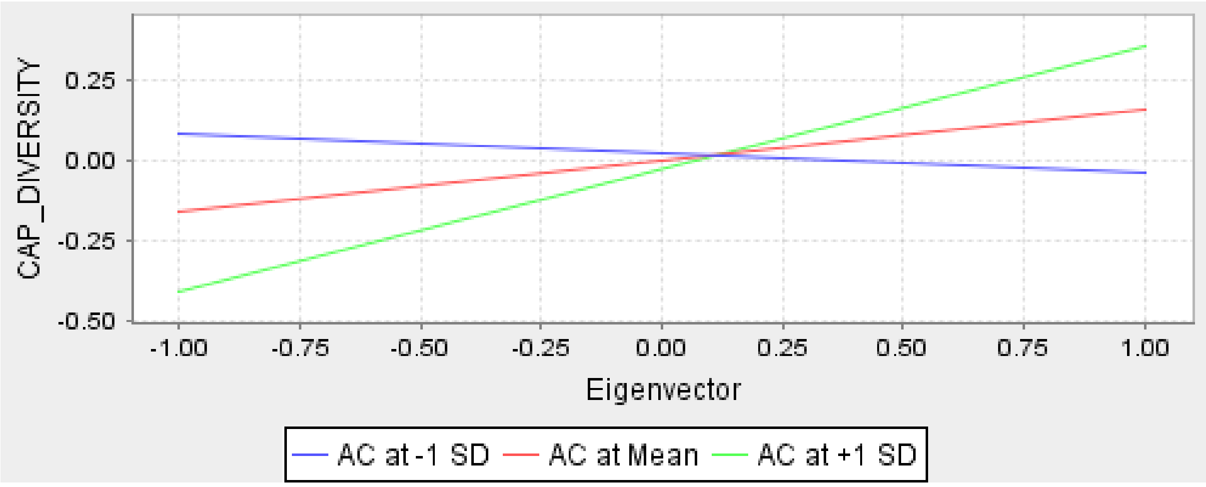


Figure 5.11 **Moderating effect of *absorptive capacity* on the relationships between *eigenvector centrality* and *capability diversification***

Conversely, *absorptive capacity* weakens relationships (-0.162**, p<0.1) between *joint problem solving* and *innovativeness* (see Figure 5.12)

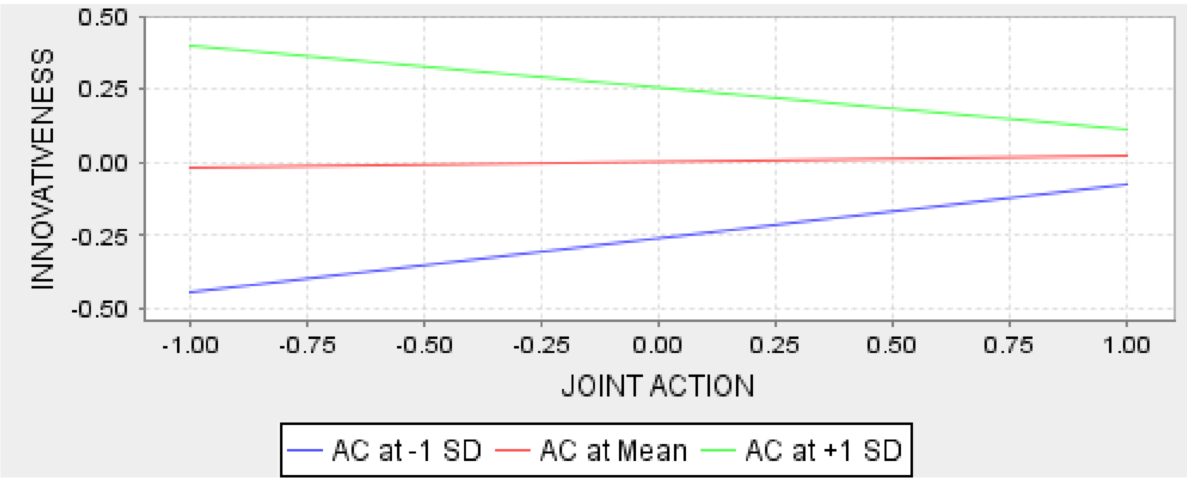


Figure 5.12 **Moderating effects of *absorptive capacity* on the relationships between *joint problem-solving* and *innovativeness***

Interestingly, the degree of *joint problem solving* has yielded significant moderating effect (0.15*, p<0.1) on the relationship between *capability diversification* and *sectoral diversification* (see Figure 5.13).

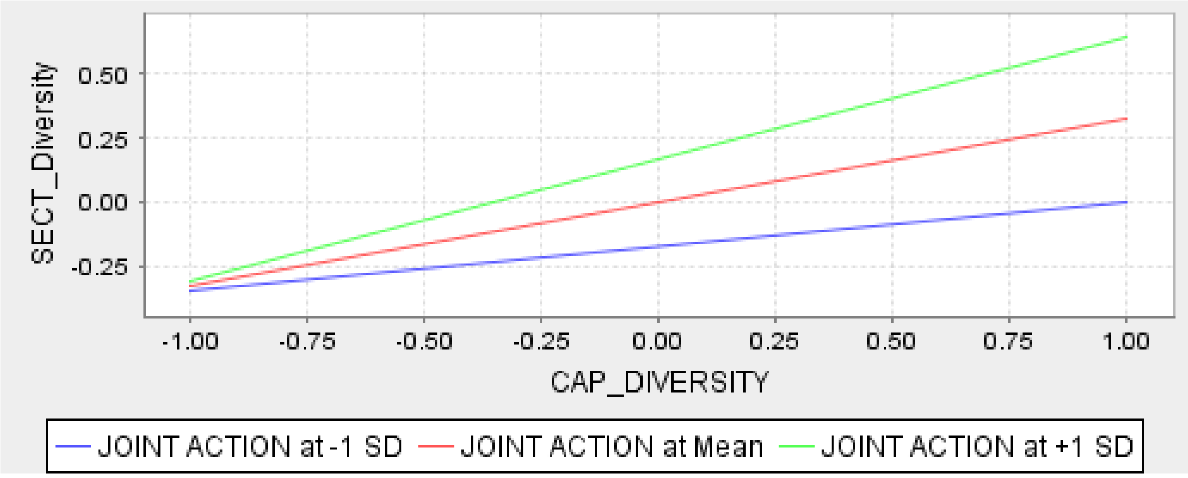


Figure 5.13 **Moderating effect of *joint problem solving* on the relationships between *sector diversification* and *capability diversification***

Joint-problem solving also moderates the relationships between *degree centrality* on *capability diversification* (0.222**, p<0.05, see Figure 5.14.)

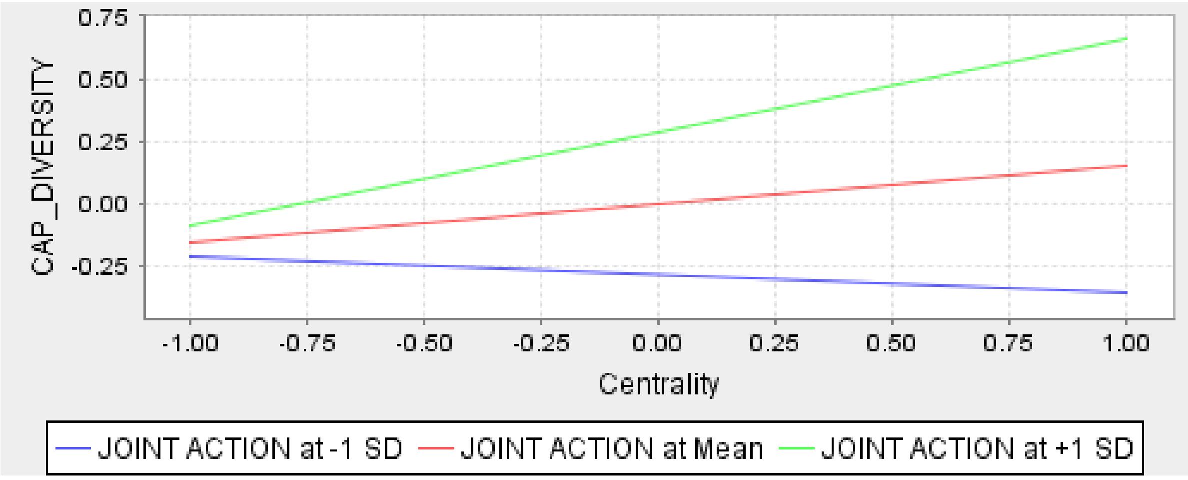


Figure 5.14 **Moderating effect of *joint problem solving* on the relationships between *centrality* and *capability diversification***

The inclusion of the significant moderating effects slightly improved the predictive power of the baseline model (see Tables 5.23 and 5.24). The inclusion of interaction terms increased the amount of variance explained for *capability diversification* by 40% and *innovativeness* by 29.3%. However, there was no increase in variance explained for the *sectoral diversification*.

Table 5.23 Bootstrapping results R^2 and R^2_{adj} with inclusion of moderator variables

Endogenous variable	R^2			R^2_{adj}		
	Sample Mean (M)	T Statistics (|O/STDEV|)	P Values	Sample Mean (M)	T Statistics (|O/STDEV|)	P Values
CAP_DIVERSIFICATION	0.306**	2.395	0.017	0.24**	1.966	0.049
SECT_DIVERSIFICATION	0.279***	3.721	0	0.212***	3.065	0.002
INNOVATIVENESS	0.269***	4.163	0	0.172***	3.096	0.002
JOINT PROBLEM-SOLVING	0.452	7.123	0	0.428	6.919	0
IE	0.062	1.314	0.189	0.044	1.15	0.25
AC	0.089	1.735	0.083	0.041	1.067	0.286

N=156. *p< 0.10, ** p<0.05

Table 5.24 Coefficient of determination R^2, R^2_{adj} and cross-validated redundancy Q^2 (comparison between initial model and model with continuous moderating effects)

Endogenous variable	R^2	R^2*	R^2_{adj}	R^2_{adj} *	Q^2	Q^2 *
CAP_DIVERSIFICATION	0.212	0.306	0.192	0.27	0.098	0.133
SECT_DIVERSIFICATION	0.254	0.279	0.23	0.226	0.167	0.178
INNOVATIVENESS	0.221	0.269	0.191	0.247	0.092	0.11
JOINT PROBLEM-SOLVING	0.453	0.452	0.446	0.445	0.313	0.319
INFORMATION EXC	0.06	0.062	0.055	0.056	0.019	0.02
ABS CAPACITY	0.079	0.089	0.061	0.066	0.001	0.002

* Model with the moderation effects

5.7.2 Multi-group analysis

Multi-group analysis was undertaken to reveal the effects of categorical moderator variables: *company size*, *tier position* in the resource supply chain and *association membership.* To examine whether there was a significant difference between groups in terms of model relationships, the partial least squares multigroup analysis (PLS-MGA) procedure was applied (Joseph F. Hair et al., 2014). While *SmartPLS* software provides several parametric and non-parametric tests, the non-parametric PLS MGA test was used for two reasons. Firstly, it does not build on distributional assumptions, and secondly, it allows for different sample sizes of groups.

The PLS-MGA method (Henseler, 2012) implemented in *SmartPLS*, is an extension of the original non-parametric Henseler's MGA method. From a procedural perspective, this approach resembles the parametric approach (Sarstedt et al., 2011). The PLS-MGA is based on bootstrapping results used for testing the potential group differences. The result is considered to be significant at the 5% probability of error level, if the *p*-value is smaller than *0.05* or larger than *0.95* for a certain difference of group-specific path coefficients.

However, concern must be expressed in regard to the ability of established methods to detect differences between groups for non-normal, highly skewed data and small sample size (e.g.Qureshi & Compeau, 2009). Thus, the results of the current analysis may underestimate the existing difference between compared groups.

When engaging in PLS-MGA, it is recommended that the number of observations in each group be checked to see if they meet the rules of thumb for minimum sample size requirements (Joseph F. Hair et al., 2014). The largest number of explanatory variables pointing to an endogenous construct was six for the *innovativeness* variable, while the minimum number of cases in each group should exceed 60.

Table 5.25 shows that sub-sample size obtained as a result of splitting the sample into two groups based on the values of the group moderator variables met the criteria.

Table 5.25 Grouping variables for multi-group analysis

Grouping variable	Segregation criteria	No. of cases Group 1	No. of cases Group 2
Company size	Group1 - Small businesses - FTE < 20 Group2 - Medium to large businesses FTE > 20	72	84
Position in Tier structure	Group1 – Tier 1-2 – work directly with resource companies or EPC/EPCM providers Group 2 – Tier 3 and below	83	73
Membership in associations	Group1 – Do not hold membership in any relevant industry association Group 2 – Active member of relevant industry associations	97	65

Evaluation of measurement invariance. *Measurement invariance* (also referred to as *measurement equivalence*) implies that the effect of a categorical moderator is applied only to the path coefficients and does not entail group-related differences in the measurement models.

> *If measurement invariance is not established, the differences in path coefficients cannot be fully attributed to true relationships, because respondents from different groups might have systematically interpreted a given measure in conceptually different ways... (Sarstedt et al., 2011, p. 214)*

Rigdon, Ringle, and Sarstedt (2010) argues that:

> *An insistence on measurement invariance across groups carries its own assumption that the impact of group membership is limited to the structural parameters of the structural model. In many cases, this assumption is questionable or even implausible, and researchers should consider group membership effects on both structural and measurement parameters… (p. 269)*

Furthermore, the PLS-SEM literature (e.g.Joseph F. Hair et al., 2014) suggests that although measurement invariance is a necessary condition in SB-SEM, in PLS-SEM being a method of approximation is:

> *Designed for the situations with a less firmly established theoretical base…It may be best for researchers to express appropriate caution in interpreting results from PLS path analysis involving multiple groups… (Rigdon et al., 2010, p. 269)*

In the current study, the measurement model was assessed separately for each subgroup following (Ahuja & Thatcher, 2005; Sarstedt et al., 2011) to ensure that it satisfied the requirements for construct reliability and discriminant validity, as well as the discriminant and convergent validity of each indicator (Wynne W. Chin, 1998). According to Ahuja and Thatcher (2005), items should load and cross-load consistently across samples.

Investigation of the moderating impact of *company size* on structural model relationships. To investigate the moderating impact of *company size* on model relationships, the PLS MGA procedure, was run for small businesses with less than five employees and enterprises with more than five employees.

PLS model analysis revealed that all measures met the suggested criteria for measurement model evaluation (Joseph F. Hair et al., 2014). Specifically, the analyses per each group showed that all indicators had loadings above 0.70 and the constructs' AVE values were above 0.50 (Appendix H — Table 1 and 2). Likewise, all constructs achieved high composite reliability values of 0.80 and higher (Appendix H – Table 3). Measurement models for both groups clearly met the requirement of construct and indicator discriminant validity.

Appendix H Tables 4 and 5 demonstrate the results of the structural model evaluation using the PLS MGA algorithm. The bootstrap procedure of 5,000 samples and a number of cases equal to the sub-group sample size (no sign change option) was conducted.

A comparison of the group-specific path coefficients in Table 5.26 reveals several differences in the effects.

Table 5.26 Identified significant differences in structural model path coefficients between groups

	β Group1	β Group2	t-Values Group1	t-Values Group2	p-Values Group1	p-Values Group2	β-difference (Group1 – Group2)	p-Value (Group1 – Group2)
ABS CAPACITY -> CAP_DIV	0.198*	-0.111		1.001	0.06	0.318		
EIGENVECTOR -> INNOVATIVENESS	0.265**	-0.113	2.441	0.873	0.015	0.383	0.375	0.018
EIGENVECTOR -> SECT_DIVERSIFICATION	0.385***	0.115	2.901	1.052	0.004	0.293	0.284	0.062
TRUST -> JOINT PROBLEM-SOLVING	0.228**	-0.044	2.33	0.409	0.02	0.683	0.279	0.021

N=156. Significant paths (β>0,*p<0.1** p<0.05, ***p<0.01). Group 1 – Small businesses (less than 5), Group 2 – Medium and Large (5-20employees, 200+)

For example, whereas *absorptive capacity* has had a strong effect on *capability diversification* in the small businesses subsample (0.191, p< 0.10), it produced an insignificant negative effect in the medium and large companies subsample.

Similarly, *eigenvector centrality* has exerted a significant and positive influence on *innovativeness* in the small businesses subsample (0.265, p<0.05), while for medium and large companies, it was non-significant and negative. Furthermore, in respect to the *small businesses group* subsample, *eigenvector centrality* also yielded a significant effect on *sectoral diversification* (0.385, p<0.05) for small businesses, as opposed to Group 2. Finally, the relationships between *trust* and *joint problem-solving* in the small business group yielded a significant effect on *joint problem-solving* (0.228, p<0.05), while there was no effect for Group 2.

Investigating the moderating impact of *tier position* on structural model relationships. To investigate the moderating impact of tier position on model relationships, the PLS MGA procedure was conducted for two groups: Group 1 – Tier 1 suppliers to resource companies and EPC/EPCM providers and Group 2 – lower tier suppliers.

Assessment of the measurement model for each group showed adequate results in terms of loadings, AVE, composite reliability and discriminant validity (Appendix H – Tables 6 - 10). Appendix H Tables 11 and 12 demonstrate the results of the structural model evaluation using the PLS MGA algorithm. The results of the structural model evaluation by means of PLS MGA are shown in Table 5.27.

Table 5.27 Significant differences in structural model path coefficients between groups

	β Group 1	β Group 2	t-Values Group 1	t-Values Group 2	p-Values Group 1	p-Values Group 2	β - difference (Group1 – Group2)	p-value (Group1 – Group2)
CAP_DIVERSIFICATION -> SECT_DIVERSIFICATION	0.397***	0.106	3.253	0.795	0.001	0.427	0.294	0.054
CENTRALITY -> CAP_DIVERSIFICATION	0.519***	-0.009	4.321	0.05	0	0.96	0.561	0

N=156. Significant paths (β>0, ***p<0.01)
Group 1 – Tier 1 suppliers to resource companies and EPC/EPCM providers, Group 2 - lower tier suppliers

Capability diversification yielded a strong effect on sector diversification in the Tier 1 supplier subsample (0.397, p<0.01), having an insignificant effect in lower tier subsample. *Degree centrality* exerted a significant and positive influence on *capability diversification* in the Tier 1 subsample (0.519, p<0.01), while for lower tiers it was non-significant.

Investigating the moderating impact of association membership on structural model relationships. To investigate the moderating impact of *association membership* on model relationships, the PLS MGA procedure was conducted for two groups: Group 1 – those not holding membership in any association and Group 2 – active members of industry associations. The significant differences between groups are demonstrated in Table 5.28.

Centrality yielded a strong effect on *capability diversification* in the non-members' subsample (0.476**, p< 0.05), while having an insignificant effect in the members' subsample. Finally, *information exchange* yielded a much higher effect on *joint problem-solving* (0.716***, p<0.01) for non-members, than for members (0.396***, p<0.01).

Assessment of the measurement model for each group showed adequate results in terms of loadings, AVE, composite reliability and discriminant validity (Joseph F. Hair et al., 2014) (Appendix H Tables 13-16). Appendix H Tables 17 and 18 demonstrate the results of the structural model evaluation using the PLS MGA algorithm.

Table 5.28 Significant differences in structural model path coefficients between groups

	β Group 1	β Group 2	t-Values Group 1	t-Values Group 2	p-Values Group 1	p-Values Group 2	β - difference (Group1 – Group2)	p-value (Group1 – Group2)
CENTRALITY -> CAP_DIVERSIFICATION	0.476**	0.142	2.52	1.227	0.012	0.22	0.364	0.067
IE -> JOINT PROBLEM-SOLVING	0.716***	0.396***	13.008	3.471	0	0.001	0.32	0.005
N=156. Significant paths (β>0, *p< 0.10, ** p<0.05, ***p<0.01) Group 1 – No involvement in industry associations, Group 2 – Active members of industry associations								

5.8 Chapter summary

This chapter presented a detailed description of the quantitative study undertaken as part of the current research to test the relationships postulated in the conceptual model.

In particular, the relationships between METS firm *innovativeness*, *capability, sectoral diversification*, and *absorptive capacity* were measured as a combined effect of investment in R&D and new product development. *Positional* and *relational embeddedness* were also tested.

Partial least square structural equation modelling (PLS-SEM) was conducted to test the relationships among variables postulated in the conceptual framework. To do so, firstly SNA of the SA resource sector regional supply chain network was undertaken to calculate the *positional embeddedness* as one of the model variables. A survey then was conducted to measure other constructs and variables in the conceptual model. For the quantitative study, the procedures of the survey questionnaire development, pilot and main study, data treatment and analysis, including measurement and structural model evaluation described in detail.

The direct, mediation and moderation effects were explored in the model. The mediational paths via indirect effects of exogenous variables on endogenous variables were investigated. The moderation effects were also tested, including multigroup analysis to test the moderation effect of METS' *company size*, *tier position in the resource supply chain*, and *membership in industry associations*. The combined effects of exogenous variables exerted on the endogenous variables *diversification* and *innovativeness* were also tested to increase the percentage of variance explained. The hypotheses testing summary is presented in Table 5.31. All significant b direct relationships in the conceptual model are shown in Figure 5.15.

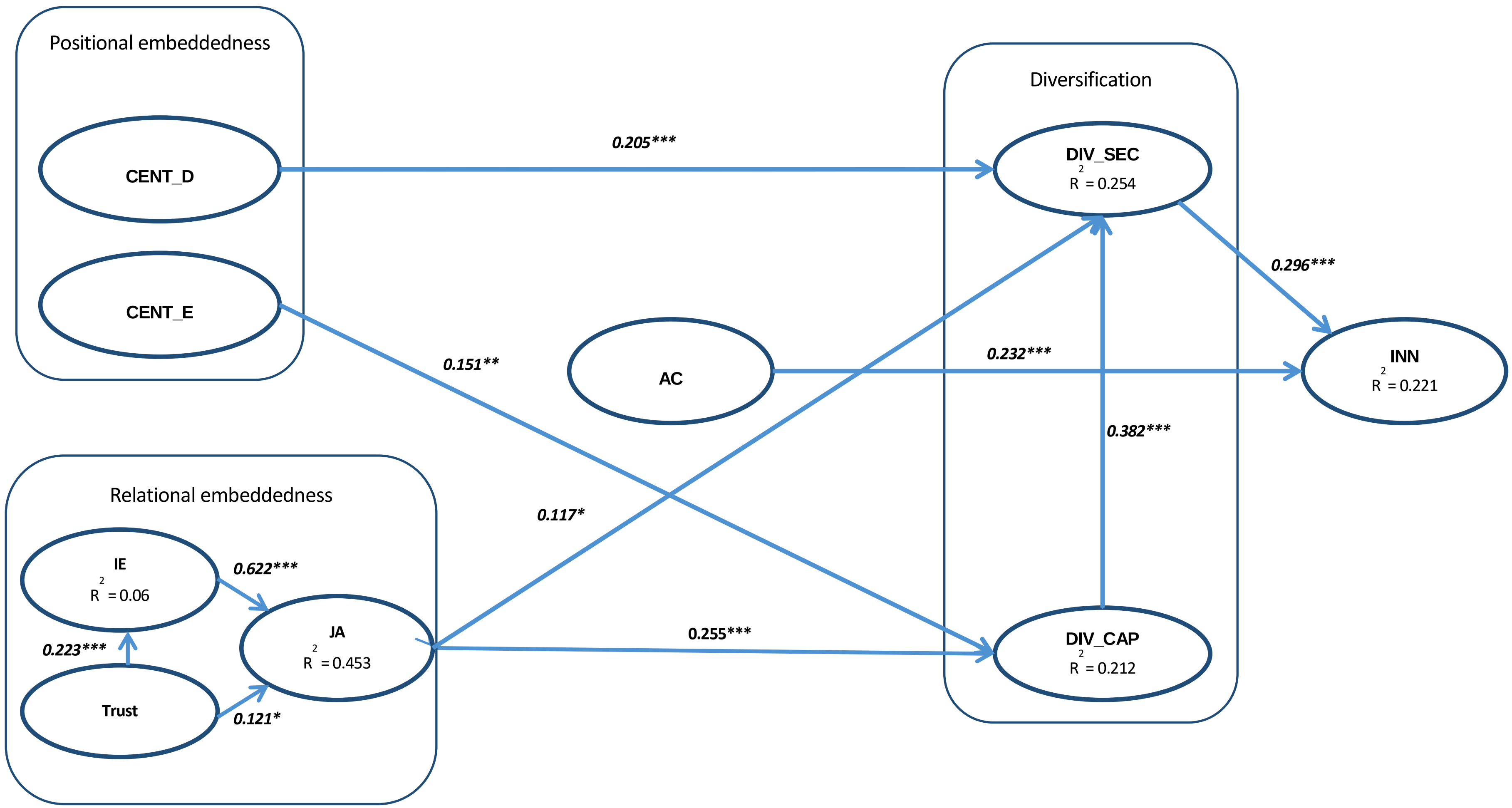


Figure 5.15 The conceptual model with significant relationships between variables

The interpretation of the results with the reference to previous literature and qualitative findings is provided in Chapter 7 – Discussion.

Table 5.29 The hypotheses testing summary

	Hypothesis	Causal Path	Hypothesis supported
H_{1a}	Positive relationships between capability diversification and sectoral diversification	CAP_DIV -> INN	Indirect effect via mediator
H_{1b}	Positive relationships between capability diversification and supplier innovativeness	CAP_DIV -> SECT_DIV	Yes
H_{1c}	Positive relationships between *sectoral diversification* and supplier *innovativeness*	SECT_DIV-> INN	Yes
H_{2a}	There is a positive relationship between supplier *absorptive capacity* and *capability diversification*	ABS CAPACITY -> CAP_DIVERSIFICATION	No
H_{2b}	There is a positive relationship between supplier *absorptive capacity* and *sectoral diversification*	ABS CAP -> SECT_DIV	No
H_{2c}	There is a positive relationship between supplier *absorptive capacity* and *supplier innovativeness*	ABS CAP -> INN	Yes
H_{3a}	There is a positive relationship between resource related regional supply network *positional embeddedness* (degree and eigenvector centrality) and *capability diversification*	CENTRALITY -> CAP_DIV EIGEN -> CAP_DIV	Yes No
H_{3b}	There is a positive relationship between firm regional *supply network positional embeddedness* (degree and eigenvector centrality) and *sectoral diversification*	CENTRALITY -> SECT_DIV EIGEN -> SECT_DIV	Full-mediation effect Yes
H_{3c}	There are positive relationships between resource regional *supply network positional embeddedness* (degree and eigenvector centrality) and firm *innovativeness*	CENTRALITY -> INN EIGEN -> INN	Full-mediation effect No
H_{4a}	There are positive relationships between *joint-problem solving* and supplier *capability diversification*	JOINT PROBLEM-SOLVING -> CAP_DIV	Yes

	Hypothesis	Causal Path	Hypothesis supported
H_{4b}	There are positive relationships between *joint-problem solving* and supplier *sectoral diversification*	JOINT PROBLEM-SOLVING -> SECT_DIV	Yes
H_{4c}	There are positive relationships *between joint-problem solving* and supplier *innovativeness*	JOINT PROBLEM-SOLVING -> INN	No
H_{5a} H_5 -> H_{4a}	There are positive relationships between the scope and quality of *information exchange* and supplier *capability diversification* mediated by *joint problem-solving* in supplier-customer relationships	IE -> JOINT PROBLEM-SOLVING-> CAP_DIV	Yes
H_{5b} H_5 -> H_{4b}	There are positive relationships between the scope and quality of *information exchange* and supplier *sectoral diversification* mediated by *joint problem-solving* in supplier-customer relationships	IE -> JOINT PROBLEM-SOLVING-> SECT_DIV	Yes
H_{5c} H_5 -> H_{4c}	There are positive relationships between the *scope and quality of information exchange* and supplier *innovativeness* mediated by *joint problem-solving* in supplier-customer relationships	IE -> JOINT PROBLEM-SOLVING -> INN	No
H_{6a}, H_{7a} H_7 -> H_{4a} H_6, H_5 -> H_{4a}	There are positive relationships between *trust* in exchange relationships and supplier *capability diversification* mediated by *information exchange* and *joint problem-solving* in supplier-customer relationships	TRUST -> JOINT PROBLEM-SOLVING-> CAP_DIV TRUST -> IE -> JOINT PROBLEM-SOLVING-> I CAP_DIV	No No
H_{6b}, H_{7b} H_7 -> H_{4b} H_6, H_5 -> H_{4b}	There are positive relationships between *trust* in exchange relationships and supplier *sectoral diversification* mediated by *information exchange* and *joint problem-solving* in supplier-customer relationships	TRUST -> JOINT PROBLEM-SOLVING-> CAP_DIV TRUST -> IE -> JOINT PROBLEM-SOLVING-> SECT_DIV	No No
H_{6c}, H_{7c} H_7 -> H_{4c} H_6, H_5 -> H_{4c}	There are positive relationships between *trust* in exchange relationships and supplier *innovativeness* mediated by *information exchange and joint problem-solving* in supplier-customer relationships	TRUST -> JOINT PROBLEM-SOLVING-> INN TRUST -> IE -> JOINT PROBLEM-SOLVING-> INN	No No
H_8	*Firm size* moderates moderates relationships postulated in the	ABS CAPACITY -> CAP_DIVERSIFICATION	Significant only for small

	Hypothesis	Causal Path	Hypothesis supported
	structural model *	EIGENVECTOR -> INNOVATIVENESS	businesses (FTE<5)
		EIGENVECTOR -> SECT_DIVERSIFICATION	
		TRUST -> JOINT PROBLEM-SOLVING	
H_9	*Tier position in the resource supply chain* – resource company or EPC/EPCM provider relationships postulated in the structural model*	CAP_DIVERSIFICATION -> SECT_DIVERSIFICATION	Significant only for Tier 1 suppliers
		CENTRALITY -> CAP_DIVERSIFICATION	
H_{10}	*Company membership in industry associations* – resource company or EPC/EPCM provider moderates relationships postulated in the structural model*	CENTRALITY -> CAP_DIVERSIFICATION	Positive significant for non-members
		IE -> JOINT PROBLEM-SOLVING	Positive significant for both, significantly larger for non-members

*Relationships with the significant difference between groups only

Chapter 6

Qualitative study

6.1 Introduction

This chapter describes the procedures and findings of the qualitative study. The objective was to triangulate the results of the quantitative analysis and get broader insights into the context and mechanisms underpinning observed relationships. The structure of the Chapter 6 is depicted in Figure 6.1.

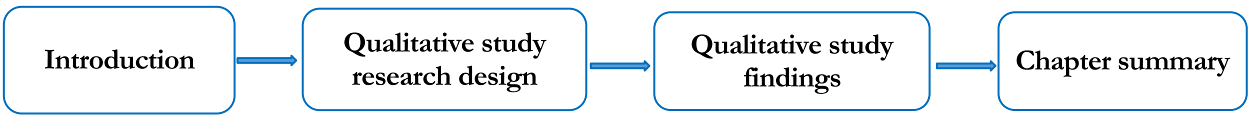


Figure 6.1 Chapter structure

The qualitative section of the study was primarily designed to answer research question (RQ)1:

> *What is the SA METS companies' ability to adapt during a downturn period in the resource sector?*

And sub-questions:

> *RQ1.1 What types of strategies have METS firms operating in South Australia adopted?*
>
> *RQ1.2 What is the current state of network governance (relational and positional embeddedness of METS firms) in the SA resource and energy supply chains?*

In addition the qualitative section sought to clarify relationships postulated in the conceptual model and tested in quantitative analysis, thus answering RQ2:

> *How do the structure and relationships in the resource sector supply networks (network governance) affect METS firms' ability to adapt to a changing business environment?*

The semi-structured interview questions were composed with the goal of answering the research questions related to the conceptual framework proposed in Chapter 3. The interview questions were structured around the concept of supply chain relationships, firm adaptability – diversification and innovativeness and adaptation strategies – and structural and relational embeddedness. Thematic analysis of the interview data was conducted and data were coded into themes and sub-themes using *NVivo* 11.

6.2 Qualitative study methods and procedures

According to Patton (1990), interview data contain direct quotations about experiences, opinions, feelings and knowledge of research participants. To get an in-depth understanding of the level of METS firms' embeddedness in the SA resource sector supply networks, attitudes to collaboration across the supply chain, barriers and opportunities and their effects on decision making and ability to innovate and diversify as perceived by SA METS firms' managers, 24 METS firms' senior managers (CEOs, owners, chairmen and general managers) were interviewed.

6.2.1 Development of the interview guide

The interview guide for METS companies was structured around hypotheses postulated in the conceptual model proposed in Chapter 3. In particular, the strategies adopted by SA METS firms and the steps taken to adapt to the downturn period in the resource sector were investigated. Furthermore, questions of *how* and *why* positional and relational embeddedness in the resource industry regional supply networks impacts METS firms' innovativeness and diversification were addressed. In addition, the role of METS firms' absorptive capacity in benefitting from embeddedness in terms of innovativeness and diversification guided qualitative data collection (see Appendix I).

A supplementary range of questions was developed to obtain views from the 'customer side' of the resource industry supply network, i.e., mining operators and Tier 1 large service providers. These questions were mainly related to resource companies' supply chain strategies, engagement of local firms, as well as factors influencing these strategies (see Appendix I).

Industry associations and government officials involved in the development of local supply chains were also interviewed to obtain a contextual background and 'big picture' view of regional supply chain development.

Interview sessions were focused on participants' opinions and perceptions of internal and external factors and mechanisms encouraging or impeding firm diversification into new markets, implementation of innovative solutions and growth strategies. Furthermore, to get broader insights through alternative views, individual semi-structured interviews with government representatives involved in the development of the METS sector in South Australia, heads of resource industry associations, major resource companies and leading EPC/EPCM providers and METS companies supplement the interview data from METS companies. The interview guides are presented in full in Appendix I.

Exhibit 6.1 Interview questions for METS companies

(Q1)	company/organisation profile, capabilities and history and current affiliation with the resource sector in South Australia
(Q2)	drivers and strategies for new products/ services introduction, organisation of R&D processes within the company
(Q3)	drivers and strategies for diversification, company's presence in other industry sectors
(Q4)	nature of company relationships with customers and suppliers
(Q5)	attitudes towards collaboration/partnering, forms of collaboration in supply chain
(Q6)	internal and external factors influencing company's strategy, including effects of downturn in the resource sector and SA resource supply networks restructuring
(Q7)	attitudes and perceived value of industry associations and specialised organisations
(Q8)	influence of government policies and initiatives METS firms ability to innovate and diversify

Government officials, industry association leaders, resource companies and EPC/EPCM providers were asked provide their insights into a 'big picture' of the current situation in the resource sector and associated supply chain problems, opportunities as well as give insights into possible solutions.

Exhibit 6.2 Interview questions for other stakeholders involved in development of SA resource supply networks

(Q1)	Current situation within the SA resource supply chain: challenges and opportunities
(Q2)	METS firms innovativeness and diversification – current level, opportunities and barriers
(Q3)	current initiatives implemented by (mining operator, EPC/EPCM provider, industry association, government agency) to engage with local suppliers and develop local supply chains and METS sector in general
(Q4)	Insight into effects of downturn in the resource sector and SA resource supply chain restructuring on SA resource supply networks
(Q5)	Other macro-level factors influencing dynamics of relationships within SA resource supply networks

6.2.2 Qualitative data collection

Using company profiles and willingness to contribute as criteria, 24 companies representing the SA METS sector were selected to participate in the research (see Appendix J). The selected cases were bound by time and place as suggested by Creswell (2013) – the METS companies supplying services to the resource sector of South Australia in 2015-2016 at a period of global downturn in the resource sector. A diverse range of core capabilities and company sizes was desirable to obtain a variety of views on the structure and nature of relationships within the resource supply chains, diversification and innovativeness. The companies differed in size and turnover, core capabilities, and position in the resource supply chain.

Face-to-face semi-structured interviews were undertaken with METS owners and senior level managers to get insights into the SA resource sector supply network 'embeddedness', diversification and innovation strategies, allowing an exploration of interpretations and meanings that could not be uncovered in the survey.

Each of the participants was interviewed by the researcher for between one and two hours. All interviews were recorded with the permission of the participants (see Chapter 4 – Research design, Section – 'Ethical considerations'). The researcher also made notes while interviewing respondents.

The analysis of the rich data obtained from the interviews was undertaken using *NVIVO* 11. The interview recordings were fully transcribed, and electronic versions of transcriptions were sent to interviewees for verification and approval.

Interview transcripts were coded using *NVivo* 11 to identify major themes corresponding to the research question. To complement and triangulate primary data obtained through in-depth semi-structured interviews, analysis of secondary sources was undertaken. Complementary sources included government and industry association reports, websites, and industry press.

6.2.3 Qualitative data analysis

According to King and Horrocks (2010), thematic analysis includes three major stages, summarised in Figure 6.1. The interpretive nature of any qualitative research assumes the non-sequential iterative process of data analysis procedures. The researcher usually goes back and forth between the three stages to refine the initial coding structure and rethink the definition of the themes emerged from the data.

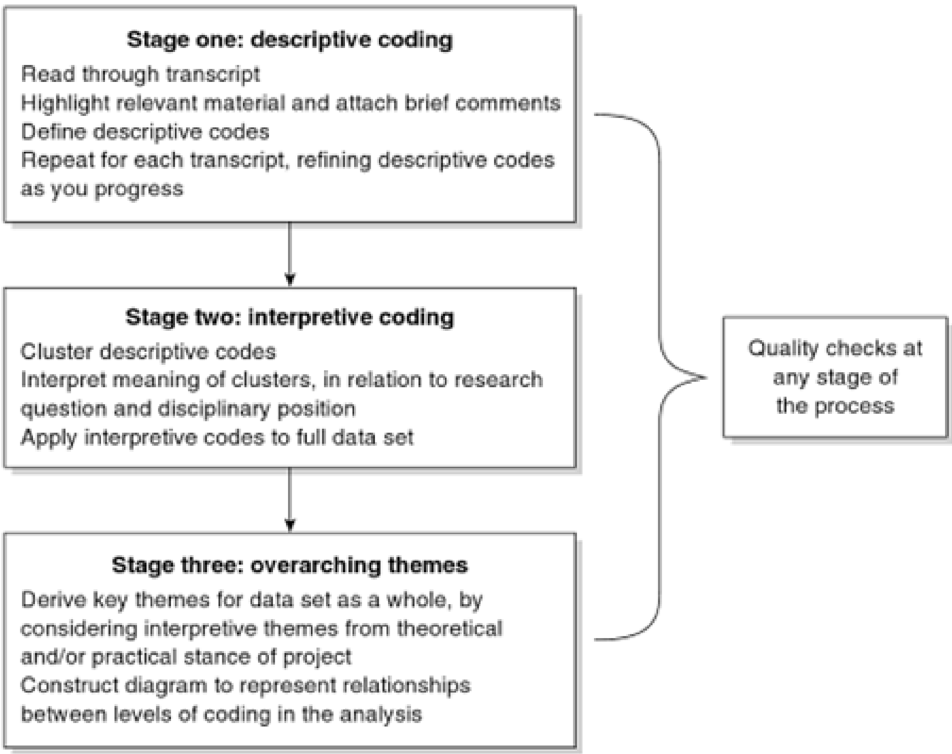


Figure 6.2 The major stages of thematic analysis from King, & Horrocks (2010, p.153)

Stage one. The first stage involved identification of the parts of the interview that were most relevant to the research problem. The objective was to describe phenomena of interest based on the interview participants' accounts, rather than interpret their actual meaning. Encoding with *NVivo* 11 was performed at this stage. This stage corresponds to the initial coding phase. It includes data examination and comparison to find similarities and differences in the data.

The *first stage of coding* was performed using structural coding, in which the initial raw data was labelled. Data were organised around research questions and the associated conceptual framework (Miles et al., 1984). The labels assigned to the data included:

- diversification strategies
- innovation strategies
- adaptation strategies
- absorptive capacity of the METS
- structural and relational embeddedness
- industry associations
- collaborative strategies.

Stage two. *The second stage* stretched the analysis beyond the description of participant perceptions by interpreting the meaning from the researcher's perspective, which was identified in the methodological literature as a 'pattern coding'. The descriptive codes that shared common meaning were collated and *interpretative meanings* for each group of descriptive codes were assigned to each group. The major underlying themes and patterns across the data segments were identified, as well as causes and explanations of the phenomena. *NVivo* 11 was used to facilitate the aggregation of ideas into higher-order theoretical constructs by creating 'parent nodes'. As a result of this process, themes and concepts were organised in a hierarchical structure.

During the *second stage* of pattern coding, the *diversification strategies* were divided into *adaptability strategies* and *adaptation strategies* following the definition provided by (Chapman et al., 2004). Among adaptability-oriented diversification strategies, *inter-sectoral diversification*, *expansion of geographical scope,* and *innovativeness,* that is, strategies related to the emergence of new market niches and renewal of the regional economy. *Adaptation strategies* that mainly focused on a company's survival included *maintaining portfolio of works of different sizes to spread risks, downsizing and changing company structure*, *maintaining existing* and *building new relationships with customers.*

Stage three. *The third stage* involved the identification of the overarching themes representing the key concepts of the analysis. The interpretative codes were aggregated in alignment with the concepts derived from the theoretical frameworks underlying this research. Interpretative meanings with reference to theoretical constructs were assigned to the descriptive nodes. Theoretical constructs from the literature, as well as themes that emerged from the data, were matched and compared. This structure served as a basis for extension and enrichment of the conceptual framework based on the analysis of the literature, and is part of the main content of this chapter.

The third pass included the identification of codes relevant to variables in the conceptual model, positional and structural embeddedness, network governance, tier position in the supply chains, and the role of industry associations. Furthermore, several themes emerged outside the scope of the conceptual model, involving supply chain restructuring issues, the role of government, and compliance to industry standards.

Theoretical constructs contained in the conceptual framework developed from the literature, were cross-tabulated with the emerging interview themes. The researcher interpreted the data based on existing knowledge of the literature and empirical studies related to the issues of resource-based regional economies development and the role of inter-firm networks. This step was taken to see whether the constructs and themes chosen could be used to categorise recurring texts from the interview transcripts, as well as the field notes taken by the researcher.

The steps of the data analysis were recorded in the research journal *NVivo* with associated mind maps, diagrams and reflection notes.

6.2.4 Trustworthiness

Triangulation of the data sources was ensured by using multiple sources of information to assess the trustworthiness of the qualitative data by establishing its credibility, transferability, dependability and conformability (Bryman & Braun, 2012; Lincoln, Lynham, & Guba, 2011).

The researcher experienced a '…prolonged and intense exposure to the phenomenon under study within its context…' (Krefting, 1991) to build rapport with METS companies' representatives, industry associations and the SA government. The multiple perspectives from the different layers of the resource supply chain and stakeholders were collected to reduce the potential for social desirability responses in the interviews (Krefting, 1991).

The field notes and *NVivo* electronic journal were kept and peer examination of the data was conducted. A double coding procedure was applied by the researcher, and the research assistant was hired to perform independent coding to triangulate codes and categories.

6.3 Qualitative study findings

This section describes themes and sub-themes that emerged as a result of interviewing METS owners and senior managers, and analysing the data. The primary objective of the qualitative study was to obtain in-depth insights into the constructs and relationships postulated in the conceptual framework. The qualitative findings enriched the explanation of the conceptual framework variables, i.e., METS diversification and innovativeness strategies, absorptive capacity, and network governance in the resource sector supply chain (relational and positional embeddedness).

A variety of SA METS adaptability (innovativeness and diversification) and adaptation strategies related to perceptions of *network governance* were explored, with *network governance* defined as business collaboration across the supply chain (relational embeddedness) and positioning in the supply chain (positional embeddedness).

Adaptability strategies, adaptation strategies, and network governance as observed in the data are discussed in the following sections of this chapter.

6.3.1 SA METS diversification strategies

METS diversification during a downturn is a mechanism of adapting to a changing market environment(Chapman et al., 2004). Findings showed that for SA regional METS developed different strategies to reduce risks during recession in the primary streams of income. Most METS developed their capabilities by addressing the specific problems of resource companies. As their expertise developed, METS became technologically capable and were able to develop a more diverse range of solutions and penetrate new markets.

Sectoral diversification. The majority of SA METS companies pursued sectoral diversification. The METS were interviewed with no regard to size, capabilities or supply chain position, and recognised the importance of a balanced portfolio of projects across several sectors, due to the ‘peaky’ nature of the mining and oil, & gas sectors. However, the most diversified firms were large size METS operating at the higher tiers of the resource value chain. Larger sized METS acknowledged that the company constantly monitored and target markets other than the resource sector. The companies providing knowledge intensive services, such as for example engineering design and project management, technical consultancy operated across several sectors, including but not limited to defence, infrastructure and water industries. More technology and labour intensive companies, such as electrical engineering, manufacturing and construction companies, also switched to large-scale projects in other industries.

An example of lateral migration of technologies through sectoral diversification includes a METS firm supplying automation and control technology to the resource sector that find applications for their technologies and services in the food and beverage and the agriculture sectors.

Analysis of the data indicated that most of the METS had a significant share in non-resource sectors. Interview participants noted that they were involved in construction, manufacturing, defence, water, utilities, transport, infrastructure and civil construction, and agriculture. The larger companies maintained project portfolios of various sizes in several industries in order to reduce the risk associated with the normal volatility of the resource sector. A number of participants commented on this. A representative from an engineering and construction company (1) said:

> *We seem to find other pockets. With the downturn in mining the last couple of years, we've been very busy in the rail traction sector. Engineering and Construction Company*

While someone from an environmental, technical and consulting service spoke about targeting the whole of the water sector, including:

> *Utilities. Water, or the SA power networks, Origin Energy, or those types of companies. Environmental, technical and consulting service*

Typically, businesses concentrated on their areas of expertise, for example, a hydraulics, and pneumatics equipment and services supplier noted that his firm was involved with 'a lot of mining, a lot of defence' and that 'agriculture's a big, general industry which is shrinking', so the firm focussed on 'just general consumable products in hydraulics'.

A recruitment and labour hire company representative explained how they were attempting to deal with the situation:

> *We're still looking to look broader again, and we need to, because there's not the work in mining, and the construction work tends to be project orientated. That means we need to go into different industry sectors…We're trying the new sectors, then the traditional business increases. Recruitment and labour hire company*

Being reasonably diverse, larger diversified companies saw the downturn in the resource sector as an opportunity rather than a challenge, and adopted proactive diversification strategies by monitoring the revenue stream from different sectors and proactively targeting sectors with growing demand. A recruitment and labour hire company representative demonstrated the adaptability of his firm, for example, remarking that:

For us it's [downturn] an opportunity to diversify; retaining our core business, but diverse on top. When the core business improves, then we reap the benefit of that as well… Recruitment and labour hire company

In emerging sectors like the IT sector, it makes sense to be involved. Technology is evolving and always will do. You kind of look at sectors that are 'recession proof'. Recruitment and labour hire company 2

The senior manager of the branch of a US owned company operating in South Australia in engine and industrial air, oil and liquid filtration solutions for more than 20 years spoke about the benefits of having a diverse portfolio to begin with when a downturn came:

Well if the industry's down, there's nothing that our company can do about that apart from try and obtain growth out of other markets and other sectors of business… The resource sector will always be very important to us. Because we are so diverse we're quite fortunate because when one industry comes down, it's normally offset by others… International company providing engine and industrial air, oil and liquid filtration solutions

Interviewees from smaller companies stressed the importance of personal networks and existing relationships with customers as assets when attempting to diversify or survive a downturn. The director of a small size METS providing automation and control services for resource companies commented on this; and the CEO of a small company implementing automated solutions explained how his contacts with clients developed as a result of working for a large automation company in the water sector. When changing his workplace, he had brought several members of the team to the new company.

After working for […] I worked for another system integration company […] who were basically specialised primarily in the water sector. I'd moved on to […], but I knew the team there and I knew the caliber of the people, and I thought they had very complimentary expertise to the team at [], so quite a few of the same team came onboard with us. And with that assisted us in penetrating that water sector, and we've been able to build on that client base from there... Engineering company specialising in integrated systems including industrial automation, robotics, and continuous process control.

A constant search for new customers expands a firm's opportunities and allows for gradual capability growth by solving different problems for customers from various sectors.

> *Try to make those contacts or form those relationships that give us the opportunity to start quoting on jobs, and then hopefully winning those jobs…. Because we service a lot of different customers and a lot of different industry sectors we get exposed to a lot of different opportunities as well… Engineering company specialising in integrated systems including industrial automation, robotics, and continuous process control.*

For smaller companies, supplying highly specialised services, such as drilling and exploration, the mining and oil, & gas industries were still considered to be a major part of their income.

The data made it clear that these firms were aware of the need to diversify, and understood the value of opportunities to extend their skills and relationships, although not all interviewees were as active as others, as indicated by a highly specialised wireline service supplier to the mining and oil and gas industry, who seemed to understand diversification was needed, but difficult for his firm. The only opportunity for the firm was to diversify across various commodities:

> *The main aim over the next 12 to 18 months is survival. Now I'm in a very challenging work environment. Beyond that, it really depends on which commodity picks up. We can tailor our services a little bit across commodities… Provider of wireline services for mining industry*

Geographical diversification. Medium and large size METS companies pursued geographical expansion by targeting overseas markets. These mainly include Asian markets – Singapore, China, Japan, Papua New Guinea, Indonesia. Availability of local networks overseas is vital for establishing business overseas which is consistent with the previous research on internationalisation. The interviewee who was a technical and consulting services provider summed up the general feeling among the participants by saying:

> *Expanding the geographical market...We've done a little bit of work in Africa, a little bit of work in Papua New Guinea as well… Technical and consulting services company*

Indonesia, Myanmar, Singapore, Hong Kong, Japan, China, Mexico, Argentina, and Chile were all mentioned as locations with which firms had made connections in order to diversify geographically.

Smaller and more specialised companies target mainly interstate markets, in particular the Northern Territory, since other Australian states are saturated with local highly competitive companies, competing for work with South Australian METS. These small specialised METS usually do not have networks and resources to internationalise. The major perceived barriers to doing work overseas were the hardships related to contractual and legal issues, equipment transfer, and lack of networks to establish business overseas, as was once more explained by the technical and consulting services provider as his firm was widely geographically active.

> *It doesn't really matter if you're doing work in Port Augusta or Africa as far as we're concerned; it's more the legal and contract side of it. That's a lot harder not having a presence in Africa, whereas if you tag along with an Australian based client that's doing work there, that's relatively easy… Technical and consulting services company*

Servitisation. A variety of servirtisation strategies also contributing to capability growth were recorded that fit equally to adaptation and adaptability. These include development of integrated services solutions through vertical integration and moving to the higher tiers, product-related services and product-service systems through internal service differentiation and and value co-creation with the supply chain partners.

Integrated service solutions/ vertical integration/ moving up in the value chain. Due to increasing trend of outsourcing of non-core capabilities to external service providers, there is a growing demand for business to business industrial services, such as facility operation and maintenance. External service providers do this at lower cost and risks and better performance. Integrated service solutions for resource companies usually involve deep, high-level understanding of the customer problem and the creation of additional value for a customer by providing a full 'turnkey solution' (R. Kumar, Singh Panesar, & Markeset, 2009; Panesar et al., 2008; Scott-kemmis, 2013).

More resourceful suppliers with the appropriate level of certification processes and systems perceive downturn in the resource sector as an opportunity to become direct providers to resource companies providing integrated services solutions. These METS used to deliver services to resource companies through a third party, such as an EPCM/EPC provider. Downturn in the sector allowed regional METS moving up the resource supply chain, becoming direct subcontractors to resource projects. During downturn times for resource companies adopting cost cutting strategies, smaller local service providers become a better choice than large national or international businesses. Local METS have the capabilities, risk profile and project management skills that allow coordinating reasonably large projects, at the same time being able to provide more flexible and cost-effective solutions with excellent knowledge of local environment and conditions compared with large international EPC/EPCM. The representative of a multifaceted engineering and design company that participated in the study commented that:

> *That's why we really fit in to what's going on. The Tier 1s are very expensive, as you know…Now the people that are sick of paying big dollars and who need to make budget because there's no money out there, all the sudden they're all dropping off their normal suppliers, and we get busier and busier... Technical services company*

The major challenge for these small companies is to market themselves to the resource companies, since they were often not visible to them.

> *The strategy initially is just to let them know what we do... What's happened in the past is we've done a lot of work for these Tier 1 suppliers. But they would never even have heard our name because the Tier 1 supplier uses our work under their own name… Technical services company*

These companies have strong collaborative relationships with their supply chains, including mergers and acquisitions allowing them to integrate diverse technical capabilities to deliver integrated solutions to the client.

Expanding through the acquisition of complementary business can increase the value of a company.

> *[We] ended up buying their business, and that's why we've now shifted the manufacturing plant from Beverly down to Lonsdale. We now do all that… Engineering and construction company*

Product-service systems. SA METS companies supplying also adopted servitisation strategies, introducing integrated service solutions, product-related services and product-service systems. Most of the METS see opportunities in developing product related services and service differentiation. Several companies introduced new services in response to customer demand, and companies were actively investigating the opportunities to deliver complementary services for existing customers.

> *We have found that the service side has expanded big time. It would have grown because our end-customers have less maintenance people and they prefer to contract out to specialists in the industry…* Hydraulics and pneumatics equipment and services

> *Our existing work in the mining industry was with small SA based mines, who need equipment modification. We plan to market a bespoke service that starts with a collaborative design process to help increase supply bottlenecks in existing equipment, then follow through with the detailing, fabrication, surface treatment, transport, & installation - expanding this service to larger and interstate opportunities… Anonimous survey participant*

> *Services, what we call 'mine site' services. That's where we actually take over direct subcontracts for delivering the service. For example, over in New South Wales, we run the light vehicle servicing departments; light vehicle maintenance. We run the whole thing. It's not just about people, it's about programming the work, ordering and controlling consumables. It's more than just people; more than just the supply and the labour…* Recruitment, & Labour Hire company

Value co-creation with a supply chain partner is another way of expanding services range for local METS firms. For example, a large SA owned METS company which is a distributor for a large international electrical equipment provider has developed a complementary product and associated service, to add value for a customer to the vendor's product.

> *We are a distributor for […]. That's only something recently new, last 12 months, but we also developed a fuel block module, which is basically a transportable building as a fuel distribution center for their engines. We're value adding to their product as well. [] is supplying the power grid and that, but we're supplying the buildings. We're supplying the fuel delivery modules…* Engineering and construction company

While a services provider value adds by providing environmental management solutions, adding their expertise to that of another METS to service existing clients.

> *We are providing environmental risk management solutions to their existing clients. We're actually just, I suppose, value adding our expertise into the area there. Environmental and Risk Management services company*

Thus, the diversification of METS companies based on the capability upgrade include finding new market niches for products and services, expanding the presence of the business geographically, including growing the scope of the services and providing integrated solutions to the customer, diversification based on emerging technology breakthroughs, and servitisation strategies extend the existing framework for the Australian METS sector.

6.3.2 SA METS innovation strategies

Diversification and METS companies' capabilities upgrade requires innovations of different kinds, including incorporation of new technologies, developing new products and services (Dachs et al., 2014). Downturn in the resource sector for many companies acts as a driver for METS supplier innovations. Resource companies adopting cost cutting strategies seek for lean and innovative ways of performing their activities to reduce operation and labour costs.

The demand for automation of mining technology processes has created opportunities for METS providing automation and control solutions. The METS which provide services related to automation and control have a positive outlook for the future and see many opportunities in the resource sector.

> *The mining companies are increasingly investing in this sort of technology, because labour is expensive, safe operations in a mine are always a challenge, and if you remove the human factor from the mine site, you reduce the risk of injury and death to miners in the field… Supply chain consultant*

Types of innovations in SA METS firms. Based on the interview results, three types of companies in regard to their *attitude towards innovations* could be identified: (1) *disruptive innovators* – companies that actively invest in research and development and introduce new-to-market products and services; (2) *problem solvers for customers* – companies developing innovative solutions in response to customers' needs, thus organically building up their capabilities and expanding existing services; (3)

highly specialised incremental innovators – these companies innovate mainly through improvement in current processes by adopting new technologies, improving processes and business models.

The majority of METS who participated in the survey could be identified as *incremental innovators* and *customer problem solvers*. They invested no more than 10% of their revenue into R&D, with an average of 50% invested into new products and processes.

Disruptive innovations based on R&D. Disruptive innovators are represented by METS led by enthusiastic owners and business founders dedicating most of the profit to R&D and business development. These companies are oriented to the constant development of new technologies and their application in various sectors and creating new niches in the existing markets.

For example, a large size engineering design, project management and construction company with a representative among the participants owned the unique technology of glass reinforced cladding (GRC), which had found application in transportable building supply. This technology is a cheaper and a leaner alternative to existing tin-clad buildings, providing the company with a comparative advantage.

> *We developed a monocoque style construction with a third-party engineer…With the transportable buildings it's quite unique. We're the only manufacturer in Australia that uses GRC [Glass Reinforced Concrete] cladding…We put a lot of engineering expertise in that to develop the project...* Engineering and construction company

The company acquired a small supplier firm, who invented the technology and was actively commercialising it through finding applications in different sectors – mining, construction, and infrastructure.

Another example among the interviewees was a branch of a vertically integrated US owned international company that had been operating in South Australia for more than 20 years. This company was proactive in their development and commercialisation of technologies. The processes and procedures exist in the company to identify value of the technology developed and its application and suitability for a particular market.

When you know that you've got a technological advantage in some field, that's obviously a big strength...If we've got nice technology that leads in the area, well that's what we should take to the marke... International company providing engine and industrial air, oil and liquid filtration solutions

Another example was a SA based small size innovative company, which has developed a disruptive technology of significantly reinforced coating that could be used in crushing machines. The technology is based ona laser deposition method, which was used to develop a technology to produce a reinforced cladding for equipment parts, significantly outperforming existing analogues in the industry. The technology allows for extended wear life and reduces overall operating costs.

In 2014 our R&D group based in SA developed a new laser deposition methodology that creates new product and service opportunities. The most attractive of these involves embedding this new technology into exportable products. Test products are in a number of new markets, some of these re converting into delivered sales orders, others require new establishing international distribution channel partners... Engineering and Manufacturing company

Currently the company strived to attract investments and connect to large resourceful players locally and internationally to make the technology an international standard. The company actively sought government grants and supply chain partners among top tier equipment suppliers to incorporate technology into their products. The company succeeded in building an alliance with the large size original equipment manufacturer operating in South Australia and continued seeking for opportunities to internationalise the technology. There were other examples of companies that have developed innovative technologies of mineral processing based on R&D results, but smaller companies usually struggle to find partners and investors to commercialise technology and create a business models.

Companies develop technologies and can then use them strategically in the market.

It's a lot faster to take something that the company's developed and then say okay, we've got this product here that is going to fit into this market or that market and so take what they've given you and then find the market. If we've got nice technology that leads an area, well that's what we should take to the market… International company providing engine and industrial air, oil and liquid filtration solutions

One participant company had developed an innovative way of cleaning fuel for trucks by using special bacteria. The company understood the market value of this technology and focussed on its commercialisation.

> *What we'll focus on here will also change comparative to the technology that we've got and its suitability to an application to make revenue…When you know that you've got a technological advantage in some field that's obviously a big strength. While we've got that strength let's get it out there… International company providing engine and industrial air, oil and liquid filtration solutions*

Innovations through problems for customers. Problem-solving for customers also drive proactive innovative METS to develop new technologies. Highly adaptive companies were primarily focused on building and maintaining long-term relationships with clients, in-depth understanding of customer problems, creating social bonds with customers and monitoring market trends. These companies were mainly diversified across sectors, outward oriented and constantly sensed the market to tailor developed solutions to customer needs. They are aware that solutions to problems can open up markets:

> *Where we think if we could come up with a good solution for that problem there's likely to be a market there… International company providing engine and industrial air, oil and liquid filtration solutions*

And that being active in a variety of industry sectors was likely to result in more opportunities:

> *Because we service a lot of different customers and a lot of different industry sectors we get exposed to a lot of different opportunities as well. We like to think that we're a fairly dynamic organisation, and we're always looking to try to differentiate ourselves in doing things innovatively. Often it will be either triggered by a customer issue, or a customer application… Engineering company specialising in integrated systems including industrial automation, robotics, and continuous process control*

The role of understanding customer problems and being able to tailor their service to solve these problems was a key driver of capability growth for smaller METS, consistent with findings from other sectors (e.g. Colombo et al., 2014; Maurizio et al., 2015). These firms also actively sought ways to apply existing services and solutions developed for resource sector clients to other sectors of the economy. Among prospective sectors for South Australian METS, food and agriculture, water, health care, and information technology were mentioned by the interview participants. Many companies spoke of seeking expansion into these sectors.

Analysis of the data demonstrated that problem solving was considered essential to diversification and innovation. METS of all sizes acknowledged that solving problems grew their company's capabilities, as was expressed by an interviewee whose firm provided automation and control services:

> *We like to think that we're a fairly dynamic organisation, and we're always looking to try to differentiate ourselves in doing things innovatively. Often it will be either triggered by a customer issue, or a customer application…Where we think if we could come up with a good solution for that problem there's likely to be a market there... Engineering company specialising in integrated systems including industrial automation, robotics, and continuous process control*

An excellent sample of how diversification could emerge was a firm that began as a supplier of geological maps for resource companies. The company had adopted a policy of understanding their customers' needs and keeping up with technologies in their field to become one of the largest international providers of integrated hardware and software IT solutions for the resource sector. The interviewee from this company stressed the importance of knowing your business, but talking to the customer in language they could understand, explaining that:

> *I was offering detailed sophisticated mathematics and all they wanted to do was draw pictures. They had this task, this labour intensive task that was slowing them down and I could use a computer to replace that task. We accidentally, fell into the market…Instead of doing the core business, we started to do these magnetic maps… Provider of mining software, hardware and services*

The general manager of the medium-size diversified subsidiary of the American company providing filtration products emphasised the importance of working with the customer to grow the business.

> *We'll go to site. We'll audit their equipment and see how they are servicing and the points that they are getting contamination in and perhaps they shouldn't.…Typically I don't even talk about our product. It's purely okay, here are your issues. Here's why these issues are happening and if you take these steps your problems will go away…International company providing engine and industrial air, oil and liquid filtration solutions*

Incremental innovations. The ability to innovate depends on company's internal resources. A company's *absorptive capacity* is a prerequisite for being able to generate new ideas. To get benefits from the position in the resource supply network and associated new knowledge and information, the company should possess a certain level of absorptive capacity to be able to make use of external inputs. Absorptive capacity is determined by the commitment of senior management to invest in research and development and the availability of highly qualified professional and talented employees. Analysis of the survey results revealed a low level of absorptive capacity among SA METS.

The companies that supplied highly specialised services to the resource sector proved to be the least adaptable in terms of offering new services and finding new paths for diversification and growth. These companies included mining services, civil construction, exploration and drilling companies. When these companies innovated, they did so by incrementally building on existing capabilities through the adoption of the new technologies and sophisticated equipment, as noted by the technical and consulting services provider.

> *If we talk say of innovations or changes, it's basically... buying more modern equipment and going for the more difficult conditions… Wireline services for mining industry*

Employing talent. Although at the national level Australia is considered to have a highly educated workforce, the attraction of young talent is a big issue in the resource and associated sectors since the resource industry is considered to be not particularly attractive for young people, who tend to prefer to work in more advanced emerging industries, such as IT or biotechnology. As the survey results showed, on average only about 20% of the METS employers had a university degree. The typical METS firm employs mainly technical professionals and employees with trade qualifications. The survey results recorded very low numbers of university graduates employed by SA METS.

However, the most innovative companies actively employ university graduates and young talent. For example, a highly innovative South Australian software and hardware development company exploits informal networks to find the best talent and is also willing to take university graduates. The company has a strong international presence and very well known in the region, and is attractive to young graduates.

In Adelaide there's people around. From the University and things like that. They've never learnt that 'you can't do that job'. If they don't know you can't do it, they just do it. We get a lot of experience of that. We often give the hardest jobs to the newest graduates…. Provider of mining software, hardware and services

Another successful resource sector specialised geotechnical consultancy company reported on the organisational structure that has significantly more knowledge workers rather than trades or technical staff. The most successful innovators had a culture within the company that encourages entrepreneurial attitude and sharing ideas among their staff.

6.3.3 Adaptation strategies to retain competitiveness -

However, for smaller companies, supplying highly specialised services, such as drilling and exploration, the mining and oil, & gas industries were still considered to be a major part of their income. These companies found other ways to sustain workflow in order to survive the downturn, including geographical diversification, introducing new strategies of building and maintaining relationships with customers and management, downsizing.

Survivors among the affected METS appeared to realise that for the future it was important to maintain a portfolio of work of different sizes to spread risks. Diversification strategies included forming and maintaining relationships through acquisition, downsizing and changing structure, as well as maintaining existing relationships and building new relationships with customers.

The data revealed, however, that the smaller, highly specialised suppliers often did not have the resources and opportunities to diversify into other sectors and adopt different approaches to survive recessions. These METS companies remained specialised in terms of core business and struggled to secure workflow during downturns in the resource sector. These companies were mainly regionally based and did not have enough resources to diversify. Attitudes among the owners also affected their efforts to adapt. An interviewee from a civil construction company said, for example:

We're good at what we do, and we stick to what we know... Civil Construction company

However, he also remarked on ways they could use their expertise, but move into new sectors, commenting that:

> *We're actually going to change direction, and get back to basics, and hit the domestic market again, into housing and that sort of thing…Civil Construction company*

Narrow specialisation strategies are a risk, as was evidenced by one large company that had been forced into bankruptcy. New management had cut down other parts of the business to make mining the core of the company's strategy. The former middle-level manager, who left to work for and electrical company, commented that:

> *They thought the whole world was gonna keep spending on major resources projects, and obviously in the last three years that's dropped right off, and their business is dying as a result... Electrical, electrical maintenance services company*

Larger sized specialised companies could remain competitive if they could manage to offer complementary services to existing ones, and adopt more sophisticated strategies to get new clients. As one interviewee noted:

> *We'll have to take a real change in strategy, and our board will have to approve that. At this stage, we're purely mining-focused…Consulting services company*

Developing a portfolio of work packages of different sizes. Companies proactively plan their project portfolios, recognising the constantly changing nature of the resource sector and the risks associated with smaller supply chain partners. Many made an effort, therefore, to deal with the larger companies to maximise opportunities and minimise risks.

The senior manager of the electric service supply company working as Tier 2 and Tier 3 acknowledged the need to be engaged in larger scale projects in order to survive through a downturn. This was considered to be a strategy for maximising opportunities and minimising the risks associated with small scale contracts. This was well-expressed by an electrical maintenance services provider:

> *I prefer the balanced approach. I would rather spread my risks and maximise my opportunity. There are other risks in doing the smaller level work…One of the biggest problems is you're dealing with smaller builders, smaller companies. In*

these pretty severe economic times we're seeing at the moment, some of those smaller builders are not viable... Electrical, electrical maintenance services company

Downsizing, reduction in asset base and changing structure. Resource companies, and, as a result, METS, have had to change structure and reduce the number of employees in response to the downturn in the resource sector.

All of the 24 interviewed companies of different sizes and backgrounds reported a significant reduction in the number of employees as a result of the reduced demand from the resource sector. Their positioning of their employees was a type of adaptation and strategic, as a member of a multifaceted engineering and design company explained:

What we find is that as the companies tend to downsize or look for reductions in cost they will take people off their own, off direct employment and bring them back as contractors; because they can control the period and tenure and also how they account for it... Technical services company

The subcontracting arrangements give companies more flexibility in terms of reducing labour costs while retaining expertise and controlling periods of engagement in a project.

Companies that suffered at the beginning of the downturn were sometimes able to grow their companies by acquiring workforce from competitors as they started to recover. The owner of a small regional exploration services company commented that:

Just before the downturn, our turnover had built up to about 14 million, which was pretty good. We had 45 staff. Then when the mining companies said, 'Go home,' we ended up with six staff. Now we're up to about 26 again, building up… Exploration and drilling Services

Developing various customer engagement strategies. To reach more clients, SA METS actively engaged customers in free education events to raise awareness about new and existing standards in the industry. Such seminars and information sessions allowed the METS to educate their potential customers, and understand potential clients' needs while indirectly promoting the company's services. As one interviewee explained:

We've had to diversify our own operational and our profile footprint to the market, by doing things such as client sessions, luncheons, breakfasts, educational type things. Not a 'salesy thing', but just educating the market…In terms of risk management, we put on client seminars and breakfasts, a lot more than we ever have… Environmental and Risk management services company

Providing free consultations and training was a way of building relationships with potential customers. This was particularly useful when change was occurring in the industry as the training benefitted the training company through exposure and the client by informing them.

Quite often if it's a major change we'll then go and do training with their people. You'll be on site for two or three days to train all their people. People don't respond well to change unless they understand why they're doing what they're doing... International company providing engine and industrial air, oil and liquid filtration solutions

Maintaining workflow and internal systems improvement. Smaller specialised METS were very focussed on managing their finances while waiting for the next upturn in the resource sector. The owner of a small drilling company acknowledged the need for small METS to maintain a balanced approach to survive through the downturn without getting loans from the government.

We had about two million in the bank, but we owed about two million. We could just turnover slowly and survive, whereas other people may have got too big, too quickly because a boom was on and overstretched and the banks wouldn't look after them…Exploration and drilling services company

Growing service offerings for clients. A general manager of the medium-size geological and geotechnical consultant company commented on how the company has tried to broaden the scope of services supplied to existing customers. The company investigates what aspects of work are within the scope of METS capability, are performed by other companies and find the possibilities to get involved.

We might, for example, be involved in BHP Billiton on a mining side, and maybe on the geotechnical side, but maybe we're not doing their geology work; so one of my things will be to find out why, who's doing it, why is our company not doing it; so that's one part of it, is to do more aspects of an existing client's work… Consulting services company

Thus a variety of adaptability and adaptation strategies was adopted by SA METS to overcome the downturn in the resource sector. SA METS pushing for adaptability strategies are in a stronger position for the future fluctuations in the resource sector, while those settled for adaptation strategies remain vulnerable.

A major factor that impacted the choice of METS company strategy was the nature of the core business activity and resource availability. Thus, highly specialised small companies that focused solely on mining industry projects, such as exploration and drilling or mining services, were in a weaker position to develop new markets and technological directions. These companies had to look mainly for geographical expansion in nearby areas because of the nature of their assets (heavy equipment) and specialised knowledge, e.g., geological and mineralogical conditions. It should be acknowledged, however, that some specialised METS invest in incremental improvements to their businesses, including upgrading business processes and staff training.

Data analysis showed that knowledge and technology-based companies, which by their nature are more nimble that companies that work with heavy machinery, tend to actively search for the new applications of their existing products and services, exploring a range of opportunities, including innovative problem solving for customers, developing breakthrough technologies, working towards integrated solutions for the end users and expanding their service range. These companies invest in R&D and new product development and encourage an entrepreneurial mindset.

6.3.4 Barriers to diversification and innovation

Investment in R&D and innovation. Being under the greatest pressure during times of downturn due to a significantly reduced amount of exploration and mining activity, the interviewees commented on the fact that there were limited projects available due to low commodity prices and general lack of capital expenditure.

> *It's just not the right time for that level of investment, especially with the level of contracts that clients are putting out now. One of the significant problems is, at the moment, there's not the stability on the contractual side or the work side to justify the investment. Clients want to put all that risk back onto contractors, so they want these new toys, but they're not willing to invest in it… Technical and consulting services company*

Some companies are keen to incorporate new technologies as a way of improving current services, but there is an uncertainty about the security of future work, which stops them from investing in new technology.

One company raised the issue of the difficulty of getting support from government, even through research and development grants. A highly successful innovative company acknowledged that the bureaucracy surrounding the grant application process discouraged companies from applying. One of the software providers summed up the situation, saying:

> *The R&D tax deduction is a waste of time. The only people that do any good at all is the consultants. You're sort of forced to use a consultant to make the R&D claim. It's not a very big amount anymore. It used to be 150% of your R&D so you claim 1.5 times of whatever you've spent. Now, it's about 40%, you get 0.4. A huge amount of paperwork. We're probably going to stop bothering. Probably shift our R&D somewhere else, I think…* Provider of mining software, hardware and services

The nature of the sector. Conservatism, rigidity and the prescriptive nature of the mining companies were acknowledged as a major hindrance for local suppliers wanting to be innovative. Some interviewees stressed overregulation, bureaucracy and very limited space to try innovative solutions to problems. An interviewee in automation and control services said:

> *I guess one of the things you see in the resources sector is they're often extremely prescriptive about how they want things done, and they have their standard specification…That stifles the opportunity for innovation.*
>
> *They just want to make sure that the system works and it's reliable, and is as cost-effective as possible. We do like getting given that opportunity to use some engineering creativity and come up with the best solutions, but I guess there's less opportunity to try to differentiate ourselves [because of the conservative approach to doing things]… Engineering company specialising in integrated systems including industrial automation, robotics, and continuous process control.*

Another challenge for innovators is to push an innovative solution through the hierarchy of a resource company and being able to find the right people in the hierarchy to talk to. Risk aversive attitudes of resource companies make them suspicious to solutions offered by smaller local companies. They tend to prefer established relationships with major international service providers. A director of a consulting company working on supply chain issues directly with resource companies commented on this.

> *As a rule, resource companies are very conservative and prefer to deal with proved vendors of specialised services and equipment to minimise risks....We develop technology here, get it all working and get excited about it. Then they shake their heads. Then after about two years they start to adopt it…They are just so slow on the uptake… Provider of mining software, hardware and services*

Another provider to the sector noted how daunting the financial aspects of innovation were, explaining:

> *The companies that have innovations want to talk with the mining company. Then the question will be – if we introduce this innovation into the process will you stand behind the process part? If it fails you will give me 50 mil dollars for lost productivity. End of conversation… Business, legal and finance, technical and consulting services company*

Furthermore, the hierarchical silo structure coupled with high staff turnover make it extremely hard for small local companies to access the right people in the resource company, those who could understand the specifics and benefits of the proposed innovation.

> *There's no one in BHP in Adelaide that would understand the systems. They would have to go to BHP in Singapore, where there might be a systems procurement team. These suppliers will go to the government and say, 'Why can't Santos or BHP, they're buying these systems from somewhere else. Why can't they buy it from us?'… Multifaceted engineering and design company*

6.4 Network governance and embedded culture in SA METS companies

The role of firm embeddedness in regional supply networks was acknowledged in the literature as a key factor for SA METS adaptation and survival during times of downturn in the resource sector. This was confirmed by the interview data provided by the METS companies. Most respondents commented on the importance of building and maintaining relationships within the industry networks to get opportunities and develop business. The business development manager of the large company, which provided environmental, mining, technical and consulting services acknowledged that his major role was building relationships with customers by establishing informal connections based on trust, reliability and loyalty.

Although definitions of *structural and positional embeddedness* vary, they incorporate the idea of a firm's structural position in the networks. In the current research, the structural aspects of embeddedness were considered:

- what was METS firm's position in the regional supply network structure and
- how close it was located to the major resource companies and large Tier 1 service providers.

Alliances and collaborative initiatives with customers also provide insights into underlying reasons of companies' positional advantages in the regional resource industry supply chains.

6.4.1 Positional embeddedness

A firm's position in the supply chain define its competitive position in the industry, closeness to the major clients, and thus propensity to benefit from collaboration and knowledge transfer as a result be more innovate and diversified. The interview data supported the fact of relationships between a firm's position within the regional supply network and its innovativeness and ability to diversify.

Engaging directly with the end-customer. Engaging directly with the end-customer was a strategy of the well-established medium and large regional METS. These companies usually had international certification and quality systems in place, talented staff and worked collaboratively with MNC (Atienza et al., 2016). For example, an international geological consultant METS company mentioned their positioning of a strong professional team that they thought put them ahead of competitors.

> *We typically work more for the bigger and higher-end companies, not exclusively, but typically… Consulting services company*

Regional medium and large METS tried to develop strategies in order to become direct suppliers to major resource companies in the region, without intermediaries. Involvement of EPC or EPCM providers as intermediaries was perceived as redundant and inefficient. Their involvement created an additional layer between the resource company and the METS supplier, and data indicated that the supplier company often felt that the company managing projects did not fully understand what the supplier service could offer. Since Tier 1 subcontractors tended to break-up projects into smaller packages and take control over the project, METS participating in the work became highly dependent on the EPCM provider, losing control of the project.

> *Even if we're approached by a consultant or an EPCM provider, we'll always aim to have our contract held by the end user rather than by a third party. That's a challenging relationship just because generally the EPC or the consultants have a very limited idea about what we do, and are unwilling to take the liability that we need them to take on, to allow us to do our job properly… Wireline service supplier to mining industry*

The METS interviewees were keenly aware of the fact that their relative position among the other firms was critical, as one engineer put it:

> *The higher up the food chain you can get, the more control you've got over your projects and obviously you're dealing directly with the client, rather than through a second, or third party... Engineering and construction company*

Subcontracting to higher tier suppliers. Subcontracting to higher tier suppliers was often the only possible way for local firms to become engaged in resource projects. EPCM providers usually took risks for the whole project and coordination. The senior manager of the branch of the Australian owned electrical company commented on this in his interview:

> *That builder, or the EPCM contractor, will manage or break up the project into smaller packages, and manage those smaller packages. We in the electrical business rarely get to be at that higher level, because we're just one part of the services that are provided… Electrical, electrical maintenance services company*

Flexible subcontracting strategies could provide opportunities for small firms to be subcontracted by Tier 1 companies. The subcontracting relationships were seen by the interviewees as the most beneficial for large Tier 1 contractors with local small and medium companies working in the resource sector. Due to the 'peakiness' of the resource industry and peculiarities of mining projects that include delays in approval and licensing, flexible organisational arrangements with subcontractors were applied by Tier 1 suppliers. The need for responsive expansion and contraction of the organisational size Tier 1 suppliers meant that they maintained a list of subcontractors to be engaged on demand, as a Tier 1 EPCM representative noted:

So for resourcing management, we have a lot of local subcontractors, contracting to start. They may be small organisations that are three or four people or previous staff that have worked for BHP Olympic Dam, who are no longer with them, but they have the knowledge of them as an organisation, so we contract them in…Tier 1 EPCM provider

The benefits of supplying directly to major resource companies were highlighted by local METS. Local firms looked to establish long-term relationships with major resource companies in the region because of new opportunities out of the local geographical area. A local engineering and project management company reported on opportunities to get work and build a reputation in the resource industry beyond the geographical boundaries of the state by providing services to large resource companies operating across Australia.

These suppliers began by working with resource companies in South Australia and, if good enough, were often offered opportunities to expand their services to client company branches located in other states, which several interviewees remarked on:

If you can maintain a relationship with them, generally wherever their projects are, you've got an opportunity to get in, and that's a good thing… Technical and Consulting Services to the mining industry

I've worked with other people in Brisbane that I worked with today. There are opportunities there straightaway… Technical services company

We lever off our relationships. That's typically how we've grown the brand and the business today… Large-size multifaceted industrial services provider

6.4.2 Relational embeddedness

Relational embeddedness was confirmed to be the major requirement of SA METS firms' ability to develop adaptability strategies, that is, being able to innovate and diversify. Collaboration around customer problems, long-term relationships with clients, understanding of their problems and consulting were cited as of first and foremost importance to regional METS firms.

In the current study, relational embeddedness was initially operationalised as a three-dimensional construct formed by *trust*, *information exchange* and *joint problem-solving* (Gulati & Sytch, 2007;

McEvily & Marcus, 2005; Uzzi, 1997). However, interview data demonstrated that the nature of the relationships between these subcategories was more complex, as a number of other dimensions of relational embeddedness emerged. These were *trust and credibility*, *reputation and referrals, social networks and personal relationships* with the clients, *understanding of customer problems and values.* These constructs were important for building long-term collaborative relationships with customers and getting opportunities for future work.

Long-term relationships with customers and relational rents. The data indicated that long-term relationships with the customers prevailed in the industry, and regional suppliers actively invested in relational rents (Dyer & Singh, 1998). Interviewees spoke freely of the importance of long-term relationships:

> *I would say, probably about 80% of our business is repeat business, from existing clients, so we do tend to build those longer term relationships… Consulting services company*

> *Most of our work is the longer-term relationships. Once we get involved, we tend to stay involved with a company… Recruitment, & Labour Hire company*

One METS company regularly re-connected with clients to ask if there was anything they needed:

> *I'm regularly just asking where we're up to with it, is there anything new that they want, anything they're not happy with. It makes a massive difference... Technical services company*

All participants in the supply chain were interested in keeping long-term reliable relationships. Partnership-based relationships between METS and resource companies were developed based on past experience working on projects.

> *I think with all clients you like to encourage and foster and develop that relationship. You're always looking for that repeat business… In the long term, you're always looking to keep that relationship going. A lot of our clients are like that…Engineering and construction company*

Trust. The need for flexibility and responsiveness to customer demand creates the importance of the social dimension in supplier-buyer relationships. Although relationships are based on commercial transactions they are sustained through social relationships between individuals.

'Competence' or 'goodwill' trust is what takes place in the South Australian resource sector as opposed to higher level collaborative forms of trust described in the cluster, industrial districts and learning regions literature as highlighted in (MacKinnon et al., 2004). Trust is a key influence in the dynamics of a regional resource supply chain. METS firms emphasise building long-term trustful relationships with customers, personal connections with clients, understanding and involvement in their problems.

The senior manager of the SA branch identified his role as the intermediary between the market and company research laboratory inventions. The set of skills that were of the most value, were deep understanding of technologies and the technological side of the customer problems, which required a strong engineering background, and the ability to grow local customer networks by building relationships with customers through doing favours.

> *It's not just about price. It's about those old valued principles…In most instances I know who their wives or partners are [clients], their kids, what hobbies they're involved with, and that comes over a period of years. That is trust…Environmental and risk management services company*

> *My role is to bring in new work and maintain existing relationships through trust, reliability, loyalty, all those things that come into when you see people... Environmental and risk management services company*

Reputation. The literature indicates that local METS leaders are concerned about building their personal brand and reputation, which are vital for maintaining work continuity. Through the delivery of products and services, local METS would build a reputation in the regional industry. Most of the interviewees highlighted the role of reputation and referrals in getting repeat work and new clients.

The companies build reputation by their work on projects, maintaining relationships with customers, developing a base of potential customers, and keeping them informed about the company's capabilities. The interviewees highlighted the need for maintaining their reputation for good work to get a constant flow of orders from customers.

You've got your range of previous contacts you've worked with over the years. It certainly puts you in good stead. You've either got a solid reputation or you've got a bad reputation… Technical services company

You build a reputation in time, and by performance. Yeah, it is possible to secure projects on the back of previous delivery and experience, and reputation…Electrical, electrical maintenance services company

The need for maintaining reputation in the industry was defined by the power imbalance between local METS and big resource companies and their Tier 1 suppliers. If a supplier failed to fulfil their commitments, they would struggle to get future work in the industry. The local embeddedness and informal networks impose pressure on local METS to perform at their best.

Direct referrals came as a result of relational embeddedness and contributed to METS firms' ability to change their position in the regional supply network. The role of referrals was stressed as a way for SMEs to get work and grow their client base. They were the result of trust and convenience, proximity, or prior alliance history. Referrals facilitated the formation and evolution of regional supply networks by providing project opportunities for local METS, as was observed by several service providers, who commented on the benefits of referrals and their importance in a small region:

Probably what's served us best over the journey is getting referrals from existing customers or suppliers or having some sort of contact with the right people decision-makers in these organisations, as opposed to just trying to push in almost a cold call format… *Engineering company specialising in integrated systems including industrial automation, robotics, and continuous process control*

It's a lot to do with Adelaide being the size of the town it is and being quite small it's very much referrals… *Recruitment, & Labour Hire company 2*

Building up multiple connections within the industrial networks was self-reinforcing, thus well-connected firms being engaged in many projects had more opportunities to sustain their businesses.

The more projects you are across, and if you do a great job and the client's happy with it, and you follow that up immediately and you just keep in touch with your clients. I think that's the secret to any business and it's not really a secret... *Technical services company*

Another path to success was to rely on contacts with which the firm maintained strong connections. For example, when the supplier knew the problem of a resource company, but could not approach them directly, they could approach them indirectly through Tier one supplier to resource companies, as one of the interviewees explained:

> *They can't get into Santos, but they know Santos' problem. They go to NEC and say, 'Santos has got this problem. Can I go with you?' … Resource supply chain consultancy*

It should be noted that the data from the interviews revealed that opportunities for medium-sized companies to connect directly to resource companies have increased due to the downturn in the resource sector. A medium-sized company that was a subcontractor to a Tier 1 provider but was not 'visible' to the resource company can now become a direct supplier as the larger company searches for cheaper solutions:

> *What's happened in the past is we've done a lot of work for these Tier 1 suppliers. They would never even have heard our name because the Tier 1 supplier will get the [company] stamp on the bottom of the drawing and change that to whatever and they would never ever see the [company] version of it… Technical services company*

The company business development manager commented on the need to become more visible for potential clients.

> *The strategy initially is just to let them know what we do, because a lot of them don't know what we do…In the mining side, they've done a lot of papers for mining, actually...My job is to actually get us out there and talking to clients to make sure they're aware of what we do... Technical services company*

Firms that keep affiliations with multiple suppliers have more chances to win tenders, being proactive in leveraging the subcontractor networks quickly to outperform the competitors.

> *When you still have to compete, in a competitive tender but you're already there and you have a bit of understanding about the job, you're pre-positioning in a way that you've got subcontractors and partners aligned…Environmental and Risk management services company*

Social networks. Interviewees from companies having experience of operations interstate in Queensland, New South Wales, Western Australia and Victoria highlighted the particular importance of social networks in South Australia. Social bonds between people created over a lifetime tightly intertwined with industrial connections, thus confirming the interpenetration of the boundaries of professional, social and industrial networks. This is explained mainly by the small size of the Adelaide, and the dominance of small and medium enterprises. The principle ‘who you know’ was highlighted by several respondents, who noted that:

> *Adelaide is a network city. Adelaide is, ‘What school did you go to, where do you come from?’… Education, & Skills, Recruitment, & Labour Hire company*

> *Although, you see, it’s South Australia. Unfortunately, it’s a bit like if you’ve got a relationship with somebody, then you’re more than likely to get the work than somebody else. If you’ve got the relationship, then the chances of getting the job are very high. It’s just a fact of life. It’s who you know… Education, & Skills - OH&S training company*

This style of doing business was referred to as ‘old-fashioned’ by several respondents, but in a positive way, when they were talking about acquiring or dealing with customers.

> *It is a lot of the core values and principles that we teach our staff, and I believe in, myself, is old-fashioned things. When you’re dealing with clients, and customers, your family, your friends, it’s just honesty and respect and reliability…Environmental and Risk management services company*

Maintaining informal connections with the industry partners was considered very important to keep business and get new clients. Having informal conversations over coffee or lunch was considered an investment into the possibility of the future work.

> *I guess, you get to know people. You talk to them, have coffees with them, talk about their families, then you know what they do. You just get to know people…Education, & Skills - OH&S training company*

Companies exchanged market information via social networks. A pipe distribution company working in the mining and oil and gas industry might find out about a business opportunity they can't take, which they share with their major vendor.

> *We might identify some business, and for whatever reason, we feel we won't be able to get it, but we think X can. We'll say, 'X, get over here. Let's go and see this chap.'…Hydraulics and pneumatics equipment and services*

These relationships contributed to the development of wider interpersonal networks. For example, when someone leaves a company, he or she will keep the supplier in mind and could engage them while working on a new project in a different company, since the social network and all the trust and knowledge of one another is in place.

> *Some of those customers leave. They may retire, or they'll apply for another job to another company, and then they'll ring me and say, 'Hey, Pete. Come over, I'm working for ...' wherever. I'll go meet them, go through the same process, but they already know me, they trust me, and they trust our company, and that's our core value… Environmental and Risk management services company*

Learning from supply chain partners through collaboration around customer problems. Both the data and the literature emphasised that learning from supply chain partners through collaboration around customer problems was also a driver for developing new products and processes innovations. Concentration of industry-specific knowledge and intelligence results in knowledge spill-over occurring through supplier-buyer relationships. Local METS interviewees felt that they learned while undertaking projects for customers, or collaborating to deliver a project.

> *We learn something new, something more from that particular organisation. When we go to the next organisation, we've got more knowledge that we can use in terms of solving the problems and helping them... Education, & Skills, Recruitment, & Labour Hire company*

> *We had this idea. We built a laser scanner. Built it just in the shed. Then we employed a laser expert. We employed an electronics expert. My son was the mechanical expert. They put together the first laser scanner… Provider of mining software, hardware and services*

There were METS who did not appreciate their technology being copied, however, and resented the fact that collaborators could steal their intellectual property and go into competition with them. For example, another large engineering and electrical METS company reported negatively about partners who took over the technology in the course of a joint project and then became a competitor.

> *Years and years we did a lot of the wind farms with them. They now believe that they can do what we can do. What'll happen now is, we'll basically go ... Instead of us working in unison with them on projects, we'll compete head-to-head with them... Engineering and Construction company*

In addition, the client might learn from using the supplier's expertise, and being doing the work themselves. The engineering and manufacturing company described such a situation:

> *We do work for a company, because they don't have the expertise. You do two, three projects with them. They think, we can do that, so they'll buy the plant and equipment and all of a sudden you're not doing that work anymore. They're self-performing… Engineering and construction company 1*

At the same time, many companies involved in more knowledge intensive services, such as consultancy and training actively share intellectual property with clients and partners, taking a collaborative approach when dealing with customers. These companies often learn from their customers and implement that knowledge in subsequent projects.

> *I mean that's how we learn most of our intellectual property is by what we do in one company. We gain and they gain. We always try to share IP so that the company is better off when we leave, but we are also better off when we leave… Education, & Skills, Recruitment, & Labour Hire company*

The state manager of the medium-sized branch of an international company performing in Adelaide commented on the detrimental effect of staff mobility on relational embeddedness. Mobility interferes with personal networks and long-term collaborative trust-based relationships which underpin effective knowledge and information exchange, and negatively affects informal links built by suppliers. When people with accumulated essential tacit knowledge and local connections with local firms leave the company, it damages local supplier businesses.

[What] is very important for the whole mining and resources sector is that continuity of employment. You get these people working for a mining house that have lost their job. It's horrible because of the amount of information and connections that goes with them… International company providing engine and industrial air, oil and liquid filtration solutions

Forms of collaboration. Larger companies were more willing to enter collaborative relationships, while small METS were cautious and preferred well-regulated subcontractual arrangements. The major concern for these companies was the risks and profit sharing in joint-ventures and alliances, and the lack of established legal frameworks for collaborative arrangements.

The two major models of work distribution among suppliers were *hierarchical* and *decentralised*. In the hierarchical model, one supplier acted on behalf of the commissioning organisation (the resource company) and was responsible for the delivery of the whole project. In a decentralised model, all suppliers have equal responsibility and collaborate to deliver the final product or service. One of the METS performing automation and control as a Tier 3 supplier commented that they were comfortable with either model.

We could work in both models. Sometimes we are the Tier 1 and sometimes we're one of the subcontractors. Sometimes it needs that collaborative relationship with the customer being the Tier 1... Electrical, electrical maintenance services company

It was felt that collaborative relationships (joint-venture agreements) provided complementary services and skills to deliver better value for customers, such as technical, environmental, marketing expertise.

Coal marketing, for example; we don't have marketing specialists; we might work with another company on that. Anything that we don't have internally, we work with the other companies… Consulting services company

If we thought it would give us a competitive advantage or that they were complementary skills. We would certainly be prepared to joint venture with our competitors…Global engineering and design services provider

Long-term subcontracting relationships based on trust were one of the most often mentioned forms of collaboration or alliances among SA METS, as explained by one of the interviewees.

Sometimes it's subcontracting; sometimes it's an alliance… When it's an alliance, you should be under the umbrella of the company that you're allies with. We're actually working for them. And when it's subcontracting, you're performing yourself… Environmental and Risk management services company

One METS firm in subcontracting relationships with overseas partners explained how they saw subcontracting relationships.

You could call our subcontractors ... you could call that cooperation or alliancing, because the people we hire, we know a person as their name. They would see it as an alliance. We see them as a short-term employee or as a subcontractor. There's an element of alliancing. We treat each other with great respect… Business, Legal and Finance, Technical and Consulting Services

The interview data from smaller companies indicated that they preferred sub-contractual relationships to formal partnerships or alliances. They did not have the legal framework and knowledge in relation to sharing profit, risks and responsibilities with partners and the engagement of external legal assistance was too costly. Larger METS firms were well-equipped with the knowledge and systems to make effective formal collaborative arrangements.

Some METS firms understood that their unwillingness to enter in more complex arrangements could reduce their profit-making capacity. One of the interviewees commented:

You're paying them for a service [subcontracting]. It lessens the risk, but also it's more money that's going out of your business. You could be losing out on any profit from that area [joint-ventures, partnerships]. You lose control over the section of work to a degree… Mining services company

The majority of the smaller METS found collaborative agreements to be constraining and were uncomfortable with sharing the ownership of the task, seeing it as a loss of control. For example, a geophysical company representative reported on the reluctance to establish closer collaborative relationships with suppliers, preferring to maintain subcontractual relationships.

It's really just very close working relationships. We don't try to have cross ownership or anything like that. We get locked in with only one supplier, the supplier then gets excluded from the rest of the marketplace as well, so it doesn't *really benefit them to any significant degree either... Wireline services supplier for mining industry*

6.4.3 Challenges of building an embedded culture

Many of the interviewed smaller size METS companies reported on the lack of trust in supply chain relationships and occasions of opportunism taking place in the resource sector. Some of these examples included getting market information and knowledge from the METS supplier and not providing any work. Thus, the suppliers become more guarded about the information they provide to companies that they have not dealt with previously. The interviews demonstrated that the lack of trust was a serious issue among the METS.

> *You don't want to give away too much because the customer could us that and give that information to the competitors. You know doing that you run the risk of them using that information and sharing it with others… Exploration and drilling services company*

> *All their doing is picking our brains and then just going go out to the cheapest price, or whatever. We come very guarded... Engineering and construction company*

Companies were also guarded about talking to the people whose aim was to collect information and generate interest in the industry, considering this as a waste of time.

> *There's a lot of people they'll get a government grant, or whatever. They get a big case from the government and they'll sell their idea… they'll run around and they'll try and generate interest and get industry to supply them with as much information as they and then they'll go out to market… Engineering and construction company*

The companies were also hesitant about revealing their prices, in order to avoid them being passed to their competitors, or used to apply for grants from the government.

> *You got to be very careful to say a moderate amount. Some people will come to us for budgets ... I'm viewing that in the context that people come to us to price project and the budget type projections and things like that… Engineering and construction company*

Several companies express negative sentiment towards open communication between parties in the industry supply chain, showing a guarded attitude towards sharing information and knowledge.

> *You've always got to be wary. You've always got to be on your toes... Exploration and drilling services company*

> *People are always looking for that market knowledge, information, that competitive edge and some people are a little bit more unscrupulous than others on how they get it... Engineering and construction company*

The volatility of demand in the mining industry influences the nature of the relationships between suppliers and resource companies. METS cannot rely on long-term contractual relationships, since resource companies can and do change their mind about subcontracting if there are marked changes in the market. Since there is often significant paperwork when METS are being hired, to have clients renege on a deal is extremely frustrating, as one interviewee explained:

> *You sign contracts, long contracts up with them. They go all through your books and make sure you're a good person, investigate you all. You sign a contract for two years. Then the market drops and they just say, 'Go away,' regardless of what you've invested to do all that sort of thing… Exploration and drilling services company*

Furthermore, critical information can get passed on to competitors, which makes METS wary of entering into relationships with some companies.

> *We've been told that they suspect that somebody told that other person who was cheaper than our prices. Somebody in the mine took a backhander and passed our pricing on. This happens a lot. People take money under the table to get the contracts... Exploration and drilling services company*

At the same time, one of the interviewees explained being taken advantage of by an influential resource company:

> *We're now talking about the … expansion. [They] come to us and they [business owners] fly to Melbourne to discuss the project. To look at new and different ways of perhaps doing it in more cost-effective ways… It didn't mean we were going to get a job out of it, but they wanted to pick our brains and expertise for nothing…Engineering and construction company*

While another described some very opportunistic behaviour that explained why he didn't collaborate with other businesses:

> *We haven't done that [collaboration with other companies]. We do know another company that we worked really closely with. They brought in another drilling company because the job got too big and they didn't want to go to the expense of getting more rigs. They thought they were friends with this other drilling company and they brought them in. Then this other drilling company did the dirty and tried to take over on them and reduce its prices to get the contracts. Unethical people… Exploration and drilling services company*

6.4.4 Industry associations and relevant organisations

Attitudes towards industry associations in general, and some of them in particular, was mixed among interviewed METS. Some of the interviewed companies saw value in membership as it allowed regular networking to maintain relationships and being noticed in the industry:

> *I actually think it's a good value, just to get along and see what's going on in the industry, and networking with the people that attend… Education, & Skills - OH&S training company 1*

> *Industry associations are important, at least you're visible, and then other companies may find your service.. Electrical maintenance services provider*

While some considered membership as a waste of time and money.

> *The trouble is there's so many of them out there and it's hard to ... You can spend a lot of money and get no real value out of them… Civil Construction company 1*

Most of the respondent METS did not see any value in being a member of local industry associations. The companies acknowledged that networking events did not help them get new work, or promote business. And the membership prices were seen to be high.

> *We didn't really see the benefit of going [to industry associations events]. It did really seem like a great branding exercise, and we know it's a good program… Pipe, Valve and Fitting products and services provider*

> *Do not really see the point. From what I'm seeing, they're not the most useful organisation for a company like us… Engineering and Manufacturing company*

Although there are a number of industry associations operating in South Australia, which are aimed at facilitating collaboration among METS, suppliers and customers, two emerged as the most known and important for the industry – the Industry Capability Network (ICN) and the South Australian Chamber of Mines and Industry.

The ICN is an independent organisation financially supported by Australian and New Zealand state and territory governments. The ICN database contains information about 70,000 suppliers in the various industry sectors across Australia, and holds information about each member company, including economic performance indicators, major capabilities and sectors in which it operates. The primary objective of ICN is to provide local suppliers with the opportunities in different sectors by informing them about upcoming tenders, as well as assisting project managers of big projects to find local suppliers. Medium to large METS working directly with resource companies explained that on the whole they found that:

> *All ICN do with that information is just give it to a mining company. They're effectively like the front end to a procurement program… Multifaceted engineering and design company*

They found that the value of ICN membership was unclear to them. Analysis of the interview data showed that they felt that the information coming through informal networks and personal connections was more timely and valuable for finding opportunities and winning work in the industry:

> *I don't know why, but I suspect that if you're a Tier 1 contractor you've already got relationships in place, you're not going to ICN to look for new ones because you already have organisations you've used before or you might have an affiliation or whatever the case may be... Resource supply chain consultancy services provider*

The South Australian Chamber of Mines and Energy (SACOME) was cited as another important industry association, which sought to raise the profile of the resource industry, lobby interests of the resource industry in relation to policies implemented by government, and hold regular networking events for mining companies and service providers. The association also organises training courses and seminars, and conducts information sessions for SA METS firms. The SACOME is the key association at the state level valued by local METS (survey data), although some of them reported that its value had diminished:

SACOME used to be very important; it's dropped away a bit... Education, & Skills, Recruitment, & Labour Hire company

The Global Maintenance Upper Spencer Gulf Resource Industry Cluster (GMUSG) is an organisation operating in SA, which draws its membership from businesses across the Upper Spencer Gulf region involved in engineering and maintenance services to the resource processing sector. The organisation serves as a front-end subcontractor to higher tier suppliers in the resource sector, drawing on the capabilities of its members, as well as providing opportunities for regional firms to connect through industrial conferences.

The organisation has a long history and reputation in the region. For example, the 'Resource Supply Chain Panel' program is aimed at assessing local firms' readiness to become a supplier to the resource sector. This includes the assessment of a firm's management and quality and occupational health and safety (OH&S) systems to identify the gaps that need to be addressed before a firm can participate in resource tenders. Some respondents reported low engagement with the association.

We've found [GMUSG] a little bit weak, doesn't do a lot for us… Pipe, Valve and Fitting products and services provider

The Resource Engineering Skills Alliance (RESA) is an independent not-for-profit organisation that implements the 'PACE Supply Chain Development Program' launched by the state government to provide training and consultancy support in relation to the required certification and accreditation, preparing tender documentation, formulating business value propositions to tailor to resource company needs and improve marketing. However, companies also do not see value in being a member.

We never really bothered. For what we get out of it it's very expensive. Our membership, we have limited benefit for us. Do not really see the point… Wireline services provider for the mining industry

Some METS firms reported the usefulness of some specialised industry organisations in terms of promoting their services and getting recognition in the industry, networking and making new business contacts.

Our main forms of advertising engagement to new clients tend to be through the Australian Institute of Minerals and Metallurgy or Australian Society of Exploration Geophysicists. They run conferences throughout the year tailored to different *commodities typically. We take a lot of those trade shows and geophysics based conferences that are more relevant to us…* *Wireline services provider for the mining industry*

The bigger companies participated in industry associations, mainly to maintain a leadership role and high profile in the regional industry, and saw membership in industry associations to be more like an obligation than a business development opportunity.

Well, we're members of the National Electrical Contractors Association, NECA. We're active in that industry. We feel that it's our corporate duty, because we're leaders in our field, we feel that we should be there quite prominent in helping the industry develop… *Electrical, electrical maintenance services company*

6.5 Chapter summary

A summary of the themes and sub-themes that emerged as a result of the interpretation of the interviews through the lens of the conceptual framework is provided in Table 6.1.

The *key findings* described in this chapter are that SA METS adopt a variety of strategies to sustain and grow business through the downturn in the resource sector. Diversification of capabilities and across industry sectors was the most common strategy among SA METS companies. *Innovative solutions* were one of the major competitive advantages that METS companies relied on. However, low margins and the lack of investment on the part of customers were cited as the major hindrance to the pursuit of innovations.

Collaboration around customer problems and *problem-solving for customers* were important for local METS firms to get and maintain their business in the SA resource sector. Companies implemented a variety of strategies to build relationships with clients, including free consulting and education sections for clients, broadening the scope of offered services to the customer, assisting in solving problems in a lean and innovative way, offering integrated solutions by engaging or acquiring business from supply chain partners.

Embeddedness and *social networks* play a key role in getting new clients and maintaining a client base. Proximity to major mining and oil, & gas operators is crucial for local firms to develop capabilities and get further opportunities. *Trust, credibility* and *reputation* were cited as the most important factors by which to obtain referrals and win tenders. At the same time, many METS companies, especially of a small size, expressed little trust in some of the supply chain partners, and were careful about openly sharing information and participating in collaborative relationships. Due to knowledge and know-how leakage, lack of legal frameworks for risks and profit sharing with partners, these companies were reluctant to enter close collaborative relationships, often preferring subcontracting and arms-length relationships with the clients.

The value of industry associations appeared unclear to the local METS, since some use opportunities for networking to be recognised in the industry, while others consider their services as a waste of time and money.

Table 6.1 Summary of the themes that emerged from the interviews

Strategy	Number of companies (from the interviews)
Adaptability strategies	
Diversification	
Sectoral diversification	13
Geographical diversification *Interstate* *Internationalisation*	10 4 6
Servitisation *Integrated service solutions/ vertical integration/ moving up in the value chain* *Product-service systems*	9 5 4
Innovativeness	
Disruptive innovations	5
Innovations to solve customer problems	21
Incremental innovations	15
Absorptive capacity	
Employing talents	3
Company culture, enabling innovations	3
Investment in R&D and development of new products and services	12
Research grants	2
Adaptation strategies (retaining short-term competitiveness)	
Developing portfolio of work packages of different size	5
Downsizing, reduction in asset base and changing structure	12
Developing various customer engagement strategies	6
Maintaining workflow and internal systems improvement	18
Incremental innovations	15
Network governance	
Positional embeddedness	
Engaging directly with the end-customer	6
Subcontracting to higher tier suppliers	15
Expanding geographical scope through customer relationships	5
Keeping relationships with potential suppliers and customers	15
Referrals in forming new supply chain connections	19
Relational embeddedness	
Understanding customer problems and values	16
Long-term relationships with customers	21
Trust and reputation	15
Social and professional networks	7
Information sharing and joint problem solving	15
Forms of collaboration: – Alliances – Partnerships – Informal collaboration	 4 8 17
Industry associations	
Valuable	12
No value	9

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Chapter 7

Discussion

7.1 Introduction

The discussion chapter summarises findings from both quantitative and qualitative aspects of the research with reference to the research questions.

The *first research question* investigated the strategies SA METS firms adopted to sustain and grow their businesses during a downturn in the resource sector, including adaptability strategies, such as diversification and innovativeness, and adaptation strategies, such as downsizing and changing company structure, building diverse portfolios of projects to mitigate risks, developing and maintaining relationships with the clients.

The *second research question* sought to investigate the impact of *positional and relational embeddedness* on SA METS firms' ability to diversify and innovate. The results of the tests of relationships postulated in the conceptual model are discussed in this section. The moderation effects of the METS company's size, its position in the supply chain tiered structure, and membership in industry associations are also discussed.

Results for *research question three* are discussed in relation to regional supply network structure and governance instruments as factors that impact regional METS firms' strategies, and ultimately the adaptability and resilience of the resource-extractive region.

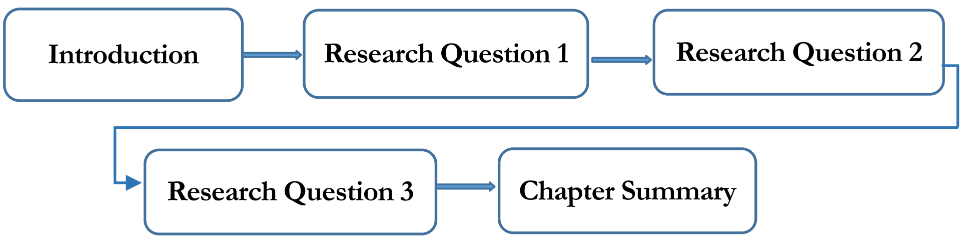

Figure 7.1 Chapter 7 structure

7.2 Research question one

This research built upon and extended the framework proposed by Chapman et al. (2004), which was grounded in evolutionary economic geography. Chapman et al. (2004) suggests that resource extractive regions adjust and renew in response to external shocks at the meso-level with reorientation strategies at the micro-level. Regional firms are viewed as key agents of change and regions and clusters as their aggregates, and their strategies occupy a place within a continuum between adaptation and adaptability.

While *adaptation* strategies aimed to maintain business operations during downturns to ensure short-term retention of competitiveness, *adaptability* strategies required 'the more fundamental capacity to redeploy existing assets and capabilities in new directions' (Chapman et al., 2004, p. 384). *Adaptation* strategies include, but are not limited to, cost-reduction and copying, leading to short-term incremental changes within the old technological paths. At the regional scale, these strategies result in regional adjustment, which allows the region to survive the economic shock while staying on the pre-existing path. But in the long term, they do not form new technological paths, nor make the regional economy more resilient.

Innovation and *diversification* strategies, on the other hand, increase firms' long-term *adaptability,* potentially leading to the emergence of new high value-added activities and new path creation, resulting in regional renewal and long-term resilience (Chapman et al., 2004; Xiaohui Hu, 2015). However, incremental innovations and reactive diversification among closely related industries do not necessarily lead to renewal in the region. Depending on whether local firms responded with adaptability or adaptation strategies to the changing economic conditions, a radical renewal or only a short-term adjustment could be achieved at the regional level[5]. Research question 1 was:

RQ1. *What kinds of strategies were used by SA METS companies to adapt during the downturn in the resource sector in 2012-2016?*

This overarching question could be answered through a set of the sub-questions:

[5] For more detail see Chapter 2, Figure 2.7

RQ1.1 What kinds of adaptability strategies including innovativeness and diversification leading to emergence of value added activities were used by SA METS firms during downturn in the resource sector in 2012-2016?

RQ1.2 What kinds of short-term adaptation strategies were used by SA METS firms during downturn in the resource sector in 2012-2016?

The following sections discuss the findings.

The strategies adopted by SA METS firms occupied the continuum between adaptation and adaptability. On the adaptability side there were radical innovations, such as new technological solutions for the sector, contributing to the development of new paths and niches in the SA economy. A variety of sectoral, capability and geographical diversification strategies were adopted to different degrees in relation to adaptation or adaptability. Furthermore, development of integrated service solutions (Panesar et al., 2008) and servitisation strategies (Dachs et al., 2014) being actively pursued by larger SA METS firms, could be seen as pre-adaptation strategies, which in the long-term may trigger further sectoral and geographical diversification and innovations.

7.2.1 Diversification strategies of SA METS firms

METS firms diversification during a downturn is a mechanism by which firms can adapt to a changing market environment. Diversification was achieved by increasing the range of ways to respond to customer issues (Scott-kemmis, 2013). Some METS firms became increasingly technologically capable and were able to penetrate new markets (Morris et al., 2012).

The SA METS companies' diversification strategies depended on the size of the firms and their core capabilities. Smaller firms in the lower tiers broadened the range of service offerings and service customisation, servitisation and geographical diversification, often moving into other Australian states.

The larger METS firms operating as tier 1 or tier 2 suppliers to resource companies and providing more generic services, including engineering and project management, as well as business services, tended to search for more radical solutions. They moved towards integrated turn-key solutions for resource companies and broadening their services. More resource industry specialised companies maintained business by balancing the sizes of the projects.

Sectoral diversification. Some previous research showed that during resource industry downturns specialised METS firms prefer geographical diversification and less so sectoral (Chapman et al., 2004), and that knowledge intensive METS firms are more adaptable and inclined to sectoral diversification while more specialised, labour intensive METS firms prefer geographical diversification, finding it hard to apply services in other sectors (Knobblock & Pettersson, 2010).

The findings of this research showed that for many SA METS firms *sectoral diversification* and *capabilitity diversification within the resource industry* were the favoured strategies. 75% of the surveyed METS firms operated in three or more sectors. They were involved in construction, manufacturing, defence, water, utilities, transport, infrastructure and civil construction, and agriculture. In line with the previous studies, the most diversified firms were larger METS firms operating at the higher tiers of the resource value chain (Atienza et al., 2016; Robson, Gallagher, & Daly, 1993). They targeted markets other than the resource sector.

Some smaller METS companies also applied their expertise (e.g., process control, pumping solutions, materials handling, construction equipment) to other sectors of the economy, thus contributing to lateral migration of technologies to unrelated industries, as had been observed in previous research (Walker & Minnitt, 2006). Among prospective sectors for South Australian METS firms, water and utilities, food and agriculture, health care, and information technology were mentioned by interview participants as more long term sustainable industries (see Figure 7.2).

Geographical diversification was the second most common strategy adopted by Australian METS firms to overcome the lower demand for services from the resource sector (see Figure 7.2). Geographical expansion has been commented on in the case of UK North Sea oil (Chapman et al., 2004), South African (Walker & Minnitt, 2006) and Swedish (Knobblock, 2013) regional suppliers. *Internationalisation strategies* were pursued by medium and large METS companies. These mainly included Asian markets, such as Singapore, China, Japan, Papua New Guinea, and Indonesia. The availability of local networks overseas was vital for companies seeking to expand geographically.

Another commonly adopted internationalisation path was through long term relationships with major clients, as has been documented in the case of North Sea oil suppliers (Chapman et al., 2004;

MacKinnon et al., 2004), the Brasil mining industry (Figueiredo & Piana, 2016). South Africa (Walker & Minnitt, 2006) and Australia (Scott-kemmis, 2013). SA METS firms' interviewees spoke of using their relationships with large customers to expand their services interstate and work in other sectors. However, relationships with clients were not found to directly contribute to SA METS internationalisation, as it was reported in examples provided above.

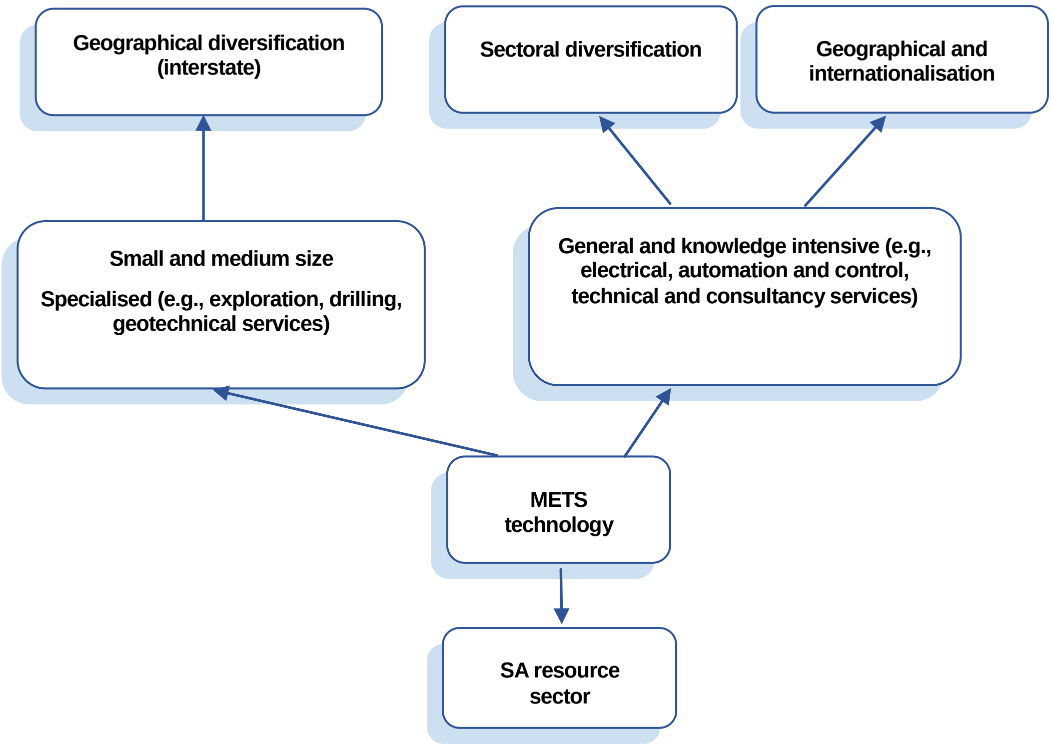

Figure 7.2 Technology transfer through sectoral and geographical diversification

Out of 156 SA METS firms that were surveyed, 18% worked solely in the resource sector, and sought to move into interstate markets, in particular, the Northern Territory, having found other states saturated with competing firms. There were also resource constraints and a lack of internationally-oriented networks. SA METS firms' interviewees perceived barriers in contractual and legal issues, equipment transfer, and lack of networks to establish business overseas.

Servitisation and service differentiation. Capability diversification through servitisation strategies within the sector leverages a firm's innovation potential and enhances customer relationships (Dachs et al., 2014).

Many SA METS firms with engineering and manufacturing core capabilities adopted servitisation strategies, introducing integrated solutions, product-related services and product-service systems. These included the development of integrated services solutions through vertical integration and moving up in the supply chain to work directly with resource companies.

Integrated service solutions/vertical integration/moving up in the value chain. The most adaptable firms in the supply chain moved from being systems and component suppliers to system integrators, installing and maintaining their products. Such paths had been reported in earlier studies (Scott-kemmis, 2012; Warrian & Mulhern, 2009). Among SA METS firms interviewees, two engineering and project management services companies, an environmental services company, and a recruitment and labour hire company pursued this strategy. (see Figure 7.3).

During a downturn all resource companies, large and small, cut costs. Local integrated service providers become a better choice, with their flexible, flat structures than costly tier 1 EPCM providers. Regional METS firms move up the resource supply chain. The tendency has been observed in Australian mining (Scott-kemmis, 2013), the Canadian resource and manufacturing sectors (e.g. Warrian & Mulhern, 2009), and the Norwegian oil and gas sectors (R. Kumar et al., 2009; Panesar et al., 2008).

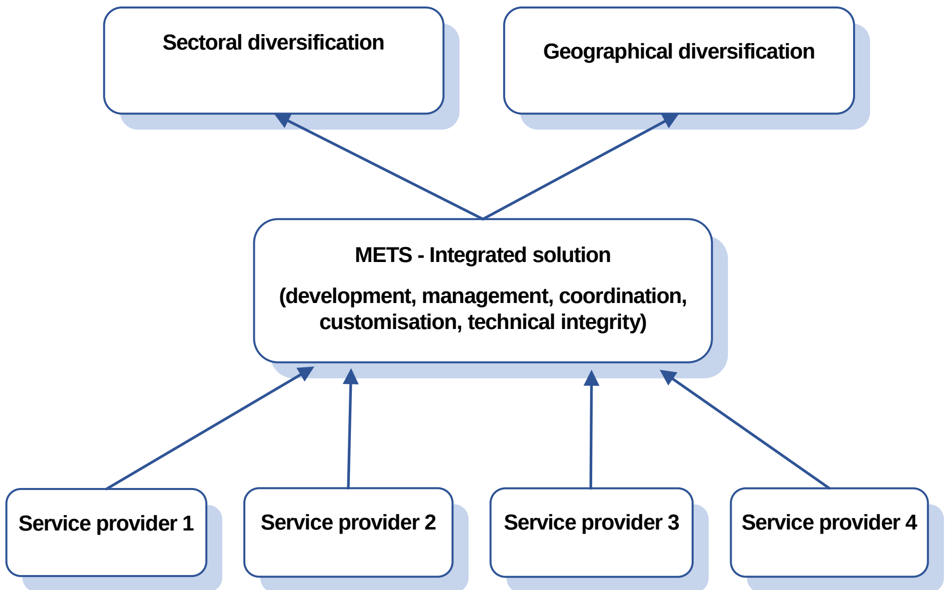

Figure 7.3 Integrated solutions value co-creation in the supply chains

Product-services systems and product-related services. Servitisation is '…offering of fuller market packages or 'bundles' of customer focussed combinations of goods, services, support, self-service and knowledge in order to add value to core corporate offerings…'(Vandermerwe & Rada, 1988). Servitisation is associated with demand driven innovations. To be able to implement these services, METS firms must possess in-depth knowledge of the individual customer's needs and preferences (Panesar et al., 2008).

One of the SA METS firms participating in the research study, for example, adopted a strategy of servitisation. The company had originally operated as a distributor of hydraulic and pneumatic equipment, hose fittings and accessories, then moved to design, manufacturing, installation, and maintenance of hydraulic and pneumatic systems (see Figure 7.4).

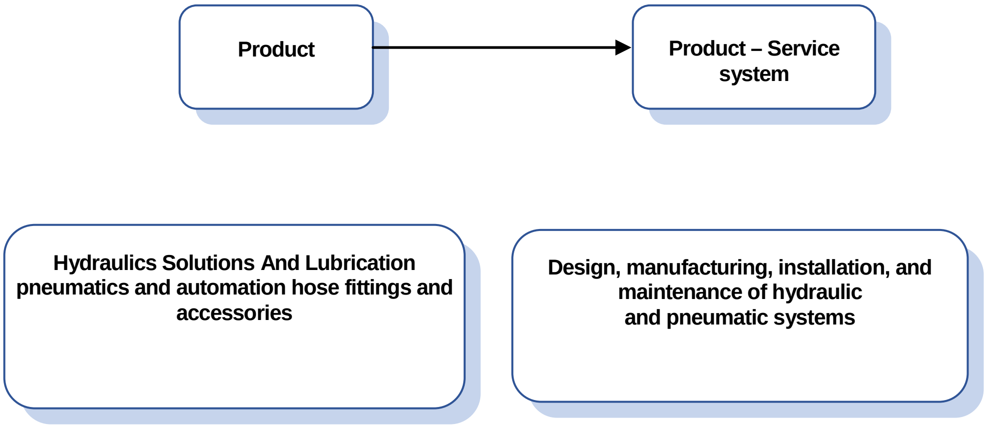

Figure 7.4 An example of servitisation paths

Furthermore, some SA METS firms developed supplementary services for vendor companies (see Figure 7.5). For example, a large SA owned METS company, a distributor for a large international electrical equipment provider, developed a complementary product and associated service, to add value to the original vendor's product and increased the benefit to a customer. Such a strategy involves research and development and can be considered more of an adaptability than adaptation. It requires frequent interaction between all parties and the ability to upgrade knowledge and technology (Figueiredo & Piana, 2016).

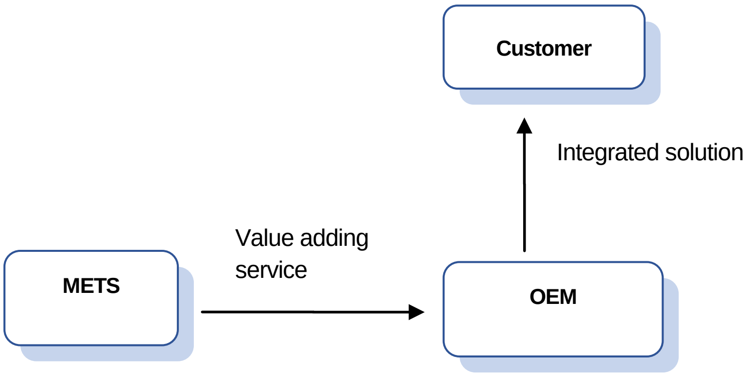

Figure 7.5 An example of value co-creation within the resource supply chain

Many SA METS firms expand service range through product and service differentiation and customisation. The companies investigated what aspects of work for current customers within the scope of existing capabilities are not performed by the company, and search for possibilities to get involved. The customisation and product differentiation falls into adaptation path strategies, since it is reactive and demand driven, based on existing resources recombination and does not include radical changes in technological and business processes (Figure 7.6) (Cumbers et al., 2003).

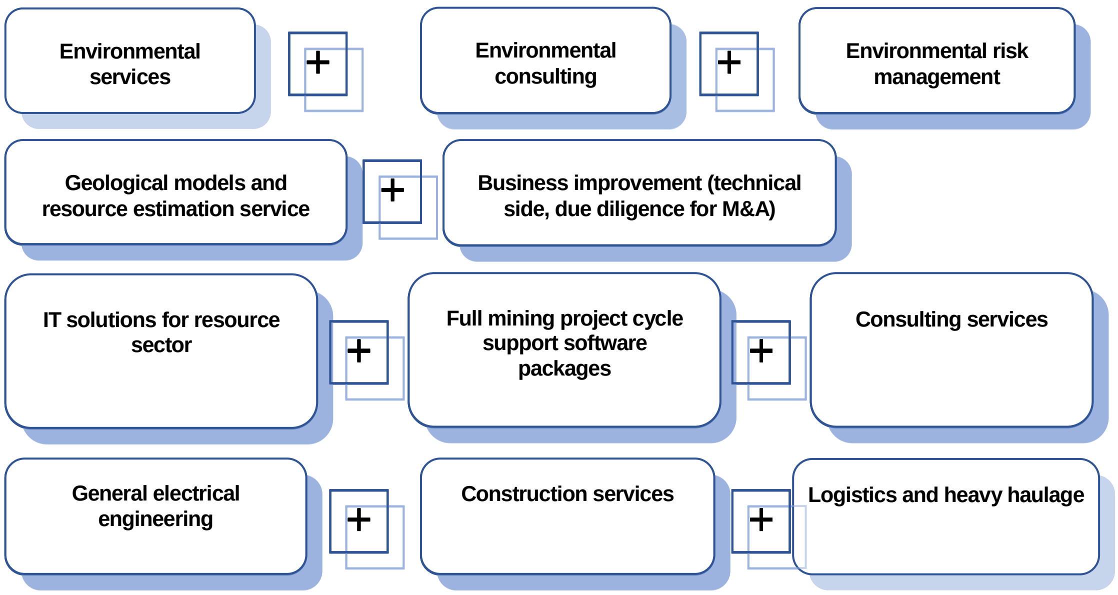

Figure 7.6 Examples of extending and introducing complementary services

7.2.2 Innovation strategies of the SA METS firms

A firm's innovate capability largely determines its ability to diversify, adapt and reinvent itself as it attempts to adapt to changes in the market and technological environment (Katila & Ahuja, 2002). In the case of small firms, innovation is closely related to diversification, to research and development, and to the discovery of new niches in which to market services and products (e.g. Chapman et al., 2004; Dachs et al., 2014). Based on the interview results, three types of SA METS companies in terms of innovativeness were identified:

(1) *disruptive innovators* – companies actively invested in research and development and introduced new-to-market technologies, products, and services

(2) *problem solvers for customers or demand driven innovators* – companies developing innovative solutions in response to customer's needs thus organically building up their capabilities and expanding existing services

(3) *incremental or organisational innovators* – companies innovating mainly through improvement in current processes by adopting new technologies, or introducing organisational innovation by improving and upgrading processes and business models.

The majority of METS firms that participated in this study were *incremental innovators* and *customer problem solvers*, ranging from those who applied current technology to develop effective solutions for customers to those who are able develop new technology to effectively solve customer problems. *Disruptive innovators* create new paths in the regional economy through the introduction of high value adding to market services. Problem solvers and disruptive innovators pursue adaptation strategies.

Disruptive innovators. 'Technology push' innovators are the most valuable for new path creation growth in a region. As interview data confirmed, such firms demonstrate strong leadership, high absorptive capacity, investment in R&D and talents, flexible organisational structure, culture that embraces a diversity of ideas and bottom-up initiatives. Emphasis is on research and development, a good knowledge of market needs, proactive strategies and a clear vision of matching innovative technologies with customer needs. The last has been documented in previous research regarding Australian METS firms by scholars (Martinez-Fernandez, 2010; Scott-kemmis, 2013). These firms 'feed' into regional knowledge systems, contributing to regional development and the emergence of value added industries in the region. There were more locally owned firms among the radical innovators at different stages of development among the study participants than subsidiaries of international companies.

Disruptive METS firms innovators invested high share of their profit into R&D, encouraging innovations within the organisation and constantly searching for new opportunities through innovative solutions in order to gain comparative advantage in the market. Based on study survey results, just 4.8% of respondents spent more than 15% of their budget on research and development. Disruptive innovators among the study participants represented METS firms led by enthusiastic owners and business founders dedicating most of their profit to R&D and business development. These companies were oriented to development of new breakthrough technologies and their application in various sectors, thus creating new niches in the existing markets and contributing to a regional renewal (Figure 7.7).

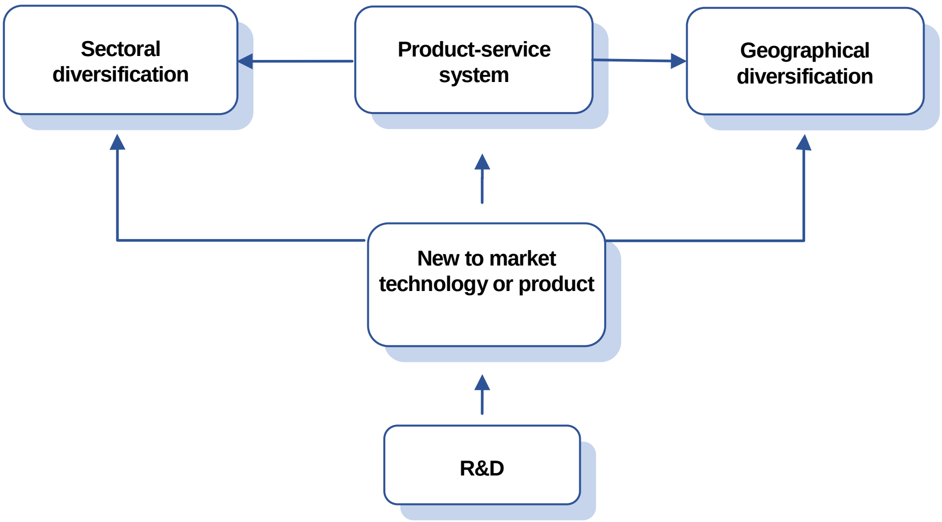

Figure 7.7 Disruptive innovations and emerging technologies

However, while larger METS companies with resources were able to commercialise their developments, small firms often struggled to find resourceful partners and investors to commercialise the technology and develop workable business models. Some of the METS firms operating in South Australia relied on new technologies and research and development performed overseas. In these instances, their knowledge of local markets was essential to match and sell developed technology with customer requirements.

Demand driven innovators – problem-solvers for customers. Data from the study showed that customer problem-solving was a driver for proactive innovative METS firms to undertake R&D and develop new technologies (see Figure 7.8), which is consistent with findings in small firm diversification literature from the other sectors (Chapman et al., 2004; Colombo et al., 2014; Corradini, Demirel, & Battisti, 2016; Døving & Gooderham, 2008). Most of study participants were diversified across sectors, outward oriented and constantly sensing the market.

Demand driven METS innovators were primarily focused on building and maintaining long-term relationships with the clients, building an in-depth understanding of customer requirements. In most cases, demand driven innovators among the survey respondents did not score high in R&D, but rather invested in new products and service developments in order to develop solutions for consumers (Scott-kemmis, 2013; Walker & Minnitt, 2006). This differs from findings of Atienza et al. (2012), who found in their Chilean study that collaboration with clients did not significantly affect METS investment in innovation.

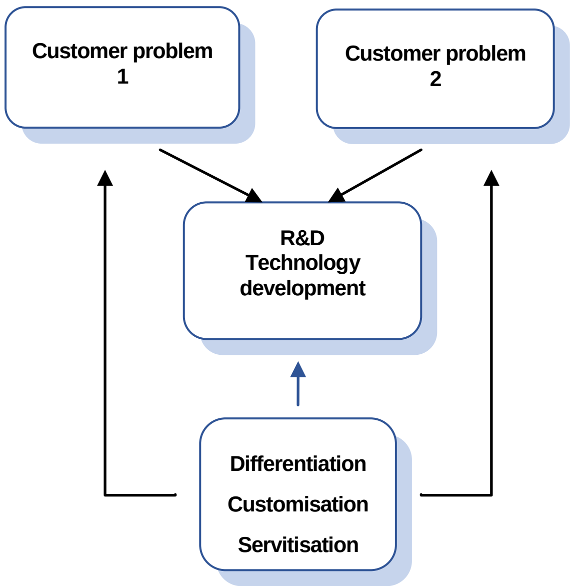

Figure 7.8 Demand driven innovations through customer problem-solving

Most of the interviewed participants introduced new products and services progressively, enlarging their service offerings with problem solving and consumer-centred business models. This pattern of the customisation of products and services in response to demand has also been observed among SMEs in the UK (Cumbers et al., 2003), and in earlier studies of Australian resource-related services companies (Martinez-Fernandez, 2010; Scott-kemmis, 2012). Customer-based models were reported in the software development industry in Italy (Colombo et al., 2014) and accounting services (Maurizio et al., 2015).

The importance of the ‘domain knowledge’ and the ability to ‘talk to customers in their own language’ was highlighted in the research data, as was customer engagement, as noted by researchers, such as (e.g. Townson et al., 2016) in an investigation of the METS sector.

Incremental innovations. The companies that had already been supplying highly specialised services to the resource sector proved to be the least adaptable. They generally provided mining, civil construction, exploration and drilling services, and innovated by incrementally building on existing capabilities through new technologies, organisational innovations and more sophisticated equipment.

Larger METS firms introduced organisational and technological innovations, updated business models, IT solutions and systems to improve operations.

7.2.3 Strategies to maintain short-term competitiveness

Study data indicated that small specialised firms found it difficult to pursue adaptation strategies, unless they targetted interstate projects. These participants focussed on short-term strategies to retain competitiveness without major changes in the company’s strategic direction. These included *downsizing* and *changing company structure, building diverse portfolios of projects to mitigate risks, developing and maintaining relationships*. A specific focus on customer relations reported in the present study agreed with earlier research (Chapman et al., 2004). Incremental innovations were considered to be adaptation strategies, since customisation in response to customer demands does not lead to technological breakthroughs and new path creation (Cumbers et al., 2003).

Interestingly, data showed that some of the METS firms’ participants proactively planned their project portfolio in anticipation of downturns, given the nature of the industry, seeking to collaborate with larger contractors on large projects. This was a strategy for maximising opportunities and minimising risks associated with the smaller scale contracts. Some companies conducted free education sessions and seminars for potential customers educating them about current standards. They understood clients’ needs and indirectly promoted their services. Some firms with lower productivity reported a struggle to survive or plans to exit the industry.

7.2.4 Summary of findings for research question one

A variety of adaptability and adaptation strategies was discovered when the data related to RQ1 were analysed. While larger METS firms mainly deploy adaptability strategies leading to long-term sustainable business outcomes, smaller, more narrowly specialised METS firms adopt short-term strategies, mainly downsizing and focusing on customer relationships (Chapman et al., 2004).

Compared to previous studies of resource extractive regions in transition (e.g.Chapman et al., 2004; MacKinnon et al., 2004; Morris et al., 2012), apart from geographical and inter-sectoral diversification, the development of integrated service solutions (Panesar et al., 2008) and servitisation strategies (Dachs et al., 2014) were actively pursued by larger SA METS firms. Innovation and diversification in most cases was driven by the need to find a solution for a customer problem, encouraging the supplier to invest in R&D.

Cumulative innovations through 'learning linkages' that influence developments in other industries were also reported during the study, which confirmed findings from previous research (e.g. Figueiredo & Piana, 2016). Diversification strategies among SA METS firms ensured the transfer of knowledge and technologies to other regional markets and sectors (e.g. Jacquemin & Berry, 1979). This contributed to the creation of related variety in the regional economy (Boschma, 2017). However, opportunities for diversification differed depending on the firm's core capabilities.

Knowledge intensive services firms had more prospects for sectoral diversification, while more narrowly specialised service providers could only find new markets in other states and, in a worst case scenario, experienced technological lock-in (Martin, 2010) and path-dependency (e.g. Knobblock & Pettersson, 2010). Narrowly specialised suppliers to the resource sector struggled to develop flexible strategies and re-orient themselves to other sectors, a problem earlier discovered by researchers studying resource extractive regional development (Agyei et al., 2013; Walker & Minnitt, 2006; Warrian & Mulhern, 2009). The larger METS firms adopted both sectoral and geographical diversification strategies, contrary to what Chapman et al. (2004) had found in the case of North Sea Oil suppliers. Chapman and his colleagues claimed that UK suppliers to the oil and gas sector adopted geographical ***or*** sectoral diversification strategies exclusively, while in SA, the firms that pursued diversification strategies pursued them in both directions.

Diversification strategies were found to be inseparable from innovative strategies since diversification requires the introduction of new products and services, technologies, processes and business models, in line with service innovation and servitisation literature (e.g. Dachs et al., 2014; Santamaría, Nieto, & Miles, 2012).

The obvious factors for differentiation between firms that developed adaptation versus adaptability strategies were mainly firm size and age, the nature of core business activities, and investment in research and development. For example, previous research, e.g, in the Swedish mining industry, highlighted significant differences between firms supplying knowledge intensive activities, such as engineering and consulting, versus those performing labour intensive activities, like transportation or mining services, in terms of adaptation to a crisis in the resource sector (Knobblock & Pettersson, 2010). While knowledge intensives easily adapted by re-orienting to other sectors, labour intensives were extremely vulnerable. Even highly specialised METS firms (not labour intensive), when pushed by competition, were able to find alternative markets for their services.

7.3 Research question two

Research question two was:

RQ 2. *How does embeddedness in regional supply networks affect the development of adaptability strategies (diversification and innovativeness) among METS firms?*

RQ2.1 *Are there relationships between SA METS firm diversification and innovativeness?*

RQ2.2 *What is the impact of SA METS firm positional embeddedness in the regional resource industry supply network on its sectoral and capability diversification strategies?*

RQ2.3 *What is the impact of SA METS firms positional embeddedness in the regional resource industry supply network on its innovativeness?*

RQ2.4 *What is the impact of SA METS firms relational embeddedness in the regional supply networks (trust, joint action and information exchange) on METS firm* *sectoral and capability diversification strategies?*

RQ2.5 What is the impact of SA METS firms relational embeddedness in the regional supply networks (trust, joint action and information exchange) on its innovativeness?

7.3.1 Relationships between SA METS firm diversification and innovativeness

RQ2.1 Are there relationships between SA METS firm diversification and innovativeness?

The current research indicated significant positive relationships (β = *0.382***, p<0.01*) between SA METS firms' *capability diversification* and *sectoral diversification* for the whole sample. Interestingly, multi-group analysis revealed that this correlation was attributed only to tier 1 – firms supplying services directly to resource extractive companies (β = *0.397***, p<0.001*), while for lower tiers there was no correlation whatsoever. This means that tier 1 suppliers in the South Australian resource sector were mainly represented by diversifiers that pursue both sectoral and capability diversification or, alternatively, they were highly specialised suppliers of only one or few products to the resource sector (such as exploration and drilling companies). Thus, for diversifiers, the assumption that firms with a broad range of capabilities operate across multiple sectors was confirmed for tier 1 suppliers. On the other hand, for lower tiers there was no relationship between the supplier's range of capabilities and the number of sectors in which it operated.

The quantitative analysis of the whole sample confirmed significant weak to moderate relationships (β = *0.296***, p<0.01*) between the number of sectors in which METS firms operated – *sectoral diversification*, and the number of new products and services they introduced – METS firm *innovativeness*. The study interviews also confirmed that the firms with more diversified portfolios were more innovative during a crisis, confirming previous studies (e.g. Lin & Chang, 2015), since diversified firms had more opportunities for internal recombination of diverse knowledge to be used for innovations (Katila & Ahuja, 2002).

Servitisation and service innovation literature explains the relationships between the number of services offered and innovation with the following arguments: 1) technological product and processes innovation may enable new services. For example, technological innovations, such as sensor technologies or GPS, facilitate the introduction of new types of services (Neely, 2007; Santamaría et al., 2012) enlarging service offerings to intensify customer relations (Dachs et al., 2014).

Capability diversification did not have a direct relationship with firm *innovativeness*; however, it exerted an indirect effect with a mediational effect of *sectoral diversification* ($\beta = 0.106^{**}, p<0.05$). Again, this is consistent with key arguments that firms with greater innovativeness are more successful in developing new capabilities and responding to their environments, thus being able to expand to new markets and grow capability (W. M. Cohen & Levinthal, 1990; Hurley & Hult, 1998). With reversed causality, the firms having greater capability and operating across several sectors have a higher propensity to innovate. Chapman et al. (2004) made a similar observation while studying diversification and innovation strategies of suppliers in the Aberdeen oil complex, however acknowledging that

> *It would be overly simplistic to imply that non-diversifying firms demonstrate a lack of entrepreneurship, as they may operate in a highly innovative and creative fashion within their existing market…Chapman et al. (2004, p. 389)*

Thus, for SA METS firms, diversification positively affected the introduction of new products and services. It should be noted, however, that this finding cannot be compared with the studies in firm innovativeness, which measure innovative output as the number of patents.

Absorptive capacity and METS firm innovativeness and capability diversification. As expected, *absorptive capacity* measured as a construct of R&D investment and investment in the development of new products and services, had a direct positive impact on METS firms' *innovativeness,* measured as the number of new products/services introduced by the firm ($\beta = 0.151^{**}, p<0.05$). Findings from the qualitative interviews demonstrated that for *disruptive innovators* R&D is an essential determinant of a firms' ability to introduce innovative products and that for *problem-solvers,* it is the clients' problems that drive the need for R&D to find the best solution. This requires in-house R&D capabilities for technology improvement and investment in systematic R&D or other organised improvement efforts.

However, interestingly, no significant relationships were discovered between *absorptive capacity* and *sectoral* and *capability diversification* despite positive direct relationships between *sectoral diversification* and *innovativeness,* and the indirect impact of *capability diversification* on *innovativeness*. This observation demonstrates that a firm might invest in new product development and R&D regardless it capabilities or the number of sectors in which it operates, and vice versa.

The exposure to a more varied range of client problems from different sectors did not increase the METS firms' suppliers propensity to invest more in research and development.

These findings differ from the previous research on small firm technological diversification, which acknowledges the role of absorptive capacity in leveraging technological resources for diversification (e.g. Breschi, Lissoni, & Malerba, 2003; Colombo et al., 2014; Suzuki & Kodama, 2004). It highlights the difference between firm *innovativeness* and *diversification* capabilities, which is opposite to the argument presented by some scholars that diversification requires specific capabilities similar to those essential for innovation (e.g. Corradini et al., 2016). However, again it should be noted that previous studies in small firm diversification are not consistent in defining and measuring small firm technological diversification, which makes comparison difficult and calls for the development of a more comprehensive definition and measurement approach to small firm diversification.

7.3.2 Relationships between SA METS firms' positional embeddedness into regional supply networks and innovativeness, capability and sectoral diversification

The research questions answered in the current section were as follows:

> *RQ2.2 What is the impact of SA METS firm positional embeddedness in the regional resource industry supply network on its sectoral and capability diversification strategies?*
>
> *RQ2.3 What is the impact of SA METS firms positional embeddedness in the regional resource industry supply network on its innovativeness?*

The role of firm embeddedness in regional supply networks was acknowledged in the literature as a key reason for regional SME diversification, adaptation and survival during downturns in the resource sector (e.g.Bas et al., 2008; Chapman et al., 2004; MacKinnon et al., 2004). Extant research into industry clusters and regional development indicates that regional networks play an essential role in providing support for innovations and capability growth for local firms (e.g. P.-A. Balland, De Vaan, & Boschma, 2013; Lechner & Leyronas, 2012; Ter Wal & Boschma, 2009). This was also reported in the resource related industries (e.g. Chapman et al., 2004; Cumbers et al., 2003; Knobblock, 2013; MacKinnon et al., 2004; Scott-kemmis, 2012).

However, scholars also claim that over-embeddedness in regional and local networks may reduce the adaptive capacity of an organisation and, due to path dependence constraint, the influx of innovative ideas from outside the network (Day et al., 2013; MacKinnon et al., 2004; Uzzi, 1996, 1997).

In the current research, it was postulated that its position in the regional production network allowed a METS firm to develop relationships with more influential players in the resource sector and get access to opportunities, knowledge and information, which positively affected the METS firm's propensity to innovate and diversify.

The interview data supported the relationships between a firm's position within the regional production network and its innovativeness and ability to diversify. The regional METS firm's propensity to develop linkages and position themselves within the regional resource production network exposed them to a more diverse range of customer problems and opportunities, which required a capability upgrade in line with earlier research in resource sector development (e.g. Morris et al., 2012). All interviewees confirmed the importance of building and maintaining relationships within the industry networks to get opportunities and develop business. Building relationships with customers by establishing informal connections based on trust, reliability and loyalty has been reported to be key to successfully operating in the sector (MacKinnon et al., 2004).

In the quantitative study, the *positional embeddedness* of the METS firm in the regional resource industry supply network was measured as a combination of *degree centrality* – the number of direct connections in the regional supply network and *eigenvector centrality* – 'power' position in the network, that is, proximity to the hubs in the network. These findings are discussed below.

Effect of degree centrality on firm diversification and innovativeness. A positive and significant relationship was established between *degree centrality* and *capability diversification* ($\beta = 0.326$***,

$p<0.01$) – the number of different capabilities or services the METS company offer – for the whole sample. This confirms the importance of the METS company having as many direct connections in the regional supply network as possible to grow its capability base.

This effect could be achieved when top tier suppliers (Tier1 and Tier2) worked directly with resource companies and EPC/EPCM providers. *Firm size* had no effect on the number of direct connections within the regional mining industry supply chain and METS firms' innovativeness and diversification. Correlation between centrality in the regional production network and capability diversification was moderate and significant ($\beta = 0.519^{***}$, $p<0.01$), while for lower tier suppliers the low number of connections in the supply network reduced capability growth.

Visibility in the sector through direct connections with mining operators and participation in various projects resulted in *capability diversification*. The corollary was that with a broader range of capabilities, firms acquired had more clients, since centrality was also attributed to reputational benefits that lad to getting more referrals and opportunities (Fernández-Olmos & Díez-Vial, 2013; Maurizio et al., 2015).

Direct interactions and strong ties are essential for transfer, combination, or production of knowledge in networks and clusters, which contributes to capability accumulation (e.g. M. Bell & Albu, 1999; Hollstein, Matiaske, & Schnapp, 2017). Firms with higher centrality have better access to the information about upcoming tenders and potential work packages and control the distribution of this critical information within their own supply networks. Similar findings were reported in the Toyota supply chain in the automotive industry (Kito et al., 2014).

These findings confirm the heterogeneity of METS firms due to segregation between lower and higher tiers i line with the previous research of Atienza et al. (2016), who found a noticeable difference between a supplier's capabilities and practices and their position in the resource supply chain. While tier 1 suppliers invested in innovation, quality control and internationalisation, lower tier suppliers mainly focused on avoiding insolvency and maintaining relationships with clients. Interview findings and previous research suggest that during a downturn, those companies that were able to develop complementary services could offer more comprehensive service packages or switch from core to complementary competencies (e.g. Chapman et al., 2004). Thus, the companies that broadened their service offerings were able to retain existing and acquire new clients by maintaining a high number of connections within the regional supply chain.

Moderating effect of *absorptive capacity* on relationships between METS firm *positional embeddedness, innovativeness and capability diversification*. As expected, there was a significant positive moderating effect ($\beta = 0.151^*$, $p<0.1$) of *absorptive capacity* on relationships between *degree centrality* and *innovativeness.* This could be explained by the fact that firms with higher absorptive capacity, that is, that invested more in R&D and new products, were also centrally positioned in the regional supply network and had higher innovative output, since they were able to effectively leverage knowledge accumulated from external sources (Soosay and Hyland, 2008). Thus, absorptive capacity enhanced the effects of holding a central position in the regional supply network, as previously suggested by (Scott-kemmis, 2013; Silvestre & Neto, 2014).

However, the joint effect of METS firms' *absorptive capacity* and *network degree centrality* on *capability diversification* was negative ($\beta = -0.256^{**}$, $p<0.05$). That is, the effect of *degree centrality* on a supplier's range of capabilities (*capability diversification*) was lower for companies with high levels of *absorptive capacity*. This indicates that METS firms with higher levels of investment in new product development focussed on specialising, and were able to position themselves centrally in the network by offering their unique products and services to a wide range of clients. Thus, a greater number of direct connections could be associated with a smaller number of capabilities.

Effect of eigenvector centrality on firm diversification and innovativeness. *Eigenvector centrality* reflected the effect of the METS firm's proximity to network hubs and its 'influence' or 'power' in the network. The social network analysis of the structure of the resource sector supply network in South Australia (see Appendix) revealed that the regional hubs were major mining and oil and gas companies and large EPC/EPCM providers creating demand for the local METS sector, confirming the presence of a hub-and-spoke structure for the resource industry in South Australia.

The analysis revealed 14 major clients for SA METS firms that had more than 50 connections with regional firms, including SA's largest mining operator with 347 connections, followed by an SA oil and gas company with 194 connections. METS suppliers with a high *eigenvector centrality* were those supplying to these mining operators and large multinational tier 1 contractors.

Eigenvector centrality, METS diversification and innovativeness. *Eigenvector centrality* was positively and significantly correlated with METS firms' *sectoral diversification* ($\beta = 0.205^{***}$, $p<0.01$). This was observed for *small* METS groups ($\beta = 0.385$, $p<0.05$). For small METS firms, *eigenvector centrality* exerted a significant and positive influence on *innovativeness* ($\beta = 0.265$, $p<0.05$), while no such relationship was established for the whole sample.

Data from the interviewed sample demonstrated that dealing directly with the end-customer was a strategy of well-established regional METS firms with highly developed capabilities, as well as smaller innovative companies providing unique technological solutions for mining operations. To become a supplier to a large international company, the local METS supplier had to be able to meet compliance criteria while taking risks and conforming to industry standards (Atienza et al., 2016). These companies had the international certification and quality systems in place, talent and collaborative skills to work with major clients (Atienza et al., 2016).

On the other hand, local METS companies operating at the 'periphery' of the regional supply network at lower tiers lacked these features and usually operated as sub-contractors to the higher tier service providers, performing very few specialised services, such as haulage or construction. [Refer (Atienza et al., 2016) for details on a similar situation in Antofagasta, Chile].

METS firms directly connected to the resource extractive companies and EPCM providers had more opportunities to diversify across sectors, overseas and interstate because of their association with the resource, construction, defence and infrastructure sectors. After METS companies have proved their worth, they are able to switch to other sectors during slack production periods in the resource sector, as indicated by the interview data.

Furthermore, as the interviews revealed, large contractors could and did 'open the door' for local suppliers to resource extractive companies. By sub-contracting to the third party – an EPCM provider or other larger contractor working directly with resource companies – a local supplier could gain a chance to introduce its service to the end-customer and then develop a direct connection. In addition, local suppliers benefited from direct connections to large resource operators and EPCM providers in terms of geographical diversification, since their contracts could involve operations in other states or even overseas. Note that a similar phenomenon of suppliers' penetration to foreign markets through relations with large oil and gas client companies was documented in Aberdeen (Chapman et al., 2004).

An interaction effect of *eigenvector centrality* and *absorptive capacity* on *capability diversification* was observed. While in the whole sample there was no direct relationship observed between *eigenvector centrality* and *capability diversification* ($\beta = 0.05$) or between *absorptive capacity* and *capability diversification* ($\beta = 0.013$), *eigenvector centrality* combined with *absorptive capacity* produced a significant positive relationship with *capability diversification* ($\beta = 0.222$**, $p<0.05$). Analysis of the data indicated that the more direct connections a supplier had with hub resource companies and tier 1 EPC/EPCM sub-contractors with high investment in R&D, the more diverse the range of capabilities it developed. Furthermore, suppliers possessing a diverse range of capabilities and with high investment in R&D had a greater propensity to become direct suppliers to major clients in the region.

7.3.3 Relationships between SA METS firms' relational embeddedness in the regional supply network and its innovativeness and diversification

The research questions addressed in the current section were as follows:

> *RQ2.4 What is the impact of SA METS firms relational embeddedness in the regional supply networks (trust, joint action and information exchange) on METS firm sectoral and capability diversification strategies?*
>
> *RQ2.5 What is the impact of SA METS firms relational embeddedness in the regional supply networks (trust, joint action and information exchange) on its innovativeness?*

The relationship between dyad-level variables characterising *relational embeddedness* – level of *trust, information exchange* and *joint problem solving* between the METS firm and its supply chain partners – clients and suppliers, on METS firms *adaptability strategies* – *innovativeness* and *diversification*, were tested. Relational embeddedness in this research was measured using conceptual frameworks developed from organisational studies literature (Gulati & Sytch, 2007; McEvily & Marcus, 2005; Uzzi, 1996, 1997).

Although being outside the scope of this research, the relationships among relational embeddedness dimensions: *trust*, *fine-grained information exchange* and *joint problem-solving* were tested in line with the previous research (Gulati & Sytch, 2007; McEvily & Marcus, 2005; Uzzi, 1996, 1997). As expected, results of the data analysis revealed that *trust* directly and significantly influenced the level of *fine-grained information exchange* between parties ($\beta = 0.223^{***}$, $p<0.01$) as also confirmed by recent studies (e.g.Birasnav et al., 2015; K. Mirkovski, P. B. Lowry, & B. Feng, 2016; Tran, Childerhouse, & Deakins, 2016; I. L. Wu, C. H. Chuang, & C. H. Hsu, 2014). As could be expected, *trust* between buyers and suppliers positively correlated with *joint problem solving* ($\beta = 0.121^{*}$, $p<0.1$). *Fine-grained information exchange* was also highly correlated with *joint problem solving* ($\beta = 0.622^{***}$, $p<0.01$). This also confirmed multiple findings from previous research in other industries, which posited that *trust* and *information exchange* are precursors to *joint problem solving* between customers and suppliers (McEvily & Marcus, 2005). However, in-depth investigation or interpretation of these relationships was not a focus of this research, but rather were tested to confirm the adequacy of the construct.

The impact of *joint problem solving* on *capability* and *sector diversity*. Direct positive significant relationships were established between *joint problem solving* and *capability diversity* ($\beta = 0.255^{***}$, $p<0.01$). This finding is logical, confirming that suppliers who indicate high levels of joint problem-solving with their customers have more opportunities to learn, adopt new solutions and broaden their range of their capabilities (McEvily, & Marcus, 2005; Zaheer, McEvily, & Perrone, 1998).

According to servitisation and service innovation literature, companies providing tailored services enjoy frequent customer communication and feedback, and higher customer involvement (Dachs et al., 2014). As study interviews revealed, SA suppliers that expanded their service range benefited from knowledge transfer occurring through collaboration around customer problems, while working on meeting technical specifications, coordinating engineering requirements, quality control, components and systems development, and certifying suppliers, which is in line with earlier studies (Warrian, & Mulhern, 2009).

Joint problem solving also yielded a direct positive, however less significant, effect on *sectoral diversification* ($\beta = 0.116^{*}$, $p<0.1$). As in the case of capability diversity, collaboration with customers affects a firm's ability to broaden its range of capabilities and technological solutions. These solutions could be further implemented in other sectors. This is similar to the situation of the Aberdeen oil complex, where networks served as the main channels for organisational learning, contributing to supplier capability development (Chapman et al., 2004; MacKinnon et al., 2004).

Interestingly, no direct or indirect effects were established between *joint problem solving* and *supplier innovativeness*. The number of new products and services introduced by a METS firm did not depend on the level of collaboration between suppliers and customers. More detailed research is required to determine whether or how knowledge transforms a METS firm and whether this results in the emergence of a new product or service.

Joint-problem solving between suppliers and customers also positively moderated the relationships between *degree centrality* and *capability diversity* (β = 0.222**, $p<0.05$). This confirms the importance of a collaborative approach and customer engagement in problem solving for the capability growth of METS firms (Basco & Calabrò, 2016; Scott-kemmis, 2013). If the METS firm is centrally located in the regional production network and working collaboratively, it is in the best position to grow its capability base, which concurs with the qualitative findings of a number of scholars (e.g., Jacquemin, & Berry, 1979; Martinez-Fernandez, 2010; Scott-Kemmis, 2013).

The interaction effect of *absorptive capacity* and *joint problem solving* on METS firm *innovativeness* was negative (β = -0.162**, $p<0.1$). This finding explains previous assumptions about the importance of the role of *absorptive capacity* as an internal knowledge source versus supply chain collaboration as an external knowledge source for SA METS firms. A high level of *absorptive capacity* not only helps a firm to transform externally sourced knowledge from multiple supplier-customer relationships, it makes the company less dependent on collaboration with supply chain partners in terms of new product development. On the other hand, *innovativeness* of companies with a lower level of investment in R&D is mainly the result of collaboration with supply chain partners.

The moderating role of industry associations membership on the model relationships. A significant difference between industry association member versus non-member groups was found for the relationship between supply network *centrality* and *capability diversification.* **Non** industry association members were influenced by centrality to build their capabilities. Furthermore, METS firms **not** belonging to an industry associations were also more obviously responsive to information exchange leading to problem solving. The correlation of information exchange and joint problem solving was much higher ($\beta = 0.716^{***}$ vs $\beta = 0.396^{***}$) for non-member group vs active members. This interesting finding should be investigated further. Based on these findings and data from the qualitative interviews, there appears to be little justification for the impact of industry association membership on enhancing embeddedness or assisting firms in the development of adaptability strategies, that is innovativeness and diversification.

7.3.4 Summary of findings for RQ2

Propensity to diversify and innovate was considered the most desirable strategy by which to develop value-added activities in the resource extractive regions. A conceptual framework was developed to evaluate whether and to what extent the embeddedness of METS firms in regional supply networks influenced their ability to adapt to an uncertain business environment through innovation and diversification. The influence of the firm's *absorptive capacity* was also evaluated. The moderating effects of *firm size*, *membership in industry associations,* and *tier position* were also examined.

The key findings from the quantitative study are as follows:

1 *Capability diversification* and *sectoral diversification* were found to positively impact the number of new products and services introduced by the METS firm over the period of downturn in the resource sector. METS firms able to diversify their services and to operate in more than a single industrial or geographical sector were able to grow their product and service offerings despite the downturn in the resource sector.

2 Both *positional* and *relational* embeddedness impacted METS firms propensity to diversify, confirming that the supplier-customer relationships in the SA resource industry regional supply networks were sources of external knowledge [confirming previous findings . There was a significant difference between SA top tier suppliers and lower tier suppliers in terms of the impact of their positional embeddedness in the regional supply networks when it came to diversification and innovativeness. For small METS firms, proximity to key clients in the region – eigenvector centrality – significantly influenced their innovativeness and capability diversification, but the impact was notably higher for top tier suppliers. This confirms the

heterogeneity of METS firms in SA and the need for more detailed studies in line with suggestions from previous research (Atienza et al., 2016; Basco & Calabrò, 2016).

3 While positional embeddedness benefited top tier suppliers more than others in terms of capability diversification, *relational embeddedness* was shown to be equally important without reference to tier structure. Relational embeddedness, operationalised through three dimensions – *trust, information exchange* and *joint-problem solving* – positively and significantly influenced METS firms' diversification strategies. In particular, trust and frequent fine-grained information-exchange between suppliers and customers proved to be the pre-requisite to joint problem-solving, which produced a significant and positive effect on a firm's diversification capability. However this runs counter to the literature on functional lock in in old industrial areas (e.g. Grabher, 1993; Hassink, 2010), which states the hierarchical relationships between customers and SMEs lead to blueprint production, few boundary spanning functions, supplier dependency leading to reduced adaptability.

Relationships between trust and joint-problem solving were significantly stronger for small size lower tier suppliers, which confirms previous qualitative research (Cumbers et al., 2003; MacKinnon et al., 2004; Martinez-Fernandez, 2010) and interview findings. No direct impact of relational embeddedness on METS firms' innovativeness was discovered.

4 Two paths for *capability growth* and *innovativeness* for SA METS firms were discovered. Firstly, solving customer problems and collaboration led to the gradual accumulation of capabilities that could then be applied in different sectors. Secondly, investment in R&D and internal development of new technologies opened new markets. Interview data demonstrated that neither tier position nor company size affected these pathways, which depended instead on internal resources and METS firm strategies. Further research could be undertaken to identify how and why some firms invest in internal development, while others are more oriented towards capability development through collaboration with customers.

5 *Absorptive capacity*, measured as a composite variable of investments in new products, services development, and R&D investment, predictably impacted firm innovativeness, and also produced several interesting interaction effects. Absorptive capacity positively moderated

relationships between degree centrality and innovativeness, thus suggesting that firms benefit more from direct connections if they are able to transform knowledge from partners into innovative products.

In terms of *capability diversification*, a combined positive effect of *eigenvector centrality* and *absorptive capacity* was observed. Thus, for firms located in the network close to powerful clients, high investment in R&D and new product development contributed to capability accumulation.

However, an interaction effect of *absorptive capacity* and *joint problem solving* on innovativeness was observed. It was explained by the fact that some firms mainly innovate due to collaboration around customer problem solving, while others focus on internal R&D and new product development. Negative interaction showed that these two were almost mutually exclusive strategies.

Finally, the combined effect of *degree centrality* and *absorptive capacity* on *capability diversification* was also negative. Thus, for METS firms highly investing in R&D, having many clients was not associated with a broad capability range. On the other hand, for companies with low investment in R&D, the number of clients to a large extent defined the capability breadth.

The effect of positional embeddedness in the alliance networks in the Australian resource sector on METS firms' market power was tested by (West, 2014). However, collaborative networks differ by nature and structure from supply networks. Thus, this research fills the gap by providing micro-level empirical evidence of the impact of the regional supply network structure and relationships on South Australian METS firms' capability development.

7.4 Research question three

Data gathered and analysed during research to address RQ1 demonstrated that South Australian METS companies operating during a decline in the resource industry from 2012 till 2016 followed a spectrum of strategies between adaptability and adaptation[6], while data analysed in relation to RQ2 showed that positional and relational embeddedness in a regional supply network influences METS

[6] For more detail see RQ1 in this section and Chapter 6 for interpretation of the interview findings

firms' adaptability strategies of *innovativeness* and *diversification*. Being positioned close to the network core and having collaborative relationships with supply chain partners positively impacted SA METS firms propensity to innovate and diversify[7].

The third research question asked:

> ***RQ3*** *How do network governance instruments contribute to adaptability and resilience of resource extractive regions through emergence of value-added industries around resource extractive activity?*
>
> *RQ3.1 How effective were governance instruments applied in the SA resource industry regional supply network during downturn from 2012 to 2016?*
>
> *RQ3.2 In what way did regional supply network structure and governance contribute to the adaptation and resilience of the SA resource extractive economy during the downturn from 2012 to 2016?*

An evolutionary view of commerce explains regional resilience as the capacity of a region to respond positively to short-term shocks by reconfiguring its industrial, network and institutional structures. This may be by developing new growth paths to avoid stagnation and decline (R. Boschma, 2014b). Scholars claim that a related variety of industries makes the region resilient, by enabling it to draw on a local pool of skills and capabilities, providing potential for inter-industry learning (R. Boschma, 2014b; Frenken & Boschma, 2007).

The findings from the research showed that the METS sector benefited from the presence of a range of related industries (*related variety*), including defence, energy, service, infrastructure, agriculture, and electronics by finding new markets and new applications for their services and products during downturns in the resource sector. *Related variety* of industries allow for the recombination of resources, such as labour and technologies (Neffke et al., 2014). Furthermore, increased competition among METS firms acted as a selection mechanism that allowed more capable and innovative METS firms to substitute for large international companies.

[7] For more detail see RQ2 in this section and Chapter 5 for quantitative analysis

However, *related variety* also makes a region vulnerable, since downturn in one sector affects other related sectors through a 'domino effect' (e.g. Boschma et al., 2017). Downturn in the SA resource sector triggered a decline in demand for the whole METS sector, with an uneven impact due to heterogeneity. Not all METS firms were able to exploit opportunities for diversification stemming from *related variety*. Much depended on their core capabilities and resources. However, the adaptability processes that stemmed from the emergence of new technologies and start-ups clashed with existing formal structures and the informal culture that existed in the South Australian resource sector supply chains. METS firms research participants expressed the view that more space for innovation and creative recombination of knowledge was needed in the sector.

Formal and informal instruments of regional supply network structure and governance and their impact on regional adaptability and the adaptation of METS firms and the regional industry as a whole are discussed below.

7.4.1 Formal network governance instruments applied in the SA regional resource industry supply network

The following formal supply network governance instruments and structures were identified in the SA regional resource industry supply network:

- tiered procurement structure of the resource industry supply chain
- industry standards
- contracts
- regulation and taxes in the SA mining industry
- industry associations as network governance organisations.

The key agents of regional supply network governance in the resource sector included:

- federal and state governments
- leading companies in the region, including resource extractive companies and EPC/EPCM providers
- standardisation and certification bodies
- industry associations
- METS companies themselves.

Tiered procurement structure. The tiered structure of the resource industry supply chain acted as a powerful formal instrument of regional supply network governance, ensuring the control of the resource operators over their supply chains (Arias, Atienza, & Cademartori, 2014; Atienza et al., 2016; Phelps, Atienza, & Arias, 2015; Walker, & Minnitt, 2006).

The tier position of a METS company is identified based on its turnover, that is, its ability to take risks with large contracts, level of managerial and project management capabilities, level of development of business processes and systems, and performance track record. Thus, procurement requirements of resource extractive companies documented in standards and contracts act as a formal selection mechanism for SA METS.

Large-scale contracts were awarded to tier 1 EPC/EPCM providers, which split the projects into smaller work packages to be distributed among tier 2 sub-contractors, and so on. Such organisation limits the possibilities for smaller suppliers in lower tiers to work directly with resource companies, even if they have innovative solutions to offer. Thus, middle and small size SA METS firms operating at the bottom of the tier structure often became 'captive' to the higher tier contractors (Gereffi et al., 2005).

Effective METS clusters, for example some in Canada and South Africa, exhibit more decentralised supply chains. For example, in Canadian mining services clusters, mining operations have been reported to outsource to local contractors dealing directly with local suppliers (Scott-kemmis, 2012; Warrian & Mulhern, 2009). In the South African METS sector, a two tiered resource industry supply chain was documented (Walker & Minnitt, 2006). Enclave literature related to developing countries, however, comments on the clear segregation between internationally owned top-tier suppliers versus local firms with underdeveloped capabilities (Arias, Atienza, & Cademartori, 2014a; Atienza et al., 2016; Phelps et al., 2015).

For firms in the lower tiers of a supply chain, the lack of market intelligence and understanding of top tier operations, meant a struggle to find work opportunities outside established relationships with existing contractors. A similar problem was discussed by Warrian and Mulhern (2009) as a hurdle to the effective adaptation of Canadian mining services clusters. He referred to organisational and attitudinal legacies that made it difficult for component and commodity suppliers to navigate the network economy.

The lack of market intelligence meant that local firms operating at the bottom of the supply chain hierarchy found it difficult to discover which of the middle tier firms, that they might serve, had been awarded a contract to service an upper tier firm. Work packages distribution and tenders often remained opaque. This was exacerbated during a downturn in the resource sector, when large international top tier operators engaged even more with their pre-established global supply chains to avoid the risk of dealing with local suppliers.

Being sidelined by higher tier organisations meant that many lower tier SA METS firms pursued the adaptation strategies of downsizing, cost reduction, and focussing on relationships with existing clients. A similar response was observed in the Chilean cluster in Antofagasta region during downturns (Arias et al., 2014a; Phelps et al., 2015), whereas, Warrian and Mulhern (2009) found that during a period of restructuring in Sudbury, Canada, local mining operators outsourced production and operations management to regional top-tier companies that managed an integrated group of local specialised suppliers operating as a collaborative network, effectively creating a ‘virtual mining company’.

In South Australia, therefore, the structure and processes of the tier organisation of the supply chain in the resource sector was revealed by the data to be a major factor contributing to the development (or not) of local supplier capabilities, acting as more of a brake than an enabler of regional industry renewal.

Role of key customer and lead firms. The changes in procurement strategies of lead firms are part of formal supply network governance affecting supplier strategies in a region (e.g. Choi & Kim, 2008; Choi & Krause, 2006; Gereffi et al., 2005; C.M. Harland & Knight, 2001). In the SA METS sector, as a result of the downturn, many resource extractive companies had to optimise their supply chains by reducing the number of suppliers, and adopting of cost-reduction strategies, which ultimately affect contract conditions and market prices for METS services. Oil and gas and mining companies sometimes reduced costs by foregoing their relationships with expensive tier 1 service providers and approached smaller local firms. In response, local suppliers moved towards integrated turn-key solutions for resource companies. Some pursued vertical integration to enlarge service offerings, while some developed complementary services with their supply chain partners. For some companies with a broad range of capabilities that had formerly operated at tier 2, the downturn in the resource sector provided an opportunity to become direct suppliers to mining operators and get increasing recognition in the resource sector.

Furthermore, the need for lean, low-cost solutions made resource operators more willing to explore new technological approaches (e.g. Martinez-Fernandez, 2010; Scott-kemmis, 2013; Warrian & Mulhern, 2009), which led to an increase in collaborative projects between resource companies and local suppliers. Thus, while less innovative companies were not able to cope with increased competition overseas and interstate, innovative METS firms got more opportunities to penetrate to resource industry market with innovative solutions.

Nevertheless, the conservative attitudes of resource companies towards innovative solutions are common (Arias et al., 2014a; Phelps et al., 2015). Interviewed SA METS firms participants reported that *resource project specifications* and *prescriptive procedures* often left no space for alternative innovative solutions. Resource operators in the supply network still preferred to deal with world leaders in knowledge and technology, and considerable work was needed to establish a favourable environment for SA METS firms to innovate in the resource sector.

Industry standards: Certification, accreditation and compliance. Compliance to industry quality, OH&S and environmental standards controls and alters formal and informal relationships in a supply network (Gereffi et al., 2005; Pilbeam et al., 2012). One of the major barriers to the sustainability of the South Australian METS firms and their entry into the resource supply chain is the lack of certification, the systems and the ability to take risks in major projects.

Resource extractive industries require accreditation standards to be met before engaging a supplier in contractual relations. METS firms must comply to quality management and occupational health and safety standards. But, even if a METS firm could deliver the required quality of services on time, they often the lacked resources to undertake a time and cost consuming certification process. Furthermore, different 'pre-qualification' compliance procedures required by different resource industry operators made it challenging for local firms to understand and prepare tender documentation. Thus, often local METS firms sub-contract to a certified larger contractor with established management systems and accreditations instead of sub-contracting directly to resource companies. This kind of governance handicaps lower tier firms and narrows the range of tasks performed by local suppliers.

Thus, *formal network governance instruments*, such as industry standards and compliance processes inadvertently serve to control the shape of the industry supply network, often impeding the opportunity for METS firms to innovate or acquire new knowledge. A similar observation was made by some supply network researchers (e.g. C.M. Harland & Knight, 2001) and those researching innovation and learning linkages in the resource sector (e.g. Figueiredo & Piana, 2016; Warrian & Mulhern, 2009).

Government legislation, taxes and initiatives. The ability of government regulations in the SA resource industry to enhance the development of capabilities among local firms and contribute to adaptability strategies was unclear, although in 2014, the development of a competitive METS sector was identified among top five economic priorities in South Australia (Department of State Development, 2015; Econsearch, 2015). The government of South Australia (SA) implemented a range of programs to facilitate the development of high value-added mining services with the objective of establishing SA as a mining services hub through collaboration and value co-creation in the regional resource supply chains. Programs for developing regional suppliers' capability, encouraging collaboration across tiers, their integration into the local and global mining supply chains were actively promoted.

However, the success of such initiatives was mixed, as similar efforts in other nations have been, e.g., Brazil, UK, South Africa, Chile and Canada (Arias et al., 2014a; Figueiredo & Piana, 2016; MacKinnon et al., 2004; Walker & Minnitt, 2006; Warrian & Mulhern, 2009).

Furthermore, in Australia, the largest form of Commonwealth government support for private sector innovation is the R&D tax incentive, which provides businesses with a tax offset for eligible R&D activities. The incentive has been designed to support innovative activity across all industries for a range of R&D investments, hoping to generate wider economic and social benefits (Deloitte, 2017).

Some innovative METS firms saw value and actively pursued these grants with positive outcomes reported, while some others expressed scepticism.

Furthermore, Australia's corporate tax rate of 30% is at the upper end of the band of comparable countries, and is above the OECD average of 22.6% (OECD, 2016). Australia has a higher tax burden for mining companies than Brazil, Indonesia, Canada, Peru and the United States. Furthermore, considering mining in particular, the interaction of state and territory royalties with federal company tax puts Australia among relatively high-tax jurisdictions for mining. Uncertainties and inconsistencies related to rents and royalties negatively affect the industry (Deloitte, 2017).

Currently, the reduction of corporate tax is seen as a strategy to encourage the growth of Australian mining and the METS sector and attract foreign investment (Deloitte, 2017). However, the successful example of Norway shows that an effective taxation system coupled with requirements to develop plans for local engagement, even with high taxes for resource operators, can result in the development of strong, internationally competitive supplier capabilities (Cappelen & Mjøset, 2009; Cumbers, 2000). In Chile, where tax on corporations is lower than in most other mining countries, many foreign mining companies operate with their experienced international METS firms suppliers, thus creating a fierce competition for local firms (Arias et al., 2014a; Phelps et al., 2015). The lack of local content regulations in states like South Australia significantly undermines the opportunities of local METS firms to compete in resource sector supply chains since they are challenged by experienced international and interstate competitors, as it has been pointed out by (Scott-kemmis, 2013). A 'social license' is at least needed to encourage mining companies to increase the level of engagement among local suppliers (Mason, Paxton, Parsons, Parr, & Moffat, 2014; Scott-kemmis, 2012).

Resource industry associations could be considered to be *network administrative organisations* (NAOs) (Provan & Kenis, 2008). Several studies report the positive impact of industry associations on the development of the internationalisation strategies of SMEs (e.g. Boehe, 2013), but in the resource sector the impact of industry associations has proved to be unclear (e.g. Chapman et al., 2004; MacKinnon et al., 2004; Scott-kemmis, 2012).

Industry associations actively run various programs to assist local METS firms with information about upcoming projects, connecting to customers, providing training and networking events, and creating spaces for collaboration, but the engagement of METS firms in these initiatives is still relatively low. Thus, the impact of industry associations in building the adaptability of SA METS firms is unclear.

For example, the Industry Capability Network (ICN) provides local suppliers with opportunities in different sectors by informing them about upcoming tenders, as well as assisting project managers of big projects to find local suppliers, and is currently getting more recognition in the industry. However, the attitudes of local METS firms about the ICN's efficacy are mixed. And the South Australian Chamber of Mines and Energy (SACOME), the major body representing the interests of the resource sector in South Australia, was observed to be of little assistance by local suppliers during a downturn.

In the Upper Spencer Gulf area of South Australia, the activities of one group were recognised by study participants as being helpful in dealing with major mining operators to connect them with the regional suppliers in the Upper Spencer Gulf area. However, the Global Maintenance Upper Spencer Gulf Resource Industry Cluster (GMUSG), a regional representative for local METS firms, is not widely known by METS companies in Adelaide and other regional areas.

The Resource Engineering Skills Alliance (RESA), an independent non-for-profit organisation, implements a range of training and consultancy programs, and is a young organisation, but still needs to build credibility in the sector.

Overall, the roles and relationships among these organisations and their relationships with the SA resource sector is complex, and, as the survey and interviews proved, their impact on the development of the adaptability strategies of local METS firms is unclear.

7.4.2 Informal mechanisms of network governance

Relational or embedded network governance is observed in supply chains where product specifications are hard to codify and transactions are complex, providing that suppliers are highly capable (Gereffi et al., 2005; Pilbeam et al., 2012; Sturgeon et al., 2008). Relational forms of governance are considered particularly important for the transition of resource regions to more decentralised network forms of production (e.g. Chapman et al., 2004; Scott-kemmis, 2012; Warrian & Mulhern, 2009).

The relational governance of regional networks is underpinned by shared norms and values among network members, trust and reputation, spatial and social proximity and ethics, information sharing and joint problem solving (e.g. MacKinnon et al., 2004; Pilbeam et al., 2012; Uzzi, 1996; Uzzi & Lancaster, 2003). Thus, relational governance plays a key role as an enabler of innovations in inter-organisational networks and allows for organisational learning (Pahl-Wostl, 2009; Pilbeam et al., 2012).

In the SA resource sector, the following forms of informal network governance emerged from the interviews, along with the ways they influenced the regional adaptability and adaptation of the local firms:

- localised social networks
- external professional networks
- trust
- reputation and credibility
- supply chain collaboration
- joint-problem solving
- information exchange.

Localised social networks emerged from the data as important for maintaining business during the downturn and receiving critical information about work opportunities, especially for small, lower tier METS firms. Social bonds between people created over a lifetime were tightly intertwined with industrial connections, thus confirming the interpenetration of the boundaries of professional, social and industrial networks.

Several research participants commented on the interconnected nature of businesses in Adelaide, which was labelled as a 'network city'. In South Australia, social networks are built by going to the same school and playing in the same football team and act as a 'lubricant' of economic transactions. METS firms' participants described doing business in Adelaide as dominated by 'old-fashioned' principles and explained that Adelaide's small size meant it was dominated by small and medium firms.

Informal professional and social networks were often mentioned as a major channel for getting market information and receiving work opportunities. Newcomer firms found it hard to 'get the foot in the door', without having a reputation and connections in the industry. [A similar observation has been made about social networks for small suppliers in the Aberdeen oil complex by (Chapman et al., 2004; MacKinnon et al., 2004) and (Knobblock, 2013) and in Sweden during mining industry restructuring.

For small SA METS firms specialising in supplying services to the resource sector, participation in local social relationships had a dual effect on capability development. On one hand, small METS suppliers got opportunities for work through sector and inter-sectoral relationships. On the other hand, most of them were 'over-embedded' locally with almost no external links. This led to reduced adaptability and flexibility of local suppliers in line with the functional lock in literature (e.g. Grabher, 1993; Hassink 2010). This situation was particularly observed among peripheral regional firms, operating at the lower tiers of the supply chain. These firms struggled to sustain business during the downturn, had low levels of innovations and limited opportunities for work. Thus, localised networks contributed to the adaptation rather than the adaptability of the regional METS firms and the region as a whole.

External professional networks. Scholars have also highlighted the role of *external professional networks* in the METS sector due to the international nature of the resource industry (Chapman et al., 2004; Figueiredo & Piana, 2016; MacKinnon et al., 2004; Scott-kemmis, 2012). Previous research in the Australian context reported on the positive impact of the expansion of Australian mining operators overseas that created opportunities for their local METS suppliers to follow major customers abroad (Scott-kemmis, 2012, 2013).

In the context of South Australia, long-term trust-based relationships within supply chains also contributed to the formation of professional networks beyond the sector and the state. The formation of international professional networks has been acknowledged by scholars (Chapman et al., 2004; MacKinnon et al., 2004). However, no examples of SA METS firms internationalisation with customers were found in the data. Quantitative findings also showed that for small SA METS firms, proximity to key clients in the regional supply network had a significant positive impact on their sectoral diversification and innovativeness[8]. Interviewees mainly highlighted the role of interstate and inter-sectoral external networks as sources of opportunities for diversification. These networks were built through two mechanisms:

1 Cross sectoral migration of highly qualified professionals – top and middle level managers – contributed to the development of links across sectors. For example, to target a new industry or geographically remote market, an SA METS firm hired a business development manager with established connections in the targeted markets;

2 Long term trust-based relationships with resource companies and top tier contractors operating interstate or across industries encouraged them use their SA suppliers to deliver services for their projects in other state and sectors.

The importance of trust-based relationships emphasised the negative effect of staff mobility on supplier relational embeddedness in local and external networks. High mobility in the resource sector interfered with established personal networks and trust-based relationships built by suppliers, which interfered with effective knowledge and information exchange. When people who had accumulated essential tacit knowledge and local connections with local firms left a resource company or top tier contractor company, their absence damaged local supplier businesses. To the best of researcher's knowledge this problem has not previously been discussed in the resource extractive literature in regard to local networks and embeddedness.

Trust, reputation and credibility. Trust and reputation as relational assets were highlighted by many scholars researching development of SMEs operating in resource extractive regions (e.g. Chapman et al., 2004; Knobblock, 2013; MacKinnon et al., 2004; Warrian & Mulhern, 2009).

The findings of the current research indicated that trust, credibility and reputation as relational assets played key roles in the SA resource sector supply networks, especially for lower tier small METS companies. Their reputations and credibility were a major intangible asset since small suppliers get

[8] Chapter 5, Section 5.7.2

work mainly through referrals from former clients. Local METS firms owners perceived a need to build their personal brand and reputation in order to maintain their position in the sector and guarantee workflow. The companies built their reputations through their work, by maintaining relationships with the major customers, and constantly developing a basis for referrals. Doing favours for customers, such as providing free expertise or advice, was perceived by local METS firms as a part of relationship building and developing trust between themselves and their customers.

'Competence' or 'goodwill' trust (MacKinnon et al., 2004) was the type of trust identified in the South Australian resource sector as opposed to higher level collaborative forms of trust described in the literature concerned with clusters, industrial districts and learning regions. The trust identified in the SA resource industry supply networks did not seem to stimulate the transfer of innovative ideas and the emergence of breakthrough innovations, in the same way it did in the knowledge intensive industries. However, transfer of technical knowledge and new ways of doing things contributed to organisational learning and the incremental growth of the SA METS firms capability base.

SA METS firms actively invested in relational assets with their clients (Dyer & Singh, 1998; Uzzi & Lancaster, 2003). By developing social bonds with customers and maintaining long-term relationships, suppliers better understood their companies' values and problems. Understanding customer company philosophy, values and internal culture was a must for many SA METS firms, and the ongoing long-term relationships were key to maintaining work in the sector during periods of downturn. The findings support previous findings that the 'exchange dimension of inter-firm networks …cannot be easily separated from social contacts …' (MacKinnon et al., 2004, p. 99).

Forms of collaboration. Collaborative arrangements, including strategic alliances, joint ventures and partnerships are essential for building innovative supply chains and clusters (Gulati & Gargiulo, 1999; Uzzi, 1996, 1997). In resource industry R&D alliances and joint-ventures allow for technology transfer between large international suppliers and resource operators (e.g. Scott-kemmis, 2012; Warrian & Mulhern, 2009; West, 2014). Prior research has indicated low involvement of small local METS firms in collaborative alliances and joint-ventures with resource operators or EPCM providers in Australia (e.g. Scott-kemmis, 2012). Due to the tiered procurement structure, resource extractive companies outsource operations to EPC and EPCM providers, who often already have established alliances with overseas companies and have no need for engagement with local firms.

The research findings showed that collaborative agreements among SA METS firms were pursued by top tier large and middle size METS companies, including those with competitors. These companies had established systems and frameworks around collaborative arrangements for IP protection and well established legal mechanisms supporting agreements.

In general small METS firms in the lower tier preferred sub-contracting relationships vs alliances, joint-ventures and partnerships because of the lack of legal frameworks for profit and risk sharing (interview data, Department of State Development, 2017). Although evidence of alliances based on trust and long-term collaboration with supply chain partners with complementary services were recorded, this was an exception rather than a rule. In general, firms in the lower-tiers of the SA resource industry supply network were hesitant to enter into collaborations because of negative experiences.

Interview analysis revealed that the most common form of collaborative arrangement among multiple suppliers in the lower tiers was a hierarchical sub-contracting model, when one supplier in the cohort acted as a ‘front-end’ organisation for the resource company or larger contractor and was responsible for delivery of the whole project, while others sub-contracted to this front-end supplier. Flatter, decentralised models, in which all suppliers had equal responsibility and collaborated to deliver the final product or service, were uncommon at this level, which differs from other successful examples of resource clusters, where suppliers did adopt flat decentralised models (Warrian & Mulhern, 2009).

These findings highlight the segregation between large, top tier METS firms and small, low tier firms in terms of benefits and relationships in the SA resource industry supply networks. The limited scale and scope of collaborative innovations pursued by small suppliers was in accordance with earlier research from developed (Cumbers et al., 2003; Scott-kemmis, 2012) and developing resource economies (Arias et al., 2014a; Phelps et al., 2015). Small firms relied on embedded ties in the network much more than larger, highly capable companies, which did not place much emphasis on local networks and relational assets.

Joint problem solving. The research findings confirmed that in the SA resource sector collaboration with customers through joint problem solving was a major source of technical knowledge and a driver of innovative developments and capability growth, in line with previous research (Martinez-Fernandez, 2010; Scott-kemmis, 2013; Walker & Minnitt, 2006). This differed from the evidence from developing countries, in which the extractive regions were largely developed as enclaves and subcontracting relationships were not a channel for knowledge transfer (e.g.Arias et al., 2014a; Atienza et al., 2016).

Learning from supply chain partners through collaboration around a customer problems was also found in the current research to be a driver for developing new products and processes innovations, as it had been observed in earlier research (e.g. Figueiredo & Piana, 2016; Kaplan, 2012; Martinez-Fernandez, 2010; Scott-kemmis, 2012; Warrian & Mulhern, 2009). Quantitative findings indicated a significant effect for trust on joint problem solving for small SA METS[9] firms. The findings showed that SA METS firms learnt from each other by being engaged in collaborative projects and adopting new technologies (Chapman et al., 2004, p. 384). Furthermore, client companies learned by copying technologies from suppliers.

Unfortunately, although copying another firms' technologies or behaviours increases knowledge in a network, such copying behaviour in supply chains leads to opportunism and mistrust, and reduces the willingness to cooperate or to share information. Research data showed that South Australian resource industry supply chains displayed this behaviour and attitudes of mistrust due to the general lack of knowledge around IP and legal frameworks among lower tier suppliers, while larger METS firms were not so afraid of their technology being copied, since their pace of development was very high. [A similar situation was observed in Canada during production process restructuring (Warrian & Mulhern, 2009) and in other states of Australia (Martinez-Fernandez, 2010; Scott-kemmis, 2013)]. It should be noted, however, that copying behaviour is a sign of adaptation. However, copying does not contribute to the emergence of new technologies and industries, and in the long term leads to technological lock-in (R. Martin & Sunley, 2015).

[9] Chapter 5, Section 5.7.2

Information sharing in the SA resource industry regional supply network. In the case of South Australian resource supply chains, market related information about upcoming tenders and work opportunities was shared through social and informal professional networks. Since official communication channels did not seem to be a source of timely information, local METS firms experienced delays in receiving information about mining projects packages, and therefore relied on informal connections and referrals rather than on public announcements, such as those provided through an ICN portal.

There was an obvious difference in the attitudes towards collaboration and knowledge sharing with customers and supply chain partners between knowledge-intensive and labour and technology intensive METS firms. The companies involved in knowledge intensive services, such as consultancy and training, actively shared their intellectual property with clients and partners, taking a collaborative approach when dealing with customers. On the other hand, technology firms were much more guarded about giving out information of any sort, including prices for services. Several interviewees expressed negative sentiments towards open communication between parties in the industry supply chain. The attitudes of the METS firms tended to reflect the fact that knowledge intensive firms build their expertise through sharing and disseminating knowledge, while for technology firms ‘know-how’ and unique devices constitute a competitive advantage.

No technical advice or idea sharing through informal networks were mentioned by study interviewees, which was different from the dynamics observed in innovative clusters (e.g. Corradini et al., 2016; E Giuliani, 2013). There was also no evidence for SA METS firms’ involvement in ‘knowledge’ or ‘innovative’ networks or ‘communities of practice’ as can often be found in knowledge intensive industries (e.g. Colombo et al., 2014). Currently, efforts are being made to build a community of practice in SA by industry associations, such as the Resource and Engineering Skills Alliance (RESA). RESA is introducing initiatives to build local collaborative networks among SA METS firms and communities of practice by offering training schemes for local firms which give them opportunities to find common grounds for future collaboration and joint initiatives.

RQ3.2 In what way regional supply network structure and governance contribute to the adaptation and resilience of the SA resource extractive economy during downturn from 2012 to 2016?

The role of governance instruments in the formation of adaptive and resilient regional networks is discussed in a variety of literature, including, but not limited to, industrial regions and clusters (P.-A. Balland, Boschma, & Frenken, 2015; R. Boschma, 2014a, 2015), network governance (Hollstein, Matiaske, & Schnapp, 2017; Jones et al., 1997; Pahl-Wostl, 2009), including supply and value chain network governance (Choi et al., 2001; Gereffi et al., 2005; Pilbeam et al., 2012; Sturgeon et al., 2008).

Success or failure in the formation of resilient clusters in the resource sector largely depends on the effectiveness and efficiency of the *network governance* of local supply chains. Formal and informal network governance instruments in resource industry supply chains may act as enablers or constraints for adaptation at the micro-level firm strategies and meso-level regional transformation (Warrian & Mulhern, 2009).

The findings of the current research showed that the regional resource industry supply network served as a vehicle for knowledge transfer and the adaptation of SA METS firms during the downturn in the resource sector. There was both copying and sharing of ideas and technology among the lower tier firms, but the highly innovative METS firms, it must be said, put more emphasis on investment in R&D, internationalisation and finding collaboration partners with whom to commercialise technology than they did on embeddedness. Thus, excessive embeddedness led to more adaptation than adaptability. Almost all participants in the current study, both survey respondents and interviewees, identified the development of new products and services as important during the downturn, but most changes were incremental improvements and the customisation of existing technologies in response to customer demand. Similar tendencies were observed among UK services suppliers (Cumbers et al., 2003).

The South Australian network, therefore, remained hierarchical during the downturn, and the activities of high tier firms put local suppliers under pressure to sustain their businesses. As interview analysis showed, adaptation survival strategies did not favour the survival of local specialised METS firms.

The structure and position of the firms in the regional supply networks was quite rigid due to maturity of the industry and already established relationships between major players in the sector. However, the turmoil of the downturn did create opportunities for capable local suppliers who could adapt quickly to changed conditions. They moved up in the tiered structure to start supplying directly to major resource companies. The METS firms who pursued adaptability versus adaptation strategies had more chances to improve their position in the regional resource supply chain.

The research findings indicated that low levels of trust, non-transparent decision making and the dominance of power structures formed by the lead firms in the regions dominated the supply chain. [This form of economic organisation of resource extractive regions was reported as an enclave structure (Arias et al., 2014a; Phelps et al., 2015)]. Furthermore, the unequal power relations between groups of METS firms led to the need for tailored policies and formal instruments for organising the supply network (Atienza et al., 2016; Cumbers et al., 2003).

Top tier suppliers with highly developed capabilities were located closer to the regional network core, and were in a better position to benefit from collaborative relationships. They were more engaged in knowledge sharing with customers and suppliers than those operating at the lower tiers. Only a new generation of innovative METS firms, which were able to develop breakthrough technical and business model innovations, were able to leverage informal and formal instruments to create value and stand out from the rest of METS firms.

High tier METS firms, the research data revealed, referred more to formal instruments, such as approved quality standards and OH&S systems, when talking about business strategies and relied less on relational mechanisms, while acknowledging their importance. Relational mechanisms were more important for lower tier suppliers who relied on informal communication, professional and social networks, and referrals.

In contrast to accounts of successful local districts and milieu, which emphasise the importance of institutional support, relationships in the South Australian resource industry supply networks were not characterised by a similar degree of trust and collaboration. In the SA regional supply chain, different instruments/forms of relational governance were applied in different supply chain tiers, although all research participants understood the value of trust, reputation and good long-terms relationships with clients and suppliers.

7.4.3 Summary of research question three

Both the formal and the informal governance instruments in the South Australian resource industry regional supply network seem to contribute more into adaptation rather than adaptability among the regional METS firms.

Formal channels of information and knowledge sharing established by lead companies and associated structures produced mixed success among local METS suppliers. The prescriptive nature of the resource project work specifications did not provide enough space for innovation and experimentation in the resource sector, as has been reported by other researchers (e.g. Piana, 2015). Government initiatives involving R&D with universities and third parties mainly attracted the interest of medium sized METS firms, while small local companies were often reluctant to take these opportunities.

Small lower tier METS firms relied on informal social and professional networks to get work opportunities. Informal governance assisted small firms to acquire work because of relationships and custom. On the other hand, established connections made it difficult for capable newcomers with innovative solutions to enter the industry. These findings highlight the need for considering the '…conception of power as a differential capacity that is activated and realised within industry networks…' as articulated earlier by (Cumbers et al., 2003, p. 1703), and for the identification of different types of networks that are able to better balance the processes of collaboration and competition and the assessment of specific ways in which networks enable or constrain innovation (Cumbers et al., 2003). The research demonstrated, therefore, that governance instruments in the SA resource regional supply network contribute to regional adaptation rather than adaptability mechanisms, which challenges the long-term resilience of the South Australian economy.

However, a number of initiatives and positive changes towards regional adaptability were identified, such as the emergence of new business models in the supply chain, collaboration and radical innovations leading to high value-added activities (Figure 7.9).

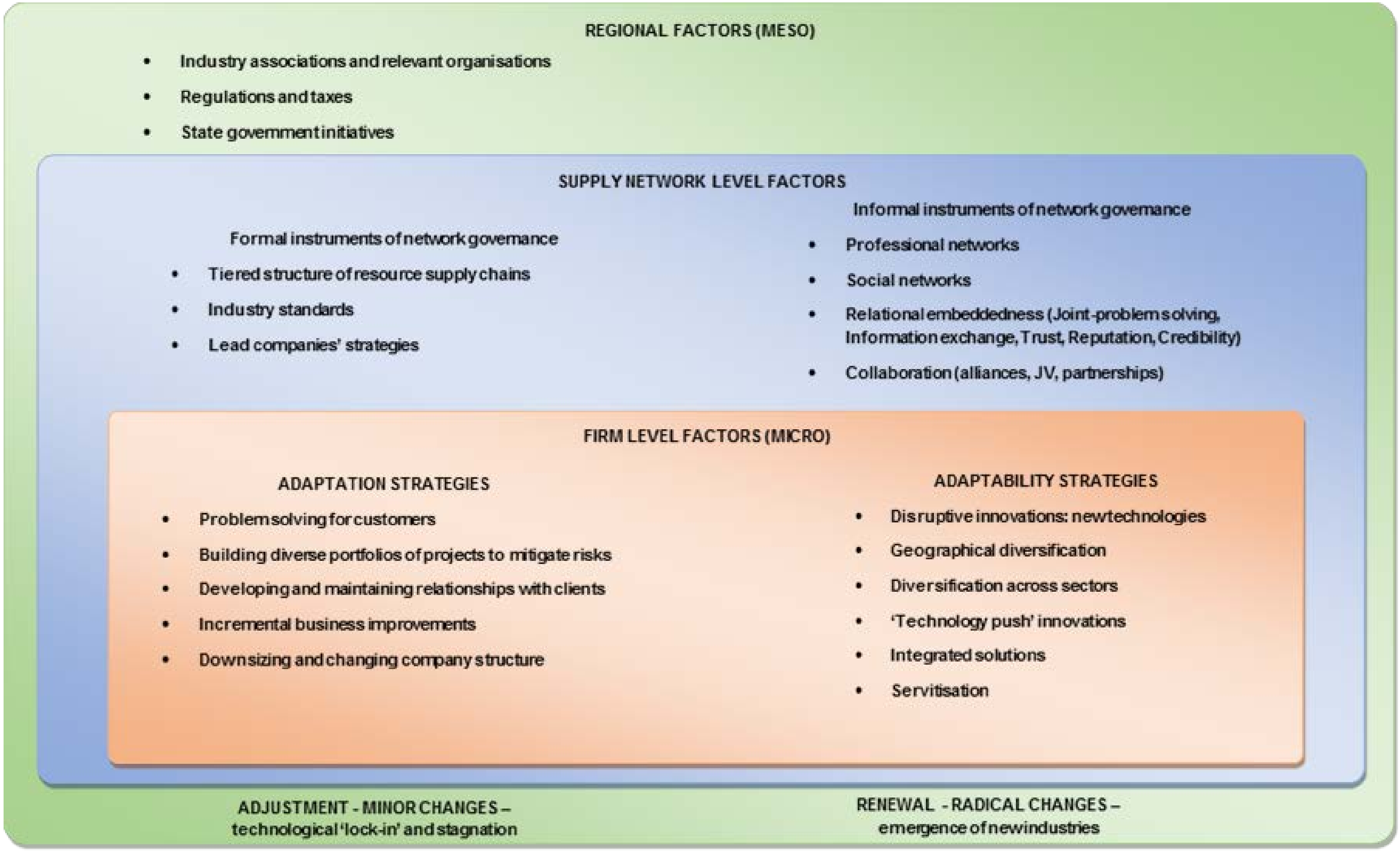

Figure 7.9 A multilevel conceptual framework that shows factors at different levels contributing to regional resilience: The case of the SA resource industry

7.5 Chapter summary

The findings of this research are concerned with regional resilience among firms in a supply network when faced with economic downturn, as SA METS firms were during the mining resource commodities downturn from 2013-2016.

The first research question elaborated the strategies SA METS firms adopted to sustain or grow their businesses during the downturn in the resource sector, which included adaptability strategies, such as diversification and innovativeness and adaptation strategies, such as problem solving for clients, developing and maintaining relationships with clients, downsizing and changing company structure, and building diverse portfolios of projects to mitigate risks. The SA METS firms that participated in the study had adopted a number of strategies to maintain or even boot their businesses. They had diversified both products and services, as well as geographic location, moved into other industry sectors, developed new technologies or modified and adapted old ones. Their activities paved the way for the renewal of the regional economy because of the emergence of high value-added activities, while adaptation strategies resulted in more modest firms' gradual adjustment to the economic situation.

The second research question sought insight into the relationship among variables postulated in the conceptual framework – positional and relational embeddedness, absorptive capacity, innovativeness and diversification.

Analysis of the quantitative study results revealed positive and significant relationships between METS firms' positional and relational embeddedness and their ability to diversify. In particular, degree and betweenness centrality in the regional supply network positively and significantly related to the number of capabilities METS firms were able to develop, but only if they were working directly with mining companies (i.e., tier 1 service providers) For lower tier suppliers, the number of connections in the regional supply network contributed little, if anything at all, to capability growth.

Eigenvector centrality positively and significantly related to the number of industry sectors where the firm operated, especially small firms. Sectoral diversity was positively and significantly associated with firm innovativeness, as were trust, information exchange and joint problem solving. Trust and frequent fine-grained information-exchange between suppliers and customers proved to be essential pre-requisites for joint problem-solving, which had a significant and positive effect on firms' diversification capability, especially for smaller SA METS companies. A firm's absorptive capacity exerted a positive effect on firm innovativeness, but did not influence diversification.

The third research question was answered by extending the multilevel theoretical framework proposed by (Chapman et al., 2004), and was focussed on the impact of METS firms' strategies, the regional supply network structure and governance on the resilience of SA resource extractive region.

The research findings go a step beyond previous research in regional resilience (Boschma et al., 2017; Boschma et al., 2013; R. Boschma, 2014b; Neffke et al., 2014) by providing empirical evidence of micro-level mechanisms contributing to related variety in the resource extractive regions, as well as the role of regional supply network structure and governance in this process.

Furthermore, by concentrating on the South Australian resource industry, this research contributes to the supply chain governance literature (Gereffi et al., 2005; Pilbeam et al., 2012; Sturgeon et al., 2008) by providing unique evidence of the multi-level mechanisms and strategies of structural adaptation practised in the regional supply network in a resource extractive region during a downturn in commodity prices, linking them to regional resilience.

Finally, the findings of this research contribute to the body of knowledge of resource extractive regions and clusters development (Arias et al., 2014a; Atienza et al., 2016; Chapman et al., 2004; Figueiredo & Piana, 2016; MacKinnon et al., 2004; Phelps et al., 2015; Warrian & Mulhern, 2009) by providing a detailed quantitative and qualitative analysis of the mechanisms underpinning the transformation of resource extractive region supply chains to more decentralised structures, which require a higher level of capability development by regional firms.

Chapter 8

Conclusion

8.1 Introduction

The research described in this thesis was an investigation into the ways in which the mining equipment and technology services (METS) sector in South Australia reacted to a downturn in the resource sector from 2012 till 2016. The particular focus of the research was the structure and governance of the resource industry regional supply network and the impact of network processes and relationships on the ability of METS firms' in the supply chain to adapt successfully to the downturn.

This conclusion summarises the research as presented in the thesis, noting the findings and highlighting the novel theoretical and practical contributions. The limitations of the research and potential for future research are also discussed. The structure of the final chapter is presented in figure 1.

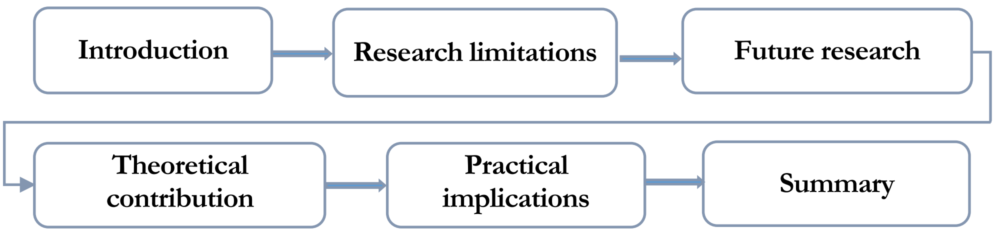

Figure 8.1 Chapter structure

8.2 Research limitations

Several limitations were identified during the course of the research, which do not necessarily negate the results. They were not regarded as fatal flaws as such, but future researchers, who want to build upon and extend this research, may want to look to overcome these limitations in future studies.

Firstly, by design this research was restricted to South Australia. The current research is tailored to the South Australian context, which has implications for policy and practice regarding specific conditions operating in a certain point of time in a particular geographical context. The contextual nature of the research questions and associated conceptual framework do not allow generalisations to be made and conclusions applied to other regions and industry contexts. Furthermore, some measurements used in the present research, e.g., *innovativeness*, *sectoral* and *capability diversification* were adapted to industry idiosyncrasies, and may not be readily applied to other industry contexts. While these measurements were adequate for this research, future research in this area may need to develop more general measures or possibly develop measures tailored to other research settings.

Secondly, there are limitations in the dataset representing the supply network connections that must be acknowledged. These include incomplete information and the unclear boundaries of the SA resource industry regional supply network. These limitations are common in supply network analysis research and acknowledged by other researchers (Kito, Brintrup, New, & Reed-tsochas, 2014; Luo, Baldwin, Whitney, & Magee, 2012; Sloane, & O'Reilly, 2013). Network examined in the research was constructed only from the supply chain connections of the suppliers listed in the Industry Capability Network database. Not all firms operating in the South Australian resource sector are members of this organisation. Therefore, some important supply chain connections may not be represented in the research. Nevertheless, the large dataset examined in this study contains rich information about individual firms and their connections in the regional supply network. This does not negate the results of the analysis; however, it makes interpretations suggestive rather than definitive.

Another limitation was the static nature of the supply network dataset, which did not allow any temporal changes in the regional supply network to be captured. Using ICN, the database was updated cumulatively, which means that the registration dates and information updates varied among members. This set the direction for the future research, which may take more snapshots at different points of time to capture the evolution of the supply network over time and its effect on supplier diversification and innovativeness.

Thirdly, the time and resource limitations of the PhD research resulted in a limited sample size for the quantitative study (156 respondents). Although the sample size met the minimum criteria for the application of partial least square structural equation modelling, a larger sample size and random sampling procedures would have increased the inferential power of the analysis.

The sample was not randomly selected from the population. Survey participants were recruited at conferences and networking events, which may have led to sample bias. However, random sampling was difficult to achieve with the target population, given the current research design and context. To overcome anticipated sampling problems, promotion of the research was undertaken at industry events and through email contact provided by industry associations mailing lists. It is possible, however, that there were METS firms in the target population that did not participate in the study, either because they had not heard of the program or because they had heard of the program but consciously chose not to engage. The limitation of less than optimum sample sizes is difficult to overcome in research, since participation depends entirely on the willingness of the companies or individuals once they have been notified of a study.

Fourthly, cross-sectional design of the quantitative study with the usage of 'one point in time' survey and network relationships datasets made it hard to establish causality among model relationships, only the fact that the relationship existed between variables. A longitudinal analysis would allow to provide deeper insights, using several datasets separated in time.

Fifthly, the limitations of the partial least square structural equation modelling (PLS SEM) method should be acknowledged. The criticism regarding its shortcomings and lack of evidence of the advantages compared with the traditional covariance based SEM (CB SEM) methods are the subject of discourse in the academic literature (e.g., Rönkkö, & Evermann, 2013). Nevertheless, management researchers increasingly use PLS in organisational behaviour, strategy and marketing studies (Hair, Sarstedt, Pieper, & Ringle, 2012). In the current research, the choice of the PLS SEM method was determined by the relatively small sample size, presence of complex constructs in the conceptual model and the exploratory nature of the research (Hair, Hult, Ringle, & Sarstedt, 2014). Future research should include a larger sample to analyse using traditional CB SEM.

Finally, the heterogeneity of the METS firms participating in the survey could also have contributed to any spuriousness of the quantitative data. The heterogeneity of the firms supplying service to the mining industry had been acknowledged by previous researchers (Atienza et al., 2016; Basco & Calabrò, 2016; Scott-kemmis, 2013). There could be a significant difference between knowledge intensive activities, like consulting and manufacturing, and activities like mining and transportation, which are more labour-intensive. However, the qualitative interviews permitted a more in-depth understanding of the process of capability development among the SA METS firms, depending on their core capabilities.

8.3 Future research directions to overcome identified limitations

To address the *first limitation*, the validity of the proposed framework could be further strengthened by being applied in other domains and industry contexts. A comparative analysis, with empirical evidence from other resource extractive regions in Australia that were experiencing downturns would enhance the strength of the interpretation of the findings.

Secondly, to overcome limitations of the 'one point in time' static dataset, longitudinal data could be collected to provide deeper insight into regional supply network evolution and its impact on regional adaptability and resilience.

Thirdly, the data were collected on a number of variables, which were not examined for this research, but which could form the basis for moderating variables hypotheses. For example, a post-hoc analysis could include the identified differences between METS firms located in regional areas and in Adelaide, locally owned versus internationally owned (Neffke et al., 2014), internationally certified and non-certified METS firms, or the length of contractual relationships (Atienza et al., 2016) as moderator variables. Examining these potential moderating hypotheses based on theoretical considerations, may provide additional insights that the current analysis was unable to provide.

Finally, at the time this research was conducted, there were no available data on the industry classification codes of the services provided by METS companies. Currently, the special account for METS ANZSIC classification has been developed and future research may include further investigation of METS related and unrelated diversification with the use of Herfindahl index (e.g. Colombo et al., 2014; Garcia-Vega, 2006; Han et al., 2013). Products and services relatedness is currently an idea being considered as an element of economic complexity (Hausmann et al., 2013), and could become a future direction for research in understanding how METS firms' diversification contributes to the economic complexity of South Australia

8.4 Theoretical contribution

This thesis addresses several issues from previous research in regional resilience (e.g. R. Boschma, 2014b) by providing evidence of the role of agency (Gillian Bristow & Adrian Healy, 2014; R. Martin & Sunley, 2015) and regional supply network governance as factors contributing to regional adaptation and adaptability. This addresses calls from researchers studying regional resilience, who have claimed that the '…impact factors and determinants of regional resilience remain under-explored, and lack in-depth empirical evidence…' (Hu & Hassink, 2015, p. 21).

Previous research in regional resilience developed macro-level and meso-level conceptual frameworks, referring to the role of related variety, agency, regional networks and institutions in shaping the adaptability and resilience of industrial regions. However, there remained a scarcity of empirical studies that explore micro-level processes of regional transformation during recession, with reference to the development of the adaptive capacity and long-term resilience of the region undergoing transformation. This is a gap addressed by the research reported here.

Furthermore, this study adopted a mixed-method research design (quantitative, qualitative and social network analysis) to understand the interplay between micro-level processes, such as agency, and meso-level factors, such as networks, thus addressing calls from resilience scholars, who argue that static macroeconomic performance metrics cannot adequately capture adaptive capacities of people and places. The dynamism of regional economies must be examined in order to really understand how they adapt over time through reorientation of their economic and industrial structures.

> *Studies seeking to operationalise resilience fully will need to move beyond emphasis upon narrow and traditional metrics of regional macro-economic performance, and static comparisons of regional performance pre- or post- shocks…more empirical work is needed to understand these lower-level processes and behaviours and how they vary spatially, as well as how they then relate to and shape the 'emergence' of macro- structures and performance outcomes…(Bristow & Healy, 2013, p. 933)*

By exploring how regional firms' strategies and supply chain relationships at the micro-level and regional supply network structure and governance at the meso-level contribute to regional resilience, this research addressed the calls for understanding the role of agency and networks in building regional resilience. A multilevel conceptual framework developed in this thesis links METS firms' embeddedness in regional supply networks with their ability to diversify and innovate.

Furthermore, the research contributes to the scant body of knowledge on adaptation and resilience in resource extractive regions (Chapman et al., 2004; Xiaohui Hu, 2017; Warrian & Mulhern, 2009). Very few studies have reviewed adaptation and resilience in such regions, which are unique due to the legacy of mass industrial production. The region's previous activity, relationships and history produce different types of transformation compared with regions containing knowledge intensive, high value-added industries.

The findings of this study also contribute to the body of knowledge of *resource extractive regions and clusters development* by providing a detailed empirical study of the mechanisms underpinning the transformation of resource extractive supply chains to more decentralised structures, which require higher levels of capability development on the part of regional firms. The research builds upon and extends the framework proposed by (Chapman et al., 2004) by evaluating the role of the regional supply network structure and governance in the development of METS firms' adaptability and adaptation strategies. The conceptual framework developed in this research goes a step further than previous work by identifying the influence of the structure and nature of regional supply networks on the regional resilience at the micro and meso level of the regional economy.

8.5 Practical implications

The findings of the study demonstrate the heterogeneity of the METS sector in the resource extractive regions in terms of size, ownership, core capabilities, and as a result, strategies and behaviour. This means that programs and policies developed in relation to the supply chain must reflect these differences. Policy frameworks and initiatives tailored to different groups should be developed to enable effective relationships in the regional supply chains.

Furthermore, distinguishing between METS firms inclined towards adaptation versus adaptability strategies would allow directed, purposeful initiatives to be put in place. For example, for lower tier METS with less potential for diversification and innovation, collaboration with supply chain partners with complementary capabilities would be a way to extend their service offerings and compete with overseas and interstate METS firms. Tailored education and mentoring programs for lower tier suppliers should be provided. These firms should also be assisted by being better informed about upcoming projects and middle-tier potential partners to whom they could offer their services. For highly innovative, R&D driven firms, an environment for effective technology commercialisation should be provided, allowing them to connect to investors, and resource rich companies.

The conceptual framework used for the study draws the attention of policy makers and supply chain practitioners to the need for new forms of governance for the benefit of all regional supply network participants. Complexity of the regional economy coupled with the complexity of the resource industry supply chains requires collaborative and participatory forms of governance, with the involvement of all key industry stakeholders. However, the structure and coordination mechanisms in the SA regional resource supply network were found to be mostly hierarchical and top down. Flatter and decentralised as opposed to a hierarchically tiered structure could be formed with the emergence of local integrated service providers able to source from local firms and acting as brokers between mining operators replacing EPC and EPCM providers. Identification, incentivisation and promotion of such local companies in the local supply chains would encourage the formation of local connections. Furthermore, collaborative forms among local METS, and the formation of partnerships and alliances should be incentivised. The formation of well-connected local supply chains will result in more effective knowledge and information sharing in the regional supply network.

To create an environment enabling space for innovation and resource allocation to support emergent high-value added activities, a collaborative and sustained effort by policy makers and industry stakeholders is required.

For policy makers, therefore, the findings of this research suggest that policies focusing on regional supply network integration and connectivity, associated with more effective flexible structures based on collaboration and decentralised approaches, should be developed. Mechanisms for information dissemination may include a web-portal providing information and resources for regional firms. Supporting organisations and policies could be created for building communities of practice and collaborative networks, enabling information exchange to foster partnering between companies.

The unification and integration of industry standards is a step by which the cost of operating in the supply chain can be reduced for local firms. Certification and accreditation costs act as a barrier to entry for local firms, but with which they could build more connections in the regional supply chains. Platforms and associated policies for data sharing and collaboration across regional supply chains would encourage the formation of horizontal links.

The key clients in the region – mining and oil and gas operators and prime top-tier EPC/EPCM contractors – play an essential role in providing opportunities for regional suppliers to grow their capability range and ability to internationalise and diversify across sectors. Therefore, client companies that contribute the most in terms of sourcing from local firms should be selectively incentivised to encourage them to work collaboratively with local suppliers (through incentives, tax regimes and regulations).

For resource extractive companies and EPCM providers, research findings suggest that it is important to gradually move towards less prescriptive specification of the project packages to create space for innovative solutions offered by suppliers. It is necessary to engage key resource extractive operators and top-tier prime contractors in regional policy and initiatives being pursued by the state government, including those aimed at building collaborative relationships across supply chain tiers. Incorporating procurement strategies that encourage collaboration among suppliers is essential.

METS firms' owners and managers, should be aware from the findings of the importance of taking a less protective and more proactive view when developing relationships with the top-tier contractors and building collaborative relationships with supply chain partners, since knowledge spillovers and learning from partners enhances their ability to diversify and innovate and ultimately make business less vulnerable to future disruption. There is a need for local METS firms to adopt more open-minded approaches to collaboration in the resource sector to facilitate organisational learning and adaptation. This requires higher absorptive capacity and the development of dynamic capabilities to navigate and learn in the networked economy to compete with innovative solutions.

The research findings also suggest that all companies in regional supply networks should be aware of their position in the regional networks so that they can identify collaboration opportunities and generate confidence between the companies in the supply chain.

8.6 Chapter summary

Chapter 8 summarises the research findings and contribution. In so doing it also discusses the key study limitations to be addressed by future research. Although there were limitations, none should be regarded as 'fatal flaws' that negate the results obtained. The results present a foundation upon which other studies can built.

The chapter provides insights into the contribution the research makes to our understanding of the micro-level mechanisms and meso-level governance instruments influencing adaptation and resilience of resource extractive regional economies during downturns in the resource sector. From the applied perspective, the research results show that the process of transformation of the SA METS regional network towards more decentralised governance enabling innovations and diversification is slow. Greater communication and collaborative effort of resource industry stakeholders is required to enhance regional adaptability and transition to high value-added activities. Policy makers and key resource operators should consider improving governance instruments to enhance formation of effective regional supply chains and resilience of the resource extractive economies to mineral commodity prices downturn.

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Appendices

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Appendix A1

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

LEVEL 7, 115 GRENFELL STREET
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CRICOS Provider Number 00123M

15 April 2015

Professor V Ireland
School: Entrepreneurship, Commercialisation and Innovation Centre

Dear Professor Ireland

ETHICS APPROVAL No: H-2015-064

PROJECT TITLE: Mining industry supply network analysis: the case of South Australian and Kazakhstan mining clusters

The ethics application for the above project has been reviewed by the Low Risk Human Research Ethics Review Group (Faculty of Arts and Faculty of the Professions) and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* involving no more than low risk for research participants. You are authorised to commence your research on **15 Apr 2015**.

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled *Annual Report on Project Status* is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/ethics/human/guidelines/reporting. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain. It is also a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol; and
- the project is discontinued before the expected date of completion.

Please refer to the following ethics approval document for any additional conditions that may apply to this project.

Yours sincerely

PROFESSOR RACHEL A. ANKENY
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

PROFESSOR PAUL BABIE
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

RESEARCH BRANCH
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CRICOS Provider Number 00123M

Applicant: **Professor V Ireland**

School: **Entrepreneurship, Commercialisation and Innovation Centre**

Project Title: **Mining industry supply network analysis: the case of South Australian and Kazakhstan mining clusters**

The University of Adelaide Human Research Ethics Committee
Low Risk Human Research Ethics Review Group (Faculty of Arts and Faculty of the Professions)

ETHICS APPROVAL No: **H-2015-064** **App. No.: 0000019866**

APPROVED for the period: **15 Apr 2015 to 30 Apr 2018**

Thank you for your response dated 03.04.2015, 10.04.2015 and 14.04.2015 to the matters raised.

This study is to be conducted by Larissa Statsenko, PhD student.

PROFESSOR RACHEL A. ANKENY
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

PROFESSOR PAUL BABIE
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

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Appendix A2

Appendix A2a: Participant Information Sheet

#

PROJECT TITLE:

Mining industry supply network analysis: the case of South Australian and Kazakhstan mining clusters

PRINCIPAL INVESTIGATOR: Vernon Ireland

STUDENT RESEARCHER: Larissa Statsenko

STUDENT'S DEGREE: PhD

Dear Participant,

You are invited to participate in the research project described below.

What is the project about?

The research objective is to explore current structures and processes of governance and policy making within mining clusters to establish more effective framework of managing cluster initiatives within mining regions

Who is undertaking the project?

This project is being conducted by Larissa Statsenko [PhD student], Prof. Vernon Ireland

This research will form the basis for the degree of [*PhD*] at the University of Adelaide under the supervision of [*Vernon Ireland*].

Why am I being invited to participate?

Senior executives from mining and associated industries as well as non-government organisations and government bodies involved in the process of development of cluster initiatives within mining regions in Australia and Kazakhstan

What will I be asked to do?

The interview will contain 12 open-ended questions related to your insights and interpretation of business environment and implementation the cluster initiatives within a region; current, past and future trends in regional mining industry as well as possibilities to innovate in mining related services. The interview will be conducted at the place of interviewees' convenience. The interview will be recorded using digital device.

How much time will the project take?

The interview will approximately take 1-1,5 hours.

Are there any risks associated with participating in this project?

There are no foreseeable risks

What are the benefits of the research project?

The implications of the research will be beneficial for mining industry leaders and policy makers at different scales: federal, state and local. Participants may benefit from information exchange about trends and issues of innovative development of mining industry.

Can I withdraw from the project?

Participation in this project is completely voluntary. If you agree to participate, you can withdraw from the study at any time.

What will happen to my information?

No information given will be disclosed. No names will be attached to any information gained in the interviews. Pseudonyms will be used throughout. Only the researcher in this application will thematically analyse the material from the interviews and only this researcher will access the data from the interviews. Transcripts will be made during the interviews. Participants will be sent a copy of interview transcript for a review and approval. If there are be any concerns regarding commercial in confidence issues, this information will be removed from the transcript. They will be free to withdraw any comments they have made before these are submitted to a journal for publication. All electronic material will be stored on the researcher's University of Adelaide computer, and written notes will be kept in a locked drawer in university office for 10 years.

Who do I contact if I have questions about the project?

Professor Vernon Ireland, Director of Project Management, The University of Adelaide, Room 530, Nexus 10
Pulteney St. (+61) (0) 411 153 861

Dr. Larissa Statsenko, PhD Candidate, The University of Adelaide, Room 530, Nexus 10 Pulteney St. (+61) (0) 435 637 365

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number **H-2015-064**). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. Contact the Human Research Ethics Committee's Secretariat on phone (08) 8313 6028 or by email to hrec@adelaide.edu.au. if you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant. Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

If I want to participate, what do I do?

If you are interested in joining the study you should contact Dr. Larissa Statsenko, (+61) (0)

Yours sincerely,

Primary researcher: Larissa Statsenko, PhD Candidate, Entrepreneurship Commercialisation and Innovation Centre, The University of Adelaide

Other researchers: Professor Vernon Ireland, ECIC, The University of Adelaide

Appendix A2b: Consent Form

#

Human Research Ethics Committee (HREC)

CONSENT FORM

1. I have read the attached Information Sheet and agree to take part in the following research project:

Title:	Mining industry supply network analysis: the case of South Australia and Kazakhstan mining clusters
Ethics Approval Number:	**H-2015-064**

2. I have had the project, so far as it affects me, fully explained to my satisfaction by the research worker. My consent is given freely.

3. Although I understand the purpose of the research project it has also been explained that involvement may not be of any benefit to me.

4. I have been informed that, while information gained during the study may be published, I will not be identified and my personal results will not be divulged.

5. I understand that I am free to withdraw from the project at any time.

6. I agree to the interview being audio/video recorded. Yes ☐ No ☐

7. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

Participant to complete:

Name: ______________________ Signature: ________________________ Date: ___________

Researcher/Witness to complete:

I have described the nature of the research to ____
(print name of participant)

and in my opinion she/he understood the explanation.

Signature: ___________________ Position: _________________________ Date: ___________

Appendix A2c: Contacts for Information on Project and Independent Complaints Procedure Document

The University of Adelaide
Human Research Ethics Committee (HREC)

This document is for people who are participants in a research project.

CONTACTS FOR INFORMATION ON PROJECT AND INDEPENDENT COMPLAINTS PROCEDURE

The following study has been reviewed and approved by the University of Adelaide Human Research Ethics Committee:

Project Title:	**Mining industry supply network analysis: the case of South Australian and Kazakhstan mining clusters**
Approval Number:	**H-2015-064**

The Human Research Ethics Committee monitors all the research projects which it has approved. The committee considers it important that people participating in approved projects have an independent and confidential reporting mechanism which they can use if they have any worries or complaints about that research.

This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research (see http://www.nhmrc.gov.au/publications/synopses/e72syn.htm)

1. If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the project co-ordinator:

Name:	**Larissa Statsenko, PhD Candidate**
Phone:	**+61(0)**

2. If you wish to discuss with an independent person matters related to:
   - making a complaint, or
   - raising concerns on the conduct of the project, or
   - the University policy on research involving human participants, or
   - your rights as a participant,

   contact the Human Research Ethics Committee's Secretariat on phone (08) 8313 6028 or by email to hrec@adelaide.edu.au

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Appendix A3

PROJECT OVERVIEW

The University of Adelaide in cooperation with the Global Maintenance Upper Spencer Gulf Resource Industry Cluster Association, supported by the Government of South Australia, is carrying out a project aimed at mapping the capabilities and supply chain connections of South Australian firms supplying to the resource and energy sector.

The resource and energy sector presents significant opportunities for local business development. But it is very complex with significant breadth and depth. **Not all firms understand the structure of supply chain relationships within the sector and how their products/services might fit.** The inability to clearly articulate value proposition to major contractors in the sector is a key constraint for local businesses to winning work in the major projects. **Understanding and developing relationships within the sector is of crucial importance for firms to survive and pursue successful diversification and growth strategy.**

The project aim is to map capabilities and supply chain connections of South Australian companies supplying services and products to the resource and energy sector.

The map would potentially allow SA firms, seeking to expand into and already supplying to the sector to:

- **Identify more opportunities for diversification to the sector**;
- **Increase visibility for major contractors in the sector**;
- **Identify opportunities for collaboration across supply chain.**

We believe that this study will provide interesting and valuable insight for the entire SA Resource and Energy Sector.

The project is conducted by Professor Vernon Ireland and Larissa Statsenko, a PhD candidate.

Appendix B

Appendix B – Social network analysis

The regional supply networks in the South Australian mining sector

The size of the nodes corresponds to their degree centrality, the regional hubs

Firms with the highest degree centrality are named

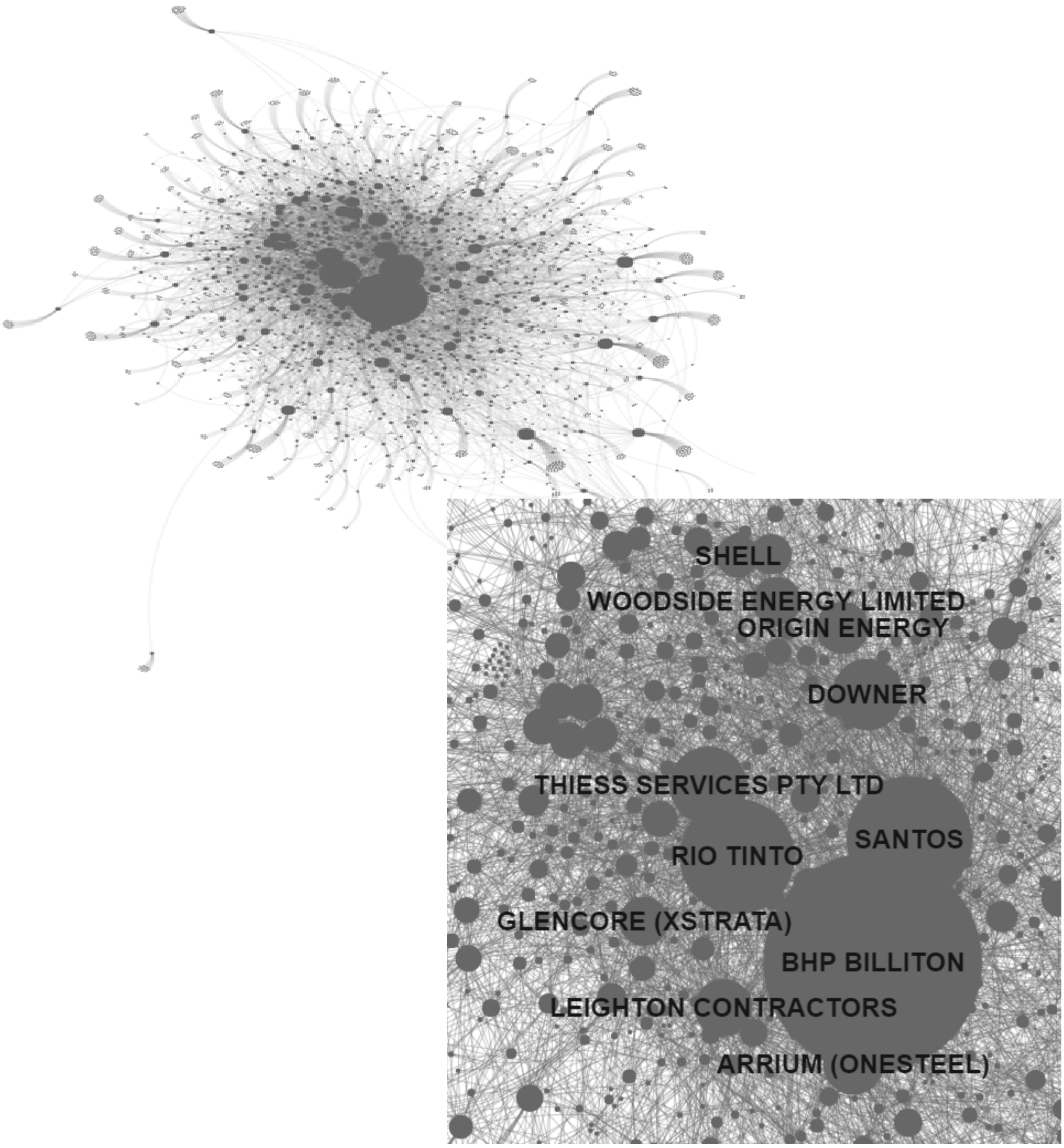

Table 1. Structural parameters of the SA mining sector regional supply network

Parameter	Value
Number of nodes	**2,455**
Number of connections	**6,683**
Average Degree	**5.28**
Density	**0.001**
Clustering coefficient (C_a)	**0.028**
Average path length (L_a)	**4.110**

Appendix C1

Appendix C1

PROJECT TITLE: MAPPING THE SOUTH AUSTRALIAN RESOURCE AND ENERGY SUPPLY CHAIN

CONFIDENTIAL

Objective: The objective of the PhD research is to get an understanding about the patterns of supplier-buyer and collaborative relationships across the South Australian resource and energy supply chain, and their effects on business performance and innovative capacity of SA services suppliers

As a part of the project, the South Australian resource and energy supply network will be constructed. This survey will complement already available data on supplier-buyer relationships from industry associations' directories and companies' web-sites.

Data use: The data collected as a part of this survey is for RESEARCH PURPOSES ONLY. COMPANY LEVEL DATA WILL NOT BE SHARED with other organisations. Only summary results will be included in public reports.

Time required to complete the survey: 20-25 minutes

THANK YOU FOR YOUR COOPERATION!

Please use a DARK PEN to mark your response as follows ●. Correct any mistakes by crossing the wrong answer as follows

Section A. Supply chain structure

This section will ask general and specific questions about the structure of supplier-buyer relationships across the South Australian resource and energy supply chain.

1. Main industry sectors the company operates in. Please select all that apply

- O Mining & Resource
- O Defence & Security
- O Oil & Gas
- O Construction
- O Manufacturing
- O Energy
- O Automotive
- O Education & Training
- O Water
- O Transport
- O Food & beverage
- O Other, please specify

2. What percentage of revenue for the end of your company's latest financial year was derived from its mining and minerals division or activity?

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O

3. Currently what stage of the mining value chain does your company business fit into?

Exploration and feasibility	Approval process and project management	Construction	Mining operations	Close and rehabilitation	Other
O	O	O	O	O	O

If you have selected "other" please specify

4. Where does your company operate in the mining supply chain?

Please select all that apply.

- O Contract mining
- O Tier 1 contractor to mining projects
- O Sub-contractor to Tier 1(s)
- O Sub-contractor to a sub-contractor(s)
- O Original Equipment Manufacturer (OEM)
- O Sub-contractor to an OEM(s)
- O Sub-contractor to an OEM sub-contractor(s)
- O Equipment, technology or services provider working directly with a mining company
- O Pre-commercial R&D provider
- O Other, please specify

5. What are your company's capabilities? Please select all that apply.

- O Manufacturing
- O Engineering
- O Construction
- O Transport & logistics
- O Equipment/Product Supply & Hire
- O Electrical
- O Business, Legal and Finance
- O Education & Skills
- O Environmental Services
- O Exploration Services
- O Accommodation
- O Mining Services
- O Technical and Consulting Services
- O Associations, Government and NGOs
- O Research and technology development
- O Recruitment & Labour Hire
- O Civil Construction
- O Industrial Services
- O Other (please specify below)

6. What percentage of your company's *clients* are local/interstate/international (adding up to 100%)?

State (South Australia)	10% O	20% O	30% O	40% O	50% O	60% O	70% O	80% O	90% O	100% O
Interstate	10% O	20% O	30% O	40% O	50% O	60% O	70% O	80% O	90% O	100% O
International	10% O	20% O	30% O	40% O	50% O	60% O	70% O	80% O	90% O	100% O

7. What percentage of your company's *suppliers* are local/interstate/international (adding up to 100%)?

State (South Australia)	10% O	20% O	30% O	40% O	50% O	60% O	70% O	80% O	90% O	100% O
Interstate	10% O	20% O	30% O	40% O	50% O	60% O	70% O	80% O	90% O	100% O
International	10% O	20% O	30% O	40% O	50% O	60% O	70% O	80% O	90% O	100% O

8. This question is in three parts.
   1. Please, list the top ***clients*** during your company's most recent financial year.
   2. Please rank them from 1 to 5 according to business importance with "1" being the most important.

3. Which of the following best describe the nature of relationships?

	Company Name	Rank	arms length	long-term strategic	collabo-rative	other
1			O	O	O	O
2			O	O	O	O
3			O	O	O	O
4			O	O	O	O
5			O	O	O	O

If you have selected "other" please specify

9. This question is in three parts.
   1. Please, list the top ***suppliers*** during your company's most recent financial year.
   2. Please rank them from 1 to 5 according to business importance with 1 being the most important.

3. Which of the following best describe the nature of relationships?

	Company Name	Rank	arms length	long-term strategic	collabo-rative	other
1			O	O	O	O
2			O	O	O	O
3			O	O	O	O
4			O	O	O	O
5			O	O	O	O

If you have selected “other” please specify

Section B. Innovations (

This section contains questions related to the innovative performance and potential of your company, as well as drivers and barriers for innovations.

10. Please identify how many new-to-market products/services for the resource and energy sector that your company introduced in the last 3 years?

10+	6-10	3-5	1-2	0
O	O	O	O	O

11. Please indicate how much of the turnover of your firm is attributed to new, dramatically improved products/services introduced in the last 3 years?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O	O

12. Please identify the percentage of spending on research and development (R&D)?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O	O

13. Please identify how many patents or trademarks your company has registered in the last 3 years?

10+	6-10	3-5	1-2	0
O	O	O	O	O

14. Please identify the percentage of University graduates employed by your company

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O	O

15. Please identify the percentage of qualified technicians employed by your company

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O	O

16. Please identify the percentage of R&D employees in your company

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O	O

17. Please indicate in terms of percentage the relative importance of: (a) knowledge developed inside the company; (b) knowledge acquired outside the company (from suppliers, customers, collaborators, etc.) adding up to 100%

Knowledge developed inside the company

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O	O

Knowledge acquired outside the company

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O	O

Section C. Supplier-buyer relationships

This section contains questions related to the nature and quality of supplier-buyer relationships

18. Do you agree with the following statement?

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
"Our company is extensively tied to the major clients through additional business and informal ties (shared board members, social relations etc.)"	O	O	O	O	O	O	O

19. Please identify to what extent your company is usually involved in the customers decision-making process regarding the following issues?

	Not at all involved	Very little	A little	A moderate amount	A lot	Quite a lot	Involved to a great extent
Initial design of the product/service	O	O	O	O	O	O	O
Cost control	O	O	O	O	O	O	O
Product/service modification	O	O	O	O	O	O	O
Production process	O	O	O	O	O	O	O
Sub-contracting	O	O	O	O	O	O	O
Forecasting commodity requirements	O	O	O	O	O	O	O

20. Please identify to what extent you agree with the following statements in regard to relationships with your clients

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Your company is engaged in ongoing discussion with the clients to jointly improve both their operations and yours	O	O	O	O	O	O	O
Both parties, supplier and customer, can make adjustments in the ongoing relationship to be able to deal with changing circumstances	O	O	O	O	O	O	O
Problems that arise in the course of the relationship are treated by parties as joint rather than individual responsibilities	O	O	O	O	O	O	O

21. Please characterise the information exchange between your company and your clients

Poor	1	2	3	4	5	6	7	Excellent
Accuracy of information received	O	O	O	O	O	O	O	
Detail of information received	O	O	O	O	O	O	O	
Timeliness of information received	O	O	O	O	O	O	O	

22. Please identify the kinds and frequency of information that your company exchanges with the clients

	Not at all exchanged 1	2	3	4	5	6	7 Exchanged very frequently
Quality information	O	O	O	O	O	O	O
Inventory information	O	O	O	O	O	O	O
Schedule and delivery information	O	O	O	O	O	O	O
Detailed cost information	O	O	O	O	O	O	O
Marketing information	O	O	O	O	O	O	O
Long-term volume projections	O	O	O	O	O	O	O
Manufacturing process information	O	O	O	O	O	O	O
Proprietary technical information	O	O	O	O	O	O	O
Design information	O	O	O	O	O	O	O
Production capacity	O	O	O	O	O	O	O
Other, please specify	O	O	O	O	O	O	O

23. Please identify to what extent you agree with the following statements in regard to relationships with your clients/suppliers

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Your company always been even handed in its negotiation with your client/supplier companies	O	O	O	O	O	O	O
Your suppliers/customers may use opportunities that arise to profit at your company's expense	O	O	O	O	O	O	O
Based on past experience, you cannot, with complete confidence, rely on your suppliers/customers to keep promises made to you	O	O	O	O	O	O	O
You are hesitant to transact with the supplier/customer when specifications are vague	O	O	O	O	O	O	O
You trust your suppliers/customers to treat you fairly	O	O	O	O	O	O	O
You trust that confidential/proprietary information shared with your suppliers/customers will be kept strictly confidential	O	O	O	O	O	O	O

Section D. Supply chain collaboration

In this section, the questions will be asked about the collaboration and sharing information across the resource and energy supply chain.

24. How many collaborative relationships (alliances, joint-ventures, partnerships) has your company been involved in over the last 3 years?

0	1-2	3-5	6-10	10+
O	O	O	O	O

25. How many joint R&D projects has your company been involved in over the last 3 years?

0	1-2	3-5	6-10	10+
O	O	O	O	O

26. What types of collaborative relationships does your company participate in? Please identify intensity of collaboration.

	No collaboration 1	2	3	4	5	6	7	8	9 Very intense collaboration
New product development	O	O	O	O	O	O	O	O	O
Research and development	O	O	O	O	O	O	O	O	O
Purchase of raw materials	O	O	O	O	O	O	O	O	O
Participation in trade fairs and events	O	O	O	O	O	O	O	O	O
Exchange of ideas and experiences	O	O	O	O	O	O	O	O	O
Study of process improvements	O	O	O	O	O	O	O	O	O
Study of improvements for the sector as a whole	O	O	O	O	O	O	O	O	O
Sharing of business relevant information	O	O	O	O	O	O	O	O	O
Purchase of machinery and equipment	O	O	O	O	O	O	O	O	O
Equipment sharing	O	O	O	O	O	O	O	O	O
Other, please specify	O	O	O	O	O	O	O	O	O

27. Please, indicate the top organisations that your company collaborate with and identify the type of collaboration

	Organisation Name	Collaboration type: Partner-ship	joint-venture	formal alliance	informal alliance	R&D	Other
1		O	O	O	O	O	O
2		O	O	O	O	O	O
3		O	O	O	O	O	O
4		O	O	O	O	O	O
5		O	O	O	O	O	O

28. Please, indicate the top organisations that you regularly exchange information with (market information, seek technical advice and etc.) and frequency of contact

Company Name	Annually	Quarterly	Monthly	Weekly	Daily
1	O	O	O	O	O
2	O	O	O	O	O
3	O	O	O	O	O
4	O	O	O	O	O
5	O	O	O	O	O

Section E. Relationships with other organisations

This section contains questions regarding collaboration with other organisations (Government, Industry associations, Research organisations, Universities)

29. Please identify industry associations/related organisations that you are member of and evaluate them according to their relative value to your company (acquiring new clients, finding opportunities for collaboration, getting valuable information)?

	Not important 1	2	3	4	Very important 5
Austmine	O	O	O	O	O
Australian Steel Institute (ASI)	O	O	O	O	O
Industry Capability Network (ICN)	O	O	O	O	O
South Australian Chamber of Mines and Energy (SACOME)	O	O	O	O	O
Global Maintenance Upper Spencer Gulf (GMUSG)	O	O	O	O	O
Resource Engineering Skills Alliance (RESA)	O	O	O	O	O
Defence Teaming Centre (DTC)	O	O	O	O	O
Austrade	O	O	O	O	O

Other, please specify

	1	2	3	4	5
	O	O	O	O	O
	O	O	O	O	O
	O	O	O	O	O

	Frequency				
	Never	Every 5 years	Annualy	Quarterly	Monthly
30. How often do you participate in the development programs organised by industry associations/ government/ other relevant organisations?	O	O	O	O	O
31. How often do you participate in the mining industry conferences and other networking events?	O	O	O	O	O

Section F. General information

First name	
Last Name	
Job title	
Company name	
Company head-office address	
Suburb	
State	
Postcode	
Email	
Mobile	

32. How many 'full time equivalent' (FTE) employees did your company have in Australia on 1 July 2015?

1-5	5-20	20-100	100-500	500+
O	O	O	O	O

33. Please identify the type of the company

O Sole trader
O Partnership
O PTY LTD Australian Stock Exchange listed
O PTY LTD Australian Stock Exchange non-listed
O Other

34. Year of establishment

35. Annual turnover, AUD

- O $0 - $499,999
- O $500,000 - $0.99m
- O $1m - $1.99m
- O $2m - $4.99m
- O $5m- $9.99m
- O $10m - $19.99m
- O $20m+

36. Percentage of revenue from overseas for product produced/service delivered

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
O	O	O	O	O	O	O	O	O	O

37. Please identify your perception of company business growth over the last 3 years

has declined	has declined slightly	not changed	has grown	has grown significantly
O	O	O	O	O

38. Please identify how many new clients has your company acquired in the last 3 years?

39. Is your company certified following international/ Australian standards?

- O ISO 9001:2008 Quality Management Systems
- O ISO 14001:2004 Environment Management Systems
- O ISO 31000:2009 Risk Management Systems
- O AS/NZS 4801 OHS
- O OHSAS 18000 OHS
- O Other, please specify

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Appendix C2

Appendix C2

Section A. Supply chain structure

Thank you for your participation.

Section A. Supply chain structure

This section asks general and specific questions about your company position and supplier-buyer relationships in the South Australian resource and energy supply chain.

Please identify the main industry sectors the company operates in. Select all that apply

- ☐ *Mining & Resource*
- ☐ *Defence & Security*
- ☐ *Oil & Gas*
- ☐ *Construction*
- ☐ *Manufacturing*
- ☐ *Energy*
- ☐ *Automotive*
- ☐ *Education & Training*
- ☐ *Water*
- ☐ *Transport*
- ☐ *Food & beverage*
- ☐ *Other*

If you have selected other, please specify

What percentage of revenue of your company's was derived from its mining division or activity in the last 3 years?

What percentage of revenue of your company's latest financial year was derived from its oil&gas division or activity in the last 3 years?

In regard to your resource sector sales, which of the following categories contributes to the highest percentage of your business turnover?

- *Exploration and feasibility*
- *Approval process and project management*
- *Construction*
- *Mining operations*
- *Close and rehabilitation*
- *Other*

If you have selected other, please specify

Where does your company operate in the mining supply chain?

- *Contract mining*
- *Tier 1 contractor to mining projects*
- *Sub-contractor to Tier 1(s)*
- *Sub-contractor to a sub-contractor(s)*
- *Original Equipment Manufacturer (OEM)*
- *Sub-contractor to an OEM(s)*
- *Sub-contractor to an OEM sub-contractor(s)*
- *Equipment, technology or services provider working directly with a mining company*
- *Pre-commercial R&D provider*
- *Other*

If you have selected other, please specify

What are your company's capabilities? Please select all that apply.

- ☐ *Manufacturing*
- ☐ *Engineering*
- ☐ *Construction*
- ☐ *Transport & logistics*
- ☐ *Equipment/Product Supply & Hire*
- ☐ *Electrical*
- ☐ *Business, Legal and Finance*
- ☐ *Education & Skills*
- ☐ *Environmental Services*
- ☐ *Exploration Services*
- ☐ *Accommodation*
- ☐ *Mining Services*
- ☐ *Technical and Consulting Services*
- ☐ *Research and Technology Development*
- ☐ *Recruitment & Labour Hire*
- ☐ *Civil Construction*
- ☐ *Industrial Services*
- ☐ *Other*

If you have selected other, please specify

*Please, type in the top **clients** during your company's most recent financial year and identify nature of relationships*

	Arms length	*Long-term strategic*	*Collaborative*	*Other*
Company 1	○	○	○	○
Company 2	○	○	○	○
Company 3	○	○	○	○
Company 4	○	○	○	○
Company 5	○	○	○	○

If you have selected other, please specify

*Please, type in the top **suppliers** during your company's most recent financial year and identify nature of relationships*

	Arms length	*Long-term strategic*	*Collaborative*	*Other*
Company 1	○	○	○	○
Company 2	○	○	○	○
Company 3	○	○	○	○
Company 4	○	○	○	○
Company 5	○	○	○	○

If you have selected other, please specify

Section B. Innovations

Section B. Innovations

This section contains questions related to the innovative performance and potential of your company, as well as drivers and barriers for innovations

Please identify how many new-to-market products/services has your company introduced in the last 3 years?

How many joint R&D projects has your company been involved in the last 3 years?

Please identify

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
The percentage of turnover of your firm attributed to new, dramatically improved products/services introduced in the last 3 years	○	○	○	○	○	○	○	○	○	○	○
The percentage of spending on research and development (R&D)	○	○	○	○	○	○	○	○	○	○	○
The percentage of R&D employees in your company	○	○	○	○	○	○	○	○	○	○	○
The percentage of University graduates employed by your company	○	○	○	○	○	○	○	○	○	○	○
The percentage of qualified technicians employed by your company	○	○	○	○	○	○	○	○	○	○	○
The percentage of knowledge developed inside the company (as the opposite to knowledge acquired outside the company, from suppliers, customers, collaborators, etc.)	○	○	○	○	○	○	○	○	○	○	○

Section C. Supplier-buyer relationships

Section C. Supplier-buyer relationships

This section contains questions related to the quality of supplier-buyer relationships across the SA resource and energy supply chain.

Do you agree with the following statement?

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Our company is tied to the major clients through additional business and informal ties (shared board members, social relations etc.)	○	○	○	○	○	○	○

Please identify to what extent your company is usually involved in the customers decision-making process regarding the following issues?

	Not at all involved	Very little	A little	A moderate amount	A lot	Quite a lot	Involved to a great extent	N/A
Initial design of the product/service								
Cost control								
Product/service modification								
Production process								
Sub-contracting								
Forecasting commodity requirements								
Quality improvement								

Do you agree with the following statement?

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Our company is engaged in ongoing discussion with the clients to jointly improve both their operations and ours							
Both parties, supplier and customer, can make adjustments in the ongoing relationship to be able to deal with changing circumstances							
Problems that arise in the course of the relationship are treated by parties as joint rather than individual responsibilities							

Please characterise the information exchange between your company and your clients

	Very poor - 1	2	3	4	5	6	Excellent - 7
Accuracy of information received							
Detail of information received							
Timeliness of information received							

Please identify the kinds and frequency of information that your company exchanges with the clients

	Not at all exchanged 1	2	3	4	5	6	Exchanged very frequently 7	N/A
Quality information								
Inventory information								
Schedule and delivery information								
Detailed cost information								
Marketing information								
Long-term volume projections								
Manufacturing process information								
Proprietary technical information								
Design information								
Production capacity								

Please identify to what extent you agree with the following statements in regard to relationships with your clients/suppliers

	Strongly disagree	Disagree	Slightly disagree	Neither Agree nor Disagree	Slightly agree	Agree	Strongly agree
Our company always been even handed in its negotiation with your client/supplier companies							
Our suppliers/customers may use opportunities that arise to profit at our company's expense							
Based on past experience, you cannot, with complete confidence, rely on your suppliers/customers to keep promises made to you							
You are hesitant to transact with the supplier/customer when specifications are vague							
You trust your suppliers/customers to treat you fairly							
You trust that confidential/proprietary information shared with your suppliers/customers will be kept strictly confidential							

Section D. Supply chain collaboration

Section D. Supply chain collaboration

In this section, the questions will be asked about the collaboration and information sharing across the resource and energy supply chain.

What types of collaborative relationships does your company participate in? Please identify intensity of collaboration.

	Not at all exchanged 1	2	3	4	5	6	7	8	Exchanged very frequently 9	N/A
New product development	○	○	○	○	○	○	○	○	○	○
Research and development	○	○	○	○	○	○	○	○	○	○
Purchase of raw materials	○	○	○	○	○	○	○	○	○	○
Participation in trade fairs and events	○	○	○	○	○	○	○	○	○	○
Exchange of ideas and experiences	○	○	○	○	○	○	○	○	○	○
Study of process improvements	○	○	○	○	○	○	○	○	○	○
Study of improvements for the sector as a whole	○	○	○	○	○	○	○	○	○	○
Sharing of business relevant information	○	○	○	○	○	○	○	○	○	○
Purchase of machinery and equipment	○	○	○	○	○	○	○	○	○	○
Equipment sharing	○	○	○	○	○	○	○	○	○	○
Other ______	○	○	○	○	○	○	○	○	○	◉

Please, indicate the organisations that your company collaborates with and identify the type of collaboration

	Partnership	Joint-venture	Formal alliance	Informal alliance	R&D	Other
Organisation 1 ______	☐	☐	☐	☐	☐	☐
Organisation 2 ______	☐	☐	☐	☐	☐	☐
Organisation 3 ______	☐	☐	☐	☐	☐	☐
Organisation 4 ______	☐	☐	☐	☐	☐	☐
Organisation 5 ______	☐	☐	☐	☐	☐	☐

If you have selected other, please specify

Section E. Institutions for collaboration

Please identify industry associations/related organisations that you are member of and evaluate them according to their relative value to your company (acquiring new clients, finding opportunities for collaboration, getting valuable information)?

	Not important - 1	2	3	4	Very important - 5	N/A
Austmine	○	○	○	○	○	●
Australian Steel Institute (ASI)	○	○	○	○	○	●
Industry Capability Network (ICN)	○	○	○	○	○	●
South Australian Chamber of Mines and Energy (SACOME)	○	○	○	○	○	●
Global Maintenance Upper Spencer Gulf (GMUSG)	○	○	○	○	○	●
Resource Engineering Skills Alliance (RESA)	○	○	○	○	○	●
Defence Teaming Centre (DTC)	○	○	○	○	○	●
Austrade	○	○	○	○	○	●
Other 1	○	○	○	○	○	●
Other 2	○	○	○	○	○	●

How often do you participate in the mining industry conferences and other networking events?

- *Never*
- *Every 5 years*
- *Annualy*
- *Quarterly*
- *Monthly*

Section F. General information

Section E. Contact details and company information

First name

${m://FirstName}

Last name

${m://LastName}

Job title

Company name

Company website

Company head-office address

Suburb

State

Postcode

Telephone

E-mail

How many ‘full time equivalent' (FTE) employees did your company have in Australia on 1 July 2015?

Please identify the type of your company

- *Sole trader*
- *Partnership*
- *PTY LTD Australian Stock Exchange listed*
- *PTY LTD Australian Stock Exchange non-listed*
- *Trust*
- *Other*

Year of establishment

Annual turnover, AUD

- *$0 - $499,999*

- $500,000 - $0.99m
- $1m - $1.99m
- $2m - $4.99m
- $5m- $9.99m
- $10m - $19.99m
- $20m+

Percentage of revenue from overseas for product produced/service delivered

Please identify your perception of company business growth over the last 3 years?

- has declined significantly
- has declined slightly
- not changed
- has grown slightly
- has grown significantly

Please identify how many new clients has your company acquired in the last 3 years?

Is your company certified following international/ Australian standards?

- ISO 9001:2008 Quality Management Systems
- ISO 14001:2004 Environment Management Systems
- ISO 31000:2009 Risk Management Systems
- AS/NZS 4801 OHS
- OHSAS 18000 OHS
- Other1
- Other2

Appendix D

Appendix D - Sample descriptive analysis

Table 1 Descriptive analysis of the sample

Variable name	Mean	Median	Min	Max	S. D.	Kurtosis	Skew
COMP_SIZE	474.66	25.00	1.00	19000.00	2215.83	47.21	6.70
COMP_SIZE_LOG	*3.32*	*3.22*	*0.00*	*9.85*	*2.14*	*0.34*	*0.57*
INN	10.15	2.00	0.00	500.00	48.45	75.46	8.29
INN_LOG	*1.18*	*1.10*	*0.00*	*6.22*	*1.07*	*5.82*	*1.87*
SECT_DIV	4.24	4.00	0.00	12.00	2.75	0.02	0.77
CAP_DIV	3.14	3.00	0.00	15.00	2.42	5.14	1.89
AC_RDSPEND	2.34	2.00	1.00	11.00	1.64	10.70	2.90
AC_RDEMP	1.87	2.00	1.00	10.00	1.36	12.17	3.08
PER_TO_NEWPR	3.41	3.00	1.00	11.00	2.56	1.34	1.43
AC_UNIGRAD	3.51	2.00	1.00	11.00	3.22	0.49	1.38
AC_QUALTECH	4.56	4.00	0.00	11.00	3.29	-1.06	0.52
PE_DEGREE	11.01	9.00	0.00	44.00	9.13	1.65	1.29
PE_CLOSENESS	84	29	2,305.13	2,188.00	0	10,715.00	1,517.11
PE_BETWEENNESS	88	30	2,917.23	2,271.14	0	20,323.16	2,816.05
PE_EIGENVECTOR	0.02	0.02	0.00	0.06	0.02	-0.19	0.67
RE_JPS_1	4.41	4.00	1.00	7.00	1.89	-1.09	-0.18
RE_JPS_2	4.12	4.00	1.00	7.00	1.82	-1.06	-0.09
RE_JPS_3	4.28	4.00	1.00	7.00	1.85	-1.07	-0.18
RE_JPS_4	3.66	4.00	1.00	7.00	2.01	-1.18	0.21
RE_JPS_5	3.22	3.00	1.00	7.00	1.90	-0.78	0.58
RE_JPS_6	2.43	1.00	1.00	7.00	1.93	0.03	1.16
RE_JPS_7	4.41	4.00	1.00	7.00	1.64	-1.14	0.05
RE_JPS_8	5.69	6.00	1.00	7.00	1.22	1.74	-1.07
RE_JPS_9	5.83	6.00	2.00	7.00	1.04	0.87	-0.90
RE_JPS_10	5.47	6.00	2.00	7.00	1.23	0.01	-0.68
RE_IE_1	5.21	5.00	2.00	7.00	1.27	-0.13	-0.50
RE_IE_2	5.01	5.00	2.00	7.00	1.34	-0.52	-0.44
RE_IE_3	4.64	5.00	1.00	7.00	1.38	-0.34	-0.36
RE_IE_4	5.18	5.00	1.00	7.00	1.65	-0.45	-0.61
RE_IE_5	3.86	4.00	1.00	7.00	2.00	-1.17	0.09
RE_IE_6	5.58	6.00	1.00	7.00	1.49	0.98	-1.18
RE_IE_7	4.88	5.00	1.00	7.00	1.84	-0.61	-0.67
RE_IE_8	4.02	4.00	1.00	7.00	1.75	-0.98	0.07
RE_IE_9	3.66	3.00	1.00	7.00	1.97	-1.27	0.21
RE_IE_10	3.47	3.00	1.00	7.00	1.91	-1.07	0.33
RE_IE_11	3.81	4.00	1.00	7.00	1.95	-1.27	0.02
RE_IE_12	4.42	5.00	1.00	7.00	1.98	-1.09	-0.33
RE_IE_13	4.32	4.00	1.00	7.00	1.96	-1.11	-0.25
RE_T_1	5.66	6.00	1.00	7.00	1.18	1.81	-1.23
RE_T_2	3.72	4.00	1.00	7.00	1.67	-0.78	0.31
RE_T_3	5.06	5.00	1.00	7.00	1.40	0.42	-0.88
RE_T_4	3.32	3.00	1.00	7.00	1.75	-0.78	0.56
RE_T_5	5.30	6.00	2.00	7.00	1.16	0.11	-0.70
RE_T_6	5.20	6.00	1.00	7.00	1.41	0.16	-0.85

Table 2 Normality tests

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
COMP_SIZE	.315	70	.000	.486	70	.000
SECT_DIV	.129	156	.002	.939	156	.001
CAP_DIV	.152	156	.000	.875	156	.000
INN	.185	156	.000	.820	156	.000
AC_RDSPEND	.326	156	.000	.698	156	.000
PER_TO_NEWPR	.246	156	.000	.843	156	.000
AC_UNIGRAD	.284	156	.000	.700	156	.000
AC_QUALTECH	.192	156	.000	.891	156	.000
PE_DEGREE	.445	156	.000	.481	156	.000
PE_CLOSENESS	.254	134	.000	.665	134	.000
PE_BETWEENNESS	.151	134	.000	.826	134	.000
PE_EIGENVECTOR	.521	156	.000	.389	156	.000
RE_JPS_1	.133	156	.001	.925	156	.000
RE_JPS_2	.128	156	.003	.935	156	.001
RE_JPS_3	.139	156	.001	.934	156	.000
RE_JPS_4	.155	156	.000	.915	156	.000
RE_JPS_5	.185	156	.000	.887	156	.000
RE_JPS_6	.279	156	.000	.742	156	.000
RE_JPS_7	.145	156	.000	.931	156	.000
RE_JPS_8	.194	156	.000	.879	156	.000
RE_JPS_9	.233	156	.000	.875	156	.000
RE_JPS_10	.203	156	.000	.910	156	.000
RE_IE_1	.197	156	.000	.923	156	.000
RE_IE_2	.166	156	.000	.927	156	.000
RE_IE_3	.152	156	.000	.948	156	.003
RE_IE_4	.140	156	.001	.916	156	.000
RE_IE_5	.105	156	.028	.919	156	.000
RE_IE_6	.237	156	.000	.866	156	.000
RE_IE_7	.179	156	.000	.909	156	.000
RE_IE_8	.144	156	.000	.945	156	.002
RE_IE_9	.160	156	.000	.913	156	.000
RE_IE_10	.152	156	.000	.922	156	.000
RE_IE_11	.145	156	.000	.924	156	.000
RE_IE_12	.172	156	.000	.928	156	.000
RE_IE_13	.164	156	.000	.920	156	.000
RE_T_1	.334	156	.000	.803	156	.000
RE_T_2	.228	156	.000	.909	156	.000
RE_T_3	.207	156	.000	.884	156	.000
RE_T_4	.168	156	.000	.910	156	.000
RE_T_5	.213	156	.000	.904	156	.000
RE_T_6	.239	156	.000	.899	156	.000
*Lilliefors Significance Correction						

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Appendix E

Appendix E – Correlation Table

Table 1 – Correlation table

	AC	CAP_ DIV	Betweenness	Closeness	Degree	EigenVector	NEW_ PR	IE_1	IE_ 2	IE_ 3	IE_4	IE_5	IE_6	IE_7	IE_8	IE_9
AC	1	-0.008	-0.122	-0.011	-0.083	-0.201	0.243	-0.065	0.006	0.039	-0.028	0.173	0.043	0.02	0.026	0.203
CAP_DIV	-0.008	1	0.407	0.233	0.272	0.125	0.128	-0.016	-0.016	0.027	0.195	0.088	0.102	0.257	0.023	-0.01
Betweeness	-0.122	0.407	1	0.359	0.802	0.28	0.109	-0.103	-0.152	-0.152	-0.038	0.026	-0.056	0.076	-0.042	0.007
Closeness	-0.011	0.233	0.359	1	0.104	-0.107	0.066	0.132	0.068	0.1	0.035	0.022	-0.049	0.003	0.036	0.006
Degree	-0.083	0.272	0.802	0.104	1	0.314	0.103	-0.157	-0.167	-0.185	-0.132	-0.057	-0.109	-0.007	-0.145	-0.035
EigenVector	-0.201	0.125	0.28	-0.107	0.314	1	0.075	-0.195	-0.187	-0.247	-0.008	-0.099	0.078	0.083	0.069	0.057
NEW_PR	0.243	0.128	0.109	0.066	0.103	0.075	1	-0.064	-0.042	0.059	-0.017	-0.088	0.101	0.012	0.056	0.238
IE_1	-0.065	-0.016	-0.103	0.132	-0.157	-0.195	-0.064	1	0.873	0.734	0.355	0.316	0.248	0.218	0.312	0.131
IE_2	0.006	-0.016	-0.152	0.068	-0.167	-0.187	-0.042	0.873	1	0.785	0.354	0.275	0.264	0.186	0.253	0.162
IE_3	0.039	0.027	-0.152	0.1	-0.185	-0.247	0.059	0.734	0.785	1	0.384	0.184	0.275	0.162	0.268	0.112
IE_4	-0.028	0.195	-0.038	0.035	-0.132	-0.008	-0.017	0.355	0.354	0.384	1	0.357	0.495	0.585	0.419	0.076
IE_4	0.173	0.088	0.026	0.022	-0.057	-0.099	-0.088	0.316	0.275	0.184	0.357	1	0.413	0.409	0.457	0.221
IE_5	0.043	0.102	-0.056	-0.049	-0.109	0.078	0.101	0.248	0.264	0.275	0.495	0.413	1	0.546	0.368	0.194
IE_6	0.02	0.257	0.076	0.003	-0.007	0.083	0.012	0.218	0.186	0.162	0.585	0.409	0.546	1	0.474	0.122
IE_7	0.026	0.023	-0.042	0.036	-0.145	0.069	0.056	0.312	0.253	0.268	0.419	0.457	0.368	0.474	1	0.331
IE_8	0.203	-0.01	0.007	0.006	-0.035	0.057	0.238	0.131	0.162	0.112	0.076	0.221	0.194	0.122	0.331	1
IE_9	0.057	-0.11	-0.168	-0.087	-0.174	-0.051	-0.031	0.289	0.317	0.243	0.265	0.449	0.5	0.274	0.284	0.251
IE_10	0.098	-0.056	-0.108	-0.03	-0.12	-0.031	0.003	0.255	0.212	0.221	0.296	0.638	0.415	0.305	0.454	0.236
IE_11	0.188	0.055	0.022	0.069	-0.055	-0.03	0.008	0.277	0.228	0.213	0.198	0.526	0.26	0.261	0.487	0.268
IE_12	0.166	0.166	0.148	0.133	0.025	0.108	0.034	0.162	0.11	0.118	0.274	0.464	0.276	0.4	0.41	0.136
JA_1	0.202	0.156	0.021	0.209	-0.085	-0.036	0.11	0.295	0.308	0.375	0.254	0.228	0.169	0.245	0.228	-0.01
JA_2	0.145	0.235	0.04	0.256	-0.121	-0.059	0.238	0.23	0.22	0.274	0.297	0.283	0.282	0.285	0.261	0.088
JA_3	0.29	0.147	-0.02	0.207	-0.107	-0.037	0.242	0.202	0.216	0.336	0.151	0.248	0.259	0.192	0.247	0.046
JA_4	0.235	0.239	-0.034	0.224	-0.093	-0.147	0.137	0.179	0.242	0.285	0.132	0.415	0.301	0.176	0.251	0.044

	IE_10	IE_11	IE_12	IE_13	JA _1	JA_ 2	JA_3	JA_4	JA_5	JA_6	JA_7	JA_8	JA_9	JA_10	T_1	T_2	T_ 3	T_ 4	T_5	T_ 6	SECT_ DIV
AC	0.057	0.098	0.188	0.166	0.202	0.145	0.29	0.235	0.022	0.116	0.137	0.068	0.052	-0.013	-0.061	0.096	-0.06	0.075	-0.019	-0.066	0.057
CAP_DIV	-0.11	-0.056	0.055	0.166	0.156	0.235	0.147	0.239	0.233	0.07	0.176	0.176	0.144	0.134	0.089	-0.105	-0.079	0.116	-0.035	-0.067	0.322
Betweeness	-0.168	-0.108	0.022	0.148	0.021	0.04	-0.02	-0.034	0.024	-0.073	0.04	-0.035	-0.029	-0.012	0.037	-0.152	-0.154	0.035	-0.094	-0.148	0.153
Closeness	-0.087	-0.03	0.069	0.133	0.209	0.256	0.207	0.224	0.178	0.17	0.163	0.146	0.104	0.106	0.053	0.073	-0.098	0.098	-0.036	-0.07	0.044
Degree	-0.174	-0.12	-0.055	0.025	-0.085	-0.121	-0.107	-0.093	-0.002	-0.16	-0.034	-0.189	-0.193	-0.141	0.052	-0.096	-0.11	0.017	-0.071	-0.112	0.105
EigenVector	-0.051	-0.031	-0.03	0.108	-0.036	-0.059	-0.037	-0.147	-0.022	-0.145	-0.072	-0.099	-0.123	-0.162	0.094	-0.14	-0.142	-0.056	-0.112	-0.078	0.222
NEW_PR	-0.031	0.003	0.008	0.034	0.11	0.238	0.242	0.137	-0.036	0.095	0.097	0.042	0.056	-0.082	0.112	-0.062	0.052	0.032	0.099	0.018	0.34
IE_1	0.289	0.255	0.277	0.162	0.295	0.23	0.202	0.179	0.11	0.156	0.31	0.425	0.478	0.583	0.201	0.042	0.333	0.074	0.328	0.232	0.004
IE_2	0.317	0.212	0.228	0.11	0.308	0.22	0.216	0.242	0.191	0.179	0.319	0.404	0.444	0.57	0.196	0.095	0.33	0.035	0.314	0.239	0.01
IE_3	0.243	0.221	0.213	0.118	0.375	0.274	0.336	0.285	0.229	0.185	0.449	0.431	0.434	0.603	0.138	0.073	0.273	0.079	0.309	0.183	0.041
IE_4	0.265	0.296	0.198	0.274	0.254	0.297	0.151	0.132	0.212	0.283	0.35	0.362	0.318	0.427	-0.085	-0.083	0.023	-0.019	0.042	0.032	0.094
IE_4	0.449	0.638	0.526	0.464	0.228	0.283	0.248	0.415	0.208	0.368	0.242	0.353	0.389	0.443	0.025	-0.071	0.014	0.049	0.093	0.003	0.033
IE_5	0.5	0.415	0.26	0.276	0.169	0.282	0.259	0.301	0.215	0.295	0.177	0.244	0.221	0.332	0.038	-0.065	0.103	-0.002	0.163	0.126	0.17
IE_6	0.274	0.305	0.261	0.4	0.245	0.285	0.192	0.176	0.215	0.207	0.203	0.385	0.389	0.408	0.079	-0.136	0.018	0.064	0.062	0.02	0.168
IE_7	0.284	0.454	0.487	0.41	0.228	0.261	0.247	0.251	0.093	0.19	0.241	0.308	0.352	0.389	0.241	0.06	0.166	0.074	0.189	0.223	0.124
IE_8	0.251	0.236	0.268	0.136	-0.01	0.088	0.046	0.044	0.002	0.178	0.051	0.081	0.079	0.157	0.122	0.045	0.09	-0.025	0.082	0.121	0.055
IE_9	1	0.539	0.49	0.343	0.079	0.126	0.08	0.22	0.135	0.341	0.234	0.251	0.27	0.269	-0.067	-0.034	-0.016	-0.062	0.145	0.087	-0.051
IE_10	0.539	1	0.664	0.567	0.208	0.242	0.223	0.416	0.168	0.344	0.261	0.285	0.362	0.383	0.07	0.015	0.086	0.012	0.15	0.097	0.087
IE_11	0.49	0.664	1	0.633	0.247	0.252	0.253	0.33	0.166	0.229	0.28	0.262	0.321	0.258	0.025	0.01	-0.031	-0.005	0.079	-0.008	0.081
IE_12	0.343	0.567	0.633	1	0.301	0.212	0.299	0.356	0.208	0.203	0.241	0.267	0.333	0.238	0.089	-0.029	-0.034	0.108	0.034	-0.053	0.141
JA_1	0.079	0.208	0.247	0.301	1	0.665	0.748	0.569	0.4	0.281	0.743	0.446	0.397	0.353	0.131	-0.024	0.115	0.133	0.274	0.11	0.151
JA_2	0.126	0.242	0.252	0.212	0.665	1	0.702	0.611	0.42	0.404	0.544	0.409	0.358	0.391	0.076	-0.04	0.015	-0.029	0.172	0.02	0.199
JA_3	0.08	0.223	0.253	0.299	0.748	0.702	1	0.677	0.39	0.241	0.572	0.437	0.328	0.34	0.132	0.071	0.064	0.026	0.2	0.028	0.126
JA_4	0.22	0.416	0.33	0.356	0.569	0.611	0.677	1	0.533	0.472	0.518	0.368	0.32	0.362	0.181	0.071	0.168	0.028	0.298	0.172	0.174

JA_5	0.022	0.233	0.024	0.178	-0.002	-0.022	-0.036	0.11	0.191	0.229	0.212	0.208	0.215	0.215	0.093	0.002	0.135	0.168	0.166	0.208	0.4	0.42	0.39	0.533	1	0.403	0.411	0.221	0.148	0.252	0.11	-0.054	0.068	0.053	0.171	0.131	0.14
JA_6	0.116	0.07	-0.073	0.17	-0.16	-0.145	0.095	0.156	0.179	0.185	0.283	0.368	0.295	0.207	0.19	0.178	0.341	0.344	0.229	0.203	0.281	0.404	0.241	0.472	0.403	1	0.369	0.23	0.207	0.226	0.041	-0.023	0.123	-0.027	0.202	0.053	0.082
JA_7	0.137	0.176	0.04	0.163	-0.034	-0.072	0.097	0.31	0.319	0.449	0.35	0.242	0.177	0.203	0.241	0.051	0.234	0.261	0.28	0.241	0.743	0.544	0.572	0.518	0.411	0.369	1	0.428	0.325	0.349	0.05	-0.068	0.055	-0.098	0.239	0.099	0.122
JA_8	0.068	0.176	-0.035	0.146	-0.189	-0.099	0.042	0.425	0.404	0.431	0.362	0.353	0.244	0.385	0.308	0.081	0.251	0.285	0.262	0.267	0.446	0.409	0.437	0.368	0.221	0.23	0.428	1	0.706	0.654	0.193	-0.006	0.182	-0.063	0.29	0.148	0.168
JA_9	0.052	0.144	-0.029	0.104	-0.193	-0.123	0.056	0.478	0.444	0.434	0.318	0.389	0.221	0.389	0.352	0.079	0.27	0.362	0.321	0.333	0.397	0.358	0.328	0.32	0.148	0.207	0.325	0.706	1	0.717	0.221	-0.031	0.244	0.1	0.298	0.177	0.134
JA_10	-0.013	0.134	-0.012	0.106	-0.141	-0.162	-0.082	0.583	0.57	0.603	0.427	0.443	0.332	0.408	0.389	0.157	0.269	0.383	0.258	0.238	0.353	0.391	0.34	0.362	0.252	0.226	0.349	0.654	0.717	1	0.219	0.02	0.28	-0.008	0.335	0.222	0.057
T_1	-0.061	0.089	0.037	0.053	0.052	0.094	0.112	0.201	0.196	0.138	-0.085	0.025	0.038	0.079	0.241	0.122	-0.067	0.07	0.025	0.089	0.131	0.076	0.132	0.181	0.11	0.041	0.05	0.193	0.221	0.219	1	0.192	0.601	0.228	0.51	0.477	0.14
T_2	0.096	-0.105	-0.152	0.073	-0.096	-0.14	-0.062	0.042	0.095	0.073	-0.083	-0.071	-0.065	-0.136	0.06	0.045	-0.034	0.015	0.01	-0.029	-0.024	-0.04	0.071	0.071	-0.054	-0.023	-0.068	-0.006	-0.031	0.02	0.192	1	0.298	0.231	0.309	0.298	-0.043
T_3	-0.06	-0.079	-0.154	-0.098	-0.11	-0.142	0.052	0.333	0.33	0.273	0.023	0.014	0.103	0.018	0.166	0.09	-0.016	0.086	-0.031	-0.034	0.115	0.015	0.064	0.168	0.068	0.123	0.055	0.182	0.244	0.28	0.601	0.298	1	0.228	0.776	0.794	0.051
T_4	0.075	0.116	0.035	0.098	0.017	-0.056	0.032	0.074	0.035	0.079	-0.019	0.049	-0.002	0.064	0.074	-0.025	-0.062	0.012	-0.005	0.108	0.133	-0.029	0.026	0.028	0.053	-0.027	-0.098	-0.063	0.1	-0.008	0.228	0.231	0.228	1	0.238	0.239	0.107
T_5	-0.019	-0.035	-0.094	-0.036	-0.071	-0.112	0.099	0.328	0.314	0.309	0.042	0.093	0.163	0.062	0.189	0.082	0.145	0.15	0.079	0.034	0.274	0.172	0.2	0.298	0.171	0.202	0.239	0.29	0.298	0.335	0.51	0.309	0.776	0.238	1	0.778	0.145
T_6	-0.066	-0.067	-0.148	-0.07	-0.112	-0.078	0.018	0.232	0.239	0.183	0.032	0.003	0.126	0.02	0.223	0.121	0.087	0.097	-0.008	-0.053	0.11	0.02	0.028	0.172	0.131	0.053	0.099	0.148	0.177	0.222	0.477	0.298	0.794	0.239	0.778	1	0.106
SECT_DIV	0.057	0.322	0.153	0.044	0.105	0.222	0.34	0.004	0.01	0.041	0.094	0.033	0.17	0.168	0.124	0.055	-0.051	0.087	0.081	0.141	0.151	0.199	0.126	0.174	0.14	0.082	0.122	0.168	0.134	0.057	0.14	-0.043	0.051	0.107	0.145	0.106	1

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Appendix F

APPENDIX F - Exploratory factor analysis

Table 1 EFA results for all variables in the conceptual framework - Pattern Matrix[a]

	Factor												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Comp_size							.949						
Annual turnover, AUD							.920						
Innovativeness										.635			
Sect_diversity										.654			
Capability diversity													
R&D spending									.858				
R&D employees									.676				
Percent to new products									.322				
University graduates													
Qualified technicians													.570
JA_initial design of the product/service	.742												
JA_cost control	.654												
JA_product/service modification	.989												
JA_production process	.478										.478		
JA_sub-contracting											.518		
JA_forecasting commodity requirements											.526		
JA_quality improvement	.306										.436		
JA_ongoing discussion								.586					

JA_adjustments in relationships								.740					
JA_joint responsibilities								.657					
IE_accuracy of information received			.864										
IE_detail of information received			.948										
IE_timeliness of information received			.782										
IE_quality information					.694								
IE_inventory information					.576								
IE_schedule and delivery information					.829								
IE_detailed cost information				.348	.423								
IE_marketing information													
IE_long-term volume projections												-.345	
IE_manufacturing process information				.604									
IE_proprietary technical information				.841									
IE_design information				.730									
IE_production capacity				.401									
Trust_even handed		.546											
Trust_use opportunities that arise to profit_rec		.358											
Trust_you cannot rely_rec		.898											
Trust_hesitant to transact_rec												.678	

Trust_customers to treat you fairly		.851											
Trust_proprietary information confidential		.923											
Centrality degree						.928							
Centrality eigenvector													
Centrality between						.915							
Extraction method: Principal axis factoring. Rotation method: Promax with kaiser normalization.													
a. rotation converged in 11 iterations.													

Table 2 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.729
Bartlett's Test of Sphericity	Approx. Chi-Square	1704.597
	df	861
	Sig.	.000

Appendix G

APPENDIX G - Confirmatory factor analysis

Joint problem-solving construct

Table 1 CFA for Joint problem-solving construct in SPSS

Item	Extracted Factors	
	1	2
1 Initial design of the product/service	.791	
2 Cost control	.772	
3 Product/service modification	.810	
4 Production process	.815	
5 Sub-contracting	.638	
6 Forecasting commodity requirements	.508	
7 Quality improvement	.724	
8 Company is engaged in ongoing discussion with the clients to jointly improve both their operations and ours.		.751
9 Both parties, supplier and customer, can make adjustments in the relationships to deal with changing circumstances.		.945
10 Problems that arise in the course of relationships are treated by parties as joint rather than individual responsibilities		.786
Extraction method: Principal axis factoring, Rotation method: Promax with Kaiser normalization,		

Table 2 CFA for Joint problem-solving construct in SPSS (low loaded items deleted)

Item	Component	
	1	2
1 Initial design of the product/service	.849	
2 Cost control	.806	
3 Product/service modification	.921	
4 Production process	.777	
7 Quality improvement	.668	
Company is engaged in ongoing discussion with the clients to jointly improve both their operations and ours.		.737
Both parties, supplier and customer, can make adjustments in the relationships to deal with changing circumstances.		.848
Problems that arise in the course of relationships are treated by parties as joint rather than individual responsibilities.		.876
Extraction method: Principal axis factoring rotation method: Promax with Kaiser normalization.		
a. Rotation converged in 3 iterations.		

Table 3 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.850
Bartlett's test of sphericity	Approx. chi-square	418.761
	df	28
	Sig.	.000

Table 4 Communalities

	Extraction
1 Initial design of the product/service	.679
2 Cost control	.688
3 Product/service modification	.807
4 Production process	.655
7 Quality improvement	.472
Company is engaged in ongoing discussion with the clients to jointly improve both their operations and ours.	.597
Both parties, supplier and customer, can make adjustments in the relationships to deal with changing circumstances.	.703
Problems that arise in the course of relationships are treated by parties as joint rather than individual responsibilities.	.748
Extraction method: Principal component analysis.	

Table 5 Component correlation matrix

Component	1	2
1	1.000	.445
2	.445	1.000
Extraction method: Principal component analysis. Rotation method: Promax with Kaiser normalization.		

Table 6 Reliability statistics

Cronbach's Alpha	N of Items
.851	8

Fine-Grained Information Exchange construct

Table 7 CFA for Information Exchange construct

	Component		
	1	2	3
Accuracy of information received		.912	
Detail of information received		.951	
Timeliness of information received		.872	
Quality information			.766
Inventory information			.740
Schedule and delivery information			.870
Detailed cost information	.345		.393
Marketing information	.405		
Long-term volume projections	.463		
Manufacturing process information	.812		
Proprietary technical information	.890		
Design information	.699		
Production capacity	.612		
extraction Method: Principal axis factoring Rotation method: Promax with Kaiser Normalization.			
a. Rotation converged in 4 iterations.			

Table 8 CFA for Information Exchange construct (low loaded items deleted)

	Component		
	1	2	3
Quality information			.750
Inventory information			.775
Schedule and delivery information			.852
Manufacturing process information		.763	
Proprietary technical information		.883	
Design information		.774	
Detail of information received	.945		
Timeliness of information received	.865		
Accuracy of information received	.917		
Extraction method: Principal axis factoring Rotation method: Promax with Kaiser normalization.			
a. Rotation converged in 5 iterations.			

Table 9 Communalities

Item	Initial	Extraction
Accuracy of information received	1.000	.849
Detail of information received	1.000	.889
Timeliness of information received	1.000	.782
Quality information	1.000	.612
Inventory information	1.000	.633
Schedule and delivery information	1.000	.700
Manufacturing process information	1.000	.636
Proprietary technical information	1.000	.762
Design information	1.000	.646
Extraction Method: Principal Axis Factoring		

Table 10 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.711
Bartlett's Test of Sphericity	Approx. Chi-Square	347.163
	df	36
	Sig.	.000

Table 11 Component Correlation Matrix

Component	1	2	3
1	1.000	.209	.352
2	.209	1.000	.275
3	.352	.275	1.000
Extraction Method: Principal Axis Factoring Rotation Method: Promax with Kaiser Normalization.			

Table 12 Reliability Statistics

Cronbach's Alpha	N of Items
.760	9

Table 13 Information Exchange construct reflective measurement model evaluation in Smart PLS

Latent variable		Indicators	Loadings	Indicator reliability	Chronbach's alpha	Composite reliability	AVE	Discri-minant validity
Fine-grained information exchange	Scope 1	Quality information	0.877	0.704	0.922	0.951	0.865	Yes
		Inventory information	0.86	0.674				
		Schedule and delivery information	0.853	0.706				
	Scope 2	Manufacturing process information	0.839	0.769	0.780	0.872	0.695	Yes
		Proprietary technical information	0.821	0.740				
		Design information	0.84	0.728				
	Quality	Detail of information received	0.934	0.872	0.831	0.898	0.746	Yes
		Timeliness of information received	0.952	0.906				
		Accuracy of information received	0.904	0.817				

Trust construct

Table 14 CFA for Trust construct

Item name		Extracted Factors
		1
1	Company is even handed in negotiations	.709
2	Company customers/suppliers may use opportunities that arise to profit at its expense (recoded)	.459
3	You cannot rely on customers/suppliers to keep promises made to you (recoded)	.907
4	You hesitant to transact with customers suppliers when specifications are vague (recoded)	.398
5	You trust your customers/ suppliers to treat you fairly	.884
6	You trust that proprietary information is kept confidential	.880
Extraction method: Principal axis factoring, rotation; Method: Promax with Kaiser normalization,		

Table 15 CFA for Trust construct (low loaded items deleted)

Component Matrix[a]	
	Component
	1
1 Company is even handed in negotiations	.725
3 You cannot rely on customers/suppliers to keep promises made to you (recoded)	.926
5 You trust your customers/ suppliers to treat you fairly	.897
6 You trust that proprietary information is kept confidential	.895
Extraction method: Principal axis factoring	
a. 1 component extracted.	

Table 16 KMO and Bartlett's Test

Kaiser-Meyer-Olkin measure of sampling adequacy		.804
Bartlett's test of sphericity	Approx. Chi-square	385.613
	df	6
	Sig.	.000

Table 17 Reliability Statistics

Cronbach's alpha	N of Items
.884	4

Absorptive capacity construct

Table 18 EFA for the absorptive capacity construct

Item name	Extracted Factor
R&D spending	.817
Percentage of turnover, attributed to new products	.838
Percentage of qualified technicians	.234
Extraction method: Principal axis factoring, Rotation method: Promax with Kaiser normalization	

Table19 Component Matrix

Item name	Component
	1
R&D spending	.806
Percent to new products	.806
Extraction method: Principal component analysis. a. 1 components extracted.	

Appendix H

Appendix H – Multigroup Analysis

Multi-group analysis – by Company size

Table 1 Measurement model evaluation. Indicator loadings on latent constructs

	Outer Loadings Original Group1	Outer Loadings Original Group2	Outer Loadings Mean Group1	Outer Loadings Mean Group2	STDEV Group1	STDEV Group2	t-Values Group1	t-Values Group2	p-Values Group1	p-Values Group2
JA_1 <- JOINT PROBLEM-SOLVING	0.837	0.888	0.839	0.888	0.077	0.023	10.846	38.529	0	0
JA_2 <- JOINT PROBLEM-SOLVING	0.947	0.873	0.941	0.872	0.023	0.03	41.997	29.551	0	0
RE_IE_Q19_1 <- IE_QUAL	0.925	0.941	0.915	0.941	0.119	0.014	7.791	66.19	0	0
RE_IE_Q19_2 <- IE_QUAL	0.927	0.967	0.914	0.967	0.124	0.009	7.465	103.918	0	0
RE_IE_Q19_3 <- IE_QUAL	0.887	0.905	0.879	0.904	0.121	0.038	7.325	23.988	0	0
RE_IE_Q20_1 <- IE_SCOPE1	0.785	0.878	0.779	0.878	0.105	0.027	7.467	32.319	0	0
RE_IE_Q20_2 <- IE_SCOPE1	0.814	0.822	0.805	0.82	0.122	0.04	6.671	20.509	0	0
RE_IE_Q20_3 <- IE_SCOPE1	0.862	0.842	0.851	0.838	0.114	0.042	7.584	20.14	0	0
RE_IE_Q20_7 <- IE_SCOPE2	0.848	0.906	0.851	0.906	0.077	0.024	11.006	37.711	0	0
RE_IE_Q20_8 <- IE_SCOPE2	0.859	0.902	0.852	0.9	0.086	0.029	9.974	31.201	0	0
RE_IE_Q20_9 <- IE_SCOPE2	0.782	0.863	0.768	0.859	0.108	0.037	7.229	23.561	0	0

Group 1 – Small (micro) businesses (less than 5 employees), Group 2 – Medium and Large (between 5 and 200+)

Table 2 **Measurement model evaluation. Latent constructs AVE**

	Average Variance Extracted (AVE) Original Group1	Average Variance Extracted (AVE) Original Group2	Average Variance Extracted (AVE) Mean Group1	Average Variance Extracted (AVE) Mean Group2	STDEV Group1	STDEV Group2	t-Values Group1	t-Values Group2	p-Values Group1	p-Values Group2
IE_QUAL	0.834	0.88	0.829	0.88	0.044	0.032	18.796	27.277	0	0
IE_SCOPE1	0.674	0.719	0.673	0.716	0.053	0.042	12.64	17.314	0	0
IE_SCOPE2	0.689	0.793	0.689	0.79	0.052	0.036	13.327	21.96	0	0
JOINT PROBLEM-SOLVING	0.799	0.776	0.798	0.775	0.049	0.035	16.391	22.046	0	0

Group 1 – Small (micro) businesses (less than 5 employees), Group 2 – Medium and Large (between 5 and 200+)

Table 3 **Measurement model evaluation. Composite reliabilities of latent constructs**

	Composite Reliability Original Group1	Composite Reliability Original Group2	Composite Reliability Mean Group1	Composite Reliability Mean Group2	STDEV Group1	STDEV Group2	t-Values Group1	t-Values Group2	p-Values Group1	p-Values Group2
IE_QUAL	0.938	0.956	0.935	0.956	0.023	0.013	40.306	73.576	0	0
IE_SCOPE1	0.861	0.885	0.858	0.882	0.032	0.021	27.241	41.317	0	0
IE_SCOPE2	0.869	0.92	0.867	0.918	0.03	0.016	29.344	55.819	0	0
JOINT PROBLEM-SOLVING	0.888	0.874	0.886	0.873	0.034	0.023	25.93	38.781	0	0

Group 1 – Small (micro) businesses (less than 5 employees), Group 2 – Medium and Large (between 5 and 200)

Table 4 – PLS MGA results - Structural model evaluation for 2 groups (Company size)

	Path Coeffi-cients Original Group1	Path Coeffi-cients Original Group2	Path Coeffi-cients Mean Group1	Path Coeffi-cients Mean Group2	STDEV Group1	STDEV Group2	t-Values Group1	t-Values Group2	p-Values Group1	p-Values Group2
ABS CAPACITY -> CAP_DIV	**0.198**	**-0.111**	**0.191**	**-0.1**	0.105	0.111	1.887	1.001	**0.06**	**0.318**
ABS CAPACITY -> INNOVATIVENESS	0.277	0.236	0.278	0.245	0.105	0.111	2.627	2.138	0.009	0.033
ABS CAPACITY -> SECT_Diversity	0.01	0.185	0.014	0.189	0.116	0.104	0.082	1.776	0.935	0.076
CAP_DIVERSITY -> INNOVATIVENESS	-0.136	0.021	-0.096	0.031	0.151	0.103	0.903	0.202	0.367	0.84
CAP_DIVERSITY -> SECT_Diversity	0.145	0.325	0.131	0.318	0.123	0.117	1.18	2.779	0.238	0.006
CENTRALITY -> CAP_DIVERSITY	0.359	0.287	0.347	0.237	0.117	0.159	3.076	1.806	0.002	0.071
CENTRALITY -> INNOVATIVENESS	0.149	0.079	0.131	0.097	0.13	0.114	1.147	0.687	0.252	0.492
EIGENVECTOR -> CAP_DIVERSITY	0.03	0.073	0.026	0.099	0.108	0.119	0.279	0.611	0.781	0.542
EIGENVECTOR -> INNOVATIVENESS	**0.279**	**-0.096**	0.265	-0.113	0.114	0.11	2.441	0.873	**0.015**	**0.383**
EIGENVECTOR -> SECT_DIV	**0.397**	**0.113**	0.385	0.115	0.137	0.108	2.901	1.052	**0.004**	**0.293**
IE -> IE_QUAL	0.712	0.797	0.703	0.795	0.139	0.056	5.122	14.342	0	0
IE -> IE_SCOPE1	0.731	0.796	0.724	0.793	0.111	0.053	6.591	14.951	0	0
IE -> IE_SCOPE2	0.713	0.698	0.711	0.695	0.094	0.105	7.583	6.635	0	0
IE -> JOINT ACTION	0.594	0.718	0.62	0.733	0.091	0.064	6.511	11.197	0	0
JOINT ACTION -> CAP_DIVERSITY	0.186	0.3	0.181	0.282	0.107	0.095	1.738	3.157	0.083	0.002
JOINT ACTION -> INNOVATIVENESS	-0.038	0.085	-0.014	0.087	0.136	0.113	0.277	0.753	0.782	0.452
JOINT ACTION -> SECT_Diversity	0.091	0.143	0.103	0.142	0.119	0.109	0.767	1.313	0.443	0.19
SECT_Diversity -> INNOVATIVENESS	0.247	0.264	0.219	0.262	0.164	0.109	1.509	2.424	0.132	0.016
TRUST -> IE	0.105	0.347	0.122	0.362	0.146	0.106	0.72	3.262	0.472	0.001
TRUST -> JOINT ACTION	**0.247**	**-0.032**	0.228	-0.044	0.106	0.078	**2.33**	**0.409**	**0.02**	**0.683**

Group 1 – Small (micro) businesses (less than 5 employees), Group 2 – Medium and Large (between 5 and 200+)

Table 5 - PLS MGA results – Assessment of the structural model (difference in path coefficients between the groups)

	Path Coefficients - diff (Group1 – Group2)	p-Value (Group1 – Group2)
ABS CAPACITY -> CAP_DIVERSITY	**0.309**	**0.025**
ABS CAPACITY -> INNOVATIVENESS	0.041	0.398
ABS CAPACITY -> SECT_DIVERSITY	0.175	0.869
CAP_DIVERSITY -> INNOVATIVENESS	0.157	0.803
CAP_DIVERSITY -> SECT_DIVERSITY	0.181	0.849
CENTRALITY -> CAP_DIVERSITY	0.072	0.358
CENTRALITY -> INNOVATIVENESS	0.07	0.331
EIGENVECTOR -> CAP_DIVERSITY	0.042	0.606
EIGENVECTOR -> INNOVATIVENESS	**0.375**	**0.018**
EIGENVECTOR -> SECT_DIVERSITY	**0.284**	**0.062**
IE -> IE_QUAL	0.085	0.694
IE -> IE_SCOPE1	0.065	0.686
IE -> IE_SCOPE2	0.015	0.458
IE -> JOINT ACTION	0.125	0.866
JOINT ACTION -> CAP_DIVERSITY	0.114	0.775
JOINT ACTION -> INNOVATIVENESS	0.123	0.756
JOINT ACTION -> SECT_Diversity	0.052	0.627
SECT_Diversity -> INNOVATIVENESS	0.017	0.498
TRUST -> IE	0.242	0.9
TRUST -> JOINT ACTION	**0.279**	**0.021**

Group 1 – Small (micro) businesses (less than 5 employees), Group 2 – Medium and Large (between 5 and 200, 200+)

Multigroup analysis – by Tier position

Table 6 Measurement model evaluation. Indicator loadings on latent constructs

	Outer Loadings Original Group1	Outer Loadings Original Group2	Outer Loadings Mean Group1	Outer Loadings Mean Group2	STDEV Group1	STDEV Group2	t-Values Group1	t-Values Group2	p-Values Group1	p-Values Group2
AC_ <- ABS CAPACITY	1	1	1	1	0	0				
CAPABILITY_DIVERSITY -> CAP_DIVERSITY	1	1	1	1	0	0				
CENT_DEGREE	1	1	1	1	0	0				
CENT_S_EIGENVECTOR <- EIGENVECTOR	1	1	1	1	0	0				
JA_1 <- JOINT ACTION	0.876	0.868	0.873	0.864	0.037	0.068	23.431	12.727	0	0
JA_2 <- JOINT ACTION	0.863	0.922	0.858	0.918	0.044	0.021	19.417	43.448	0	0
NEW_PR_LOG_PLUS_1 -> INNOVATIVENESS	1	1	1	1	0	0				
RE_IE_Q19_1 <- IE_QUAL	0.923	0.944	0.922	0.944	0.019	0.014	48.093	69.292	0	0
RE_IE_Q19_2 <- IE_QUAL	0.958	0.944	0.958	0.943	0.012	0.019	82.102	48.583	0	0
RE_IE_Q19_3 <- IE_QUAL	0.884	0.907	0.881	0.907	0.036	0.04	24.606	22.884	0	0
RE_IE_Q20_1 <- IE_SCOPE1	0.821	0.844	0.807	0.841	0.101	0.046	8.158	18.515	0	0
RE_IE_Q20_2 <- IE_SCOPE1	0.821	0.841	0.819	0.839	0.075	0.04	10.906	21.077	0	0
RE_IE_Q20_3 <- IE_SCOPE1	0.829	0.863	0.816	0.856	0.087	0.042	9.57	20.492	0	0
RE_IE_Q20_7 <- IE_SCOPE2	0.857	0.903	0.857	0.905	0.042	0.02	20.449	46.163	0	0
RE_IE_Q20_8 <- IE_SCOPE2	0.852	0.92	0.85	0.916	0.04	0.026	21.248	35.401	0	0
RE_IE_Q20_9 <- IE_SCOPE2	0.807	0.85	0.802	0.842	0.057	0.046	14.275	18.451	0	0
SECT_DIVERSITY <- SECT_DIVERSITY	1	1	1	1	0	0				
TRUST <- TRUST	1	1	1	1	0	0				

Group 1 – top-tier suppliers (to resource companies and EPC/EPCM providers), Group 2 - lower tier suppliers

Table 7 Measurement model evaluation. Latent constructs AVE

	Average Variance Extracted (AVE) Original Group1	Average Variance Extracted (AVE) Original Group2	Average Variance Extracted (AVE) Mean Group1	Average Variance Extracted (AVE) Mean Group2	STDEV Group1	STDEV Group2	t-Values Group1	t-Values Group2	p-Values Group1	p-Values Group2
ABS CAPACITY	1	1	1	1	0	0				
IE_QUAL	0.851	0.868	0.848	0.869	0.034	0.035	25.356	25.15	0	0
IE_SCOPE1	0.678	0.722	0.67	0.716	0.049	0.047	13.944	15.316	0	0
IE_SCOPE2	0.704	0.795	0.702	0.79	0.045	0.038	15.53	20.663	0	0
JOINT ACTION	0.756	0.801	0.75	0.798	0.042	0.043	18.176	18.635	0	0
SECT_DIVERSITY	1	1	1	1	0	0				
TRUST	1	1	1	1	0	0				

Group 1 – top-tier suppliers (to resource companies and EPC/EPCM providers), Group 2 - lower tier suppliers

Table 8 Measurement model evaluation. Composite reliability

	Composite Reliability Original Group1	Composite Reliability Original Group2	Composite Reliability Mean Group1	Composite Reliability Mean Group2	STDEV Group1	STDEV Group2	t-Values Group1	t-Values Group2	p-Values Group1	p-Values Group2
IE_QUAL	0.945	0.952	0.943	0.952	0.014	0.014	66.823	67.666	0	0
IE_SCOPE1	0.863	0.886	0.858	0.882	0.028	0.024	30.904	36.221	0	0
IE_SCOPE2	0.877	0.921	0.875	0.918	0.024	0.018	36.491	52.047	0	0
JOINT ACTION	0.861	0.89	0.857	0.886	0.028	0.04	30.971	22.14	0	0

Group 1 – top-tier suppliers (to resource companies and EPC/EPCM providers), Group 2 - lower tier suppliers

Table 9 Measurement model evaluation. Indicator discriminant validity group1 (Group 1 – Tier1)

	ABS CAPA-CITY	CAP DIVER-SITY	CENT-RA-LITY	EIGEN-VEC-TOR	IE	IE QUAL	IE SCOPE 1	IE SCOPE 2	INNO-VATI-VE-NESS	JOINT AC-TION	SECT Diver-sity	TRUST
ABS CAPACITY	1											
CAP DIVERSITY	-0.043											
CENTRALITY	-0.136	0.598	1									
EIGENVECTOR	-0.235	0.149	0.198	1								
IE	0.313	-0.006	-0.11	-0.154								
IE_QUAL	0.191	-0.13	-0.194	-0.298	0.793	0.922						
IE_SCOPE1	0.104	0.128	-0.034	0.066	0.666	0.256	0.824					
IE_SCOPE2	0.383	0.061	0.055	-0.014	0.671	0.24	0.34	0.839				
INNOVA-TIVENESS	0.229	0.194	0.099	0.075	0.141	0.064	0.127	0.123				
JOINT ACTION	0.319	0.14	-0.049	-0.106	0.621	0.538	0.355	0.397	0.179	0.869		
SECT DIVERSITY	0.14	0.423	0.159	0.27	0.16	0.047	0.188	0.114	0.363	0.216	1	
TRUST	-0.002	-0.164	-0.166	-0.088	0.316	0.421	0.058	0.04	0.186	0.272	0.126	1

Group 1 – top-tier suppliers (to resource companies and EPC/EPCM providers), Group 2 - lower tier suppliers

Table 10 Measurement model evaluation. Indicator discriminant validity group1 (Group 2 – Low tiers)

	ABS CAPA-CITY	CAP DIVER-SITY	CENT-RA-LITY	EIGEN-VEC-TOR	IE	IE QUAL	IE SCOPE 1	IE SCOPE 2	INNO-VA-TIVE-NESS	JOINT AC-TION	SECT Diver-sity	TRUST
ABS CAPACITY	1											
CAP DIVERSITY	0.093											
CENTRALITY	-0.076	0.043	1									
EIGEN-VECTOR	-0.132	0.073	0.477	1								
IE	-0.07	0.197	-0.152	-0.094								
IE QUAL	-0.159	0.11	-0.157	-0.202	0.757	0.932						
IE SCOPE1	-0.009	0.311	-0.069	0.024	0.822	0.425	0.85					
IE SCOPE2	-0.012	0.026	-0.117	0.023	0.719	0.262	0.479	0.891				
INNOVA-TIVENESS	0.278	0.04	0.133	0.081	-0.122	-0.113	-0.062	-0.109				
JOINT ACTION	0.133	0.277	-0.148	-0.213	0.654	0.523	0.499	0.437	0.067	0.895		
SECT Diversity	0.039	0.146	0.125	0.133	0.062	-0.043	0.108	0.106	0.325	0.103	1	
TRUST	-0.131	0.066	-0.095	-0.178	0.201	0.273	0.104	0.049	-0.094	0.268	0.048	1

Group 1 – top-tier suppliers (to resource companies and EPC/EPCM providers), Group 2 - lower tier suppliers

Table 11 – PLS MGA results - Structural model evaluation for 2 groups (Tier position)

	Path Coefficients Original (TIER(1.0))	Path Coefficients Original (TIER(2.0))	Path Coefficients Mean (TIER(1.0))	Path Coefficients Mean (TIER(2.0))	STDEV (TIER(1.0))	STDEV (TIER(2.0))	t-Values (TIER(1.0))	t-Values (TIER(2.0))	p-Values (TIER(1.0))	p-Values (TIER(2.0))
ABS CAPACITY -> CAP_DIVERSITY	-0.006	0.074	-0.002	0.089	0.085	0.136	0.076	0.547	0.939	0.585
ABS CAPACITY -> INNOVATIVENESS	0.188	0.281	0.201	0.275	0.115	0.095	1.635	2.944	0.103	0.003
ABS CAPACITY -> SECT_Diversity	0.169	0.037	0.179	0.034	0.089	0.102	1.898	0.364	0.058	0.716
CAP_DIVERSITY -> INNOVATIVENESS	0.034	-0.048	0.041	-0.017	0.164	0.109	0.208	0.435	0.835	0.664
CAP_DIVERSITY -> SECT_Diversity	**0.454**	**0.1**	**0.462**	**0.098**	**0.145**	**0.137**	**3.134**	**0.727**	**0.002**	**0.468**
CENTRALITY -> CAP_DIVERSITY	**0.597**	**0.041**	**0.571**	**0.029**	**0.142**	**0.126**	**4.201**	**0.322**	**0**	**0.747**
CENTRALITY -> INNOVATIVENESS	0.054	0.102	0.057	0.118	0.131	0.138	0.413	0.743	0.68	0.458
CENTRALITY -> SECT_Diversity	-0.139	0.1	-0.145	0.092	0.118	0.153	1.172	0.653	0.242	0.514
EIGENVECTOR -> CAP_DIVERSITY	0.048	0.128	0.052	0.134	0.101	0.111	0.476	1.152	0.634	0.25
EIGENVECTOR -> INNOVATIVENESS	0.031	0.04	0.033	0.015	0.124	0.169	0.249	0.238	0.804	0.812
EIGENVECTOR -> SECT_Diversity	0.283	0.106	0.283	0.102	0.108	0.157	2.627	0.675	0.009	0.5
IE -> IE_QUAL	0.791	0.758	0.792	0.754	0.058	0.095	13.722	7.997	0	0
IE -> IE_SCOPE1	0.667	0.822	0.666	0.818	0.096	0.05	6.966	16.315	0	0

IE -> IE_SCOPE2	0.672	0.719	0.668	0.705	0.104	0.11	6.443	6.523	0	0
IE -> JOINT ACTION	0.6	0.628	0.621	0.652	0.075	0.091	7.954	6.916	0	0
JOINT ACTION -> CAP_DIVERSITY	0.18	0.299	0.181	0.288	0.08	0.112	2.267	2.675	0.024	0.008
JOINT ACTION -> INNOVATIVENESS	0.053	0.032	0.056	0.059	0.097	0.145	0.541	0.218	0.589	0.827
JOINT ACTION -> SECT_Diversity	0.126	0.106	0.122	0.105	0.097	0.14	1.299	0.76	0.194	0.448
SECT_Diversity -> INNOVATIVENESS	0.292	0.298	0.278	0.259	0.141	0.16	2.073	1.863	0.039	0.063
TRUST -> IE	0.313	0.201	0.325	0.228	0.121	0.117	2.582	1.713	0.01	0.087
TRUST -> JOINT ACTION	0.092	0.143	0.087	0.12	0.083	0.102	1.106	1.396	0.269	0.163

Group 1 – top-tier suppliers (to resource companies and EPC/EPCM providers), Group 2 - lower tier suppliers

Table 12 - PLS MGA results – Assessment of the structural model (difference in path coefficients between the groups)

	Path Coefficients-diff (|TIER(1.0) - TIER(2.0)|)	p-Value(TIER(1.0) vs TIER(2.0))
ABS CAPACITY -> CAP_DIVERSITY	0.081	0.694
ABS CAPACITY -> INNOVATIVENESS	0.092	0.74
ABS CAPACITY -> SECT_Diversity	0.131	0.165
CAP_DIVERSITY -> INNOVATIVENESS	0.082	0.32
CAP_DIVERSITY -> SECT_Diversity	**0.355**	**0.037**
CENTRALITY -> CAP_DIVERSITY	**0.557**	**0.002**
CENTRALITY -> INNOVATIVENESS	0.048	0.593
CENTRALITY -> SECT_Diversity	0.239	0.885
EIGENVECTOR -> CAP_DIVERSITY	0.08	0.7
EIGENVECTOR -> INNOVATIVENESS	0.009	0.529
EIGENVECTOR -> SECT_Diversity	0.177	0.177
IE -> IE_QUAL	0.034	0.4
IE -> IE_SCOPE1	0.154	0.94
IE -> IE_SCOPE2	0.047	0.646
IE -> JOINT ACTION	0.028	0.611
JOINT ACTION -> CAP_DIVERSITY	0.118	0.804
JOINT ACTION -> INNOVATIVENESS	0.021	0.439
JOINT ACTION -> SECT_Diversity	0.02	0.456
SECT_Diversity -> INNOVATIVENESS	0.006	0.53
TRUST -> IE	0.112	0.251
TRUST -> JOINT ACTION	0.051	0.649

Group 1 – top-tier suppliers (to resource companies and EPC/EPCM providers), Group 2 - lower tier suppliers

Multi-group analysis – by Association Membership

Table 13 Measurement model evaluation. Indicator loadings on latent constructs Association Membership

	Outer Loadings Original (GROUP1)	Outer Loadings Original (GROUP2)	Outer Loadings Mean (GROUP1)	Outer Loadings Mean (GROUP2)	STDEV (GROUP1)	STDEV (GROUP2)	t-Values (GROUP1)	t-Values (GROUP2)	p-Values (GROUP1)	p-Values (GROUP2)
AC <- ABS CAPACITY	1	1	1	1	0	0				
CAPABILITY_DIVERSITY -> CAP_DIVERSITY	1	1	1	1	0	0				
DEGREE <- CENTRALITY	1	1	1	1	0	0				
EIGENVECTOR <- EIGENVECTOR	1	1	1	1	0	0				
JA_1 <- JOINT ACTION	0.863	0.85	0.862	0.844	0.037	0.071	23.281	11.889	0	0
JA_2 <- JOINT ACTION	0.914	0.862	0.912	0.851	0.019	0.089	48.634	9.677	0	0
NEW_PR_LOG_PLUS_1 -> INNOVATIVENESS	1	1	1	1	0	0				
RE_IE_Q19_1 <- IE_QUAL	0.945	0.923	0.944	0.923	0.012	0.021	78.107	44.456	0	0
RE_IE_Q19_1 -> IE	0.693	0.75	0.682	0.748	0.09	0.099	7.725	7.565	0	0
RE_IE_Q19_2 <- IE_QUAL	0.955	0.947	0.954	0.948	0.016	0.011	58.802	83.663	0	0
RE_IE_Q19_2 -> IE	0.665	0.725	0.651	0.725	0.093	0.082	7.119	8.884	0	0
RE_IE_Q19_3 <- IE_QUAL	0.92	0.867	0.92	0.862	0.02	0.063	46.823	13.778	0	0
RE_IE_Q19_3 -> IE	0.688	0.692	0.677	0.69	0.08	0.099	8.611	7.021	0	0
RE_IE_Q20_1 <-	0.807	0.889	0.806	0.885	0.045	0.032	18.085	27.47	0	0

IE_SCOPE1										
RE_IE_Q20_1 -> IE	0.694	0.634	0.689	0.619	0.062	0.096	11.276	6.591	0	0
RE_IE_Q20_2 <- IE_SCOPE1	0.782	0.857	0.777	0.856	0.049	0.037	16.117	23.357	0	0
RE_IE_Q20_2 -> IE	0.62	0.663	0.616	0.649	0.074	0.089	8.422	7.472	0	0
RE_IE_Q20_3 <- IE_SCOPE1	0.856	0.834	0.855	0.828	0.032	0.046	26.414	18.038	0	0
RE_IE_Q20_3 -> IE	0.671	0.563	0.667	0.547	0.069	0.111	9.698	5.075	0	0
RE_IE_Q20_7 <- IE_SCOPE2	0.895	0.845	0.896	0.843	0.023	0.121	38.724	6.973	0	0
RE_IE_Q20_7 -> IE	0.689	0.573	0.691	0.545	0.054	0.163	12.842	3.516	0	0
RE_IE_Q20_8 <- IE_SCOPE2	0.906	0.838	0.904	0.811	0.023	0.153	39.407	5.462	0	0
RE_IE_Q20_8 -> IE	0.705	0.417	0.706	0.387	0.06	0.183	11.791	2.275	0	0.023
RE_IE_Q20_9 <- IE_SCOPE2	0.836	0.839	0.834	0.817	0.038	0.145	21.78	5.799	0	0
RE_IE_Q20_9 -> IE	0.637	0.487	0.636	0.455	0.079	0.175	8.112	2.784	0	0.006
SECT_DIVERSITY <- SECT_Diversity	1	1	1	1	0	0				
TRUST <- TRUST	1	1	1	1	0	0				

Table 14 Measurement model evaluation. Latent constructs AVE

	Average Variance Extracted (AVE) Original (GROUP1)	Average Variance Extracted (AVE) Original (GROUP2)	Average Variance Extracted (AVE) Mean (GROUP1)	Average Variance Extracted (AVE) Mean (GROUP2)	STDEV (GROUP1)	STDEV (GROUP2)	t-Values (GROUP1)	t-Values (GROUP2)	p-Values (GROUP1)	p-Values (GROUP2)
ABS CAPACITY	1	1	1	1	0	0				
CAP_DIVERSITY										
EIGENVECTOR	1	1	1	1	0	0				
IE_QUAL	0.884	0.834	0.883	0.833	0.024	0.043	36.713	19.507	0	0
IE_SCOPE1	0.665	0.74	0.663	0.736	0.04	0.044	16.525	16.883	0	0
IE_SCOPE2	0.774	0.706	0.773	0.699	0.036	0.057	21.214	12.434	0	0
INNOVATIVENESS										
JOINT ACTION	0.79	0.733	0.788	0.724	0.034	0.056	23.348	13.171	0	0
SECT_Diversity	1	1	1	1	0	0				
TRUST	1	1	1	1	0	0				

Table 15 Measurement model evaluation. Composite reliabilities of latent constructs

	Composite Reliability Original (GROUP1)	Composite Reliability Original (GROUP2)	Composite Reliability Mean (GROUP1)	Composite Reliability Mean (GROUP2)	STDEV (GROUP1)	STDEV (GROUP2)	t-Values (GROUP1)	t-Values (GROUP2)	p-Values (GROUP1)	p-Values (GROUP2)
ABS CAPACITY	1	1	1	1	0	0				
CAP_DIVERSITY										
EIGENVECTOR	1	1	1	1	0	0				
IE_QUAL	0.958	0.938	0.957	0.936	0.01	0.019	100.255	49.897	0	0
IE_SCOPE1	0.856	0.895	0.854	0.892	0.023	0.022	37.765	40.646	0	0
IE_SCOPE2	0.911	0.878	0.91	0.872	0.017	0.034	53.166	25.832	0	0
INNOVATIVENESS										
JOINT ACTION	0.883	0.846	0.881	0.837	0.022	0.049	40.682	17.285	0	0
SECT_Diversity	1	1	1	1	0	0				
TRUST	1	1	1	1	0	0				

Table 16 Measurement model evaluation. Cronbach's Alpha of latent constructs

	Cronbach's Alpha Original (GROUP1)	Cronbach's Alpha Original (GROUP2)	Cronbach's Alpha Mean (GROUP1)	Cronbach's Alpha Mean (GROUP2)	STDEV (GROUP1)	STDEV (GROUP2)	t-Values (GROUP1)	t-Values (GROUP2)	p-Values (GROUP1)	p-Values (GROUP2)
ABS CAPACITY	1	1	1	1						
CAP_DIVERSITY										
EIGENVECTOR	1	1	1	1						
IE_QUAL	0.934	0.9	0.933	0.897	0.016	0.034	59.545	26.829	0	0
IE_SCOPE1	0.748	0.825	0.743	0.819	0.047	0.042	16.066	19.532	0	0
IE_SCOPE2	0.853	0.795	0.851	0.791	0.031	0.049	27.248	16.365	0	0
INNOVATIVENESS										
JOINT ACTION	0.738	0.636	0.733	0.621	0.053	0.101	13.913	6.274	0	0
SECT_DIVERSITY	1	1	1	1						
TRUST	1	1	1	1						

Table 17 – PLS MGA results - Structural model evaluation for 2 groups (Association Membership)

	Path Coefficients Original (GROUP1)	Path Coefficients Original (GROUP2)	Path Coefficients Mean (GROUP1)	Path Coefficients Mean (GROUP2)	STDEV (GROUP1)	STDEV (GROUP2)	t-Values (GROUP1)	t-Values (GROUP2)	p-Values (GROUP1)	p-Values (GROUP2)
ABS CAPACITY -> CAP_DIVERSITY	-0.027	0.085	-0.015	0.072	0.083	0.157	0.322	0.544	0.747	0.586
ABS CAPACITY -> INNOVATIVENESS	0.302	0.124	0.301	0.148	0.081	0.171	3.708	0.726	0	0.468
ABS CAPACITY -> SECT_Diversity	0.016	0.211	0.008	0.211	0.077	0.116	0.207	1.819	0.836	0.069
CAP_DIVERSITY -> INNOVATIVENESS	-0.012	-0.054	0.002	-0.047	0.133	0.148	0.089	0.367	0.929	0.714
CAP_DIVERSITY -> SECT_Diversity	0.163	0.364	0.181	0.374	0.136	0.098	1.199	3.719	0.231	0
CENTRALITY -> CAP_DIVERSITY	**0.522**	**0.158**	**0.464**	**0.168**	**0.197**	**0.111**	**2.651**	**1.424**	**0.008**	**0.155**
CENTRALITY -> INNOVATIVENESS	0.13	0.121	0.145	0.123	0.104	0.104	1.253	1.165	0.211	0.245
CENTRALITY -> SECT_Diversity	0.041	-0.12	0.029	-0.12	0.115	0.131	0.354	0.92	0.724	0.358
EIGENVECTOR -> CAP_DIVERSITY	-0.076	0.239	-0.059	0.23	0.093	0.166	0.823	1.44	0.411	0.15
EIGENVECTOR -> INNOVATIVENESS	0.001	-0.017	-0.019	0.008	0.114	0.162	0.01	0.105	0.992	0.917
EIGENVECTOR -> SECT_Diversity	**0.211**	**0.323**	**0.21**	**0.309**	**0.111**	**0.138**	**1.899**	**2.338**	**0.058**	**0.02**
IE -> IE_QUAL	0.726	0.792	0.715	0.793	0.086	0.085	8.436	9.323	0	0
IE -> IE_SCOPE1	0.813	0.723	0.812	0.714	0.044	0.097	18.477	7.46	0	0
IE -> IE_SCOPE2	0.771	0.595	0.773	0.578	0.058	0.172	13.201	3.465	0	0.001

IE -> JOINT ACTION	**0.716**	**0.396**	**0.721**	**0.428**	**0.06**	**0.114**	**11.93**	**3.462**	**0**	**0.001**
JOINT ACTION -> CAP_DIVERSITY	**0.223**	**0.229**	**0.213**	**0.221**	**0.086**	**0.13**	**2.592**	**1.76**	**0.01**	**0.079**
JOINT ACTION -> INNOVATIVENESS	-0.039	0.19	-0.024	0.209	0.105	0.157	0.373	1.213	0.71	0.226
JOINT ACTION -> SECT_Diversity	**0.167**	**-0.019**	**0.163**	**-0.017**	**0.1**	**0.138**	**1.669**	**0.141**	**0.096**	**0.888**
SECT_Diversity -> INNOVATIVENESS	**0.317**	**0.317**	**0.298**	**0.297**	**0.128**	**0.15**	**2.486**	**2.118**	**0.013**	**0.035**
TRUST -> IE	**0.089**	**0.367**	**0.084**	**0.409**	**0.11**	**0.119**	**0.808**	**3.077**	**0.42**	**0.002**
TRUST -> JOINT ACTION	**0.065**	**0.279**	**0.064**	**0.254**	**0.075**	**0.146**	**0.856**	**1.907**	**0.392**	**0.057**

Table 18 - PLS MGA results – Assessment of the structural model (Association Membership)

	Path Coefficients-diff (|GROUP1 - GROUP2 |)	p-Value (GROUP1 vs GROUP2)
ABS CAPACITY -> CAP_DIVERSITY	0.112	0.742
ABS CAPACITY -> INNOVATIVENESS	0.178	0.175
ABS CAPACITY -> SECT_Diversity	0.195	0.921
CAP_DIVERSITY -> INNOVATIVENESS	0.042	0.406
CAP_DIVERSITY -> SECT_Diversity	0.202	0.883
CENTRALITY -> CAP_DIVERSITY	**0.364**	**0.067**
CENTRALITY -> INNOVATIVENESS	0.01	0.48
CENTRALITY -> SECT_Diversity	0.161	0.171
EIGENVECTOR -> CAP_DIVERSITY	0.315	0.948
EIGENVECTOR -> INNOVATIVENESS	0.018	0.44
EIGENVECTOR -> SECT_Diversity	0.112	0.744
IE -> IE_QUAL	0.066	0.739
IE -> IE_SCOPE1	0.09	0.18
IE -> IE_SCOPE2	0.176	0.151
IE -> JOINT ACTION	**0.32**	**0.005**
JOINT ACTION -> CAP_DIVERSITY	0.006	0.533
JOINT ACTION -> INNOVATIVENESS	0.229	0.888
JOINT ACTION -> SECT_Diversity	0.187	0.132
SECT_Diversity -> INNOVATIVENESS	0	0.498
TRUST -> IE	0.278	0.957
TRUST -> JOINT ACTION	0.215	0.908

Appendix I

APPENDIX I

The interview guide for METS firms

Demographic questions (company's capability, size, turnover, organisational structure, years of operation in Australia, percentage of income from the resource extractive sector, tier position)

How does your business do currently? How many other sectors does company operate in? How this changed during downturn?

How the decisions about introduction of new products and services come? Do you explore new areas for application of your products and services?

What is company strategy to maintain and improve their position in the resource supply chain? What sort of relationships does your company maintain with the clients, suppliers, and competitors? What is the company experience in dealing with the resource companies and key EPC/EPCM providers? Do you collaborate? What forms of collaboration does your business participate (alliances, partnerships, joint-ventures)? Why?

What is firm strategy in terms of employing graduates, investment in Research and Development, attitudes toward innovations? Why?

Is your company a member of any of industry associations? Is there a value of being an association member? Why?

How does downturn in the resource sector impacted company's strategy and structure? What are the barriers and opportunities for your business to sustain and grow?

The interview guide for mining operators and Tier 1 service providers

Demographic questions (company's capability, size, turnover, organisational structure, years of operation in Australia, percentage of income from the resource extractive sector, tier position)

Please describe organisation of procurement strategies used by your company.

How does your company ensure engagement of local suppliers? What kind of challenges does your company experience when engaging local suppliers? Why do you think this is the case?

Does your company participate in the collaborative projects with local companies? What forms of collaboration? What was the experience? Why?

What do you think is the major problems and opportunities for local resource industry supply chains development?

Appendix J

APPENDIX J

THE SUMMARY OF COMPANIES AND ORGANISATIONS INTERVIEWED

Table 6.1 Organisations interviewed

Organisation / department interviewed	Number of Organisation/ Departments
Government departments	5 departments
Industry associations	6 industry associations
Mining Companies	2 major and 2 junior mining operators
METS providers	24 companies
Total	37

Table 6.3 METS companies interviewed

METS company	Tier	Capabilities	Size	Ownership	Designation of interviewee	Comp Age/ Year
Recruitment & Labour Hire company 1	Tier 3,4	Recruitment & Labour Hire	275/25	Pty Ltd, ASX Non-listed (Aust)	Operations Manager	1997
Education & Skills - OH&S training company 1	Tier 4	Education & Skills - OH&S training	3	Pty Ltd, ASX Non-listed (Aust)	Director	1990
Recruitment & Labour Hire company 2	Tier 4	Recruitment & Labour Hire	14	Listed on Euro NYSE (Aust)	Director	2012
Engineering and construction company 1	Tier 1, 2	Engineering and construction	230	Trust (Aust)	Managing Director	1997
Civil Construction company 1	Tier 4	Civil Construction	4	Pty Ltd, ASX Non-listed (Aust)	Managing Director	2012
Electrical maintenance services provider	Tier 2,3	Engineering, Equipment/Product Supply & Hire, Electrical, electrical maintenance	15000	Pty Ltd, ASX Non-listed (Aust)	General Manager	1916
Pipe, Valve and Fitting products and services provider	Tier 1,2	Pipe, Valve and Fitting products and services provider	5000	NYSE listed (USA)	General Manager	2012
Provider of software, hardware and services for mining industry	Tier 1	Provider of software, hardware and services for the mining industry	140	Pty Ltd, ASX Non-listed (Aust)	Founder	1981
Education & Skills, Recruitment & Labour Hire services provider 3	Tier 2,3	Education & Skills, Recruitment & Labour Hire, organisational development consulting	22	Pty Ltd, ASX Non-listed (Aust)	Director Development	2001
Engineering and Manufacturing company	Tier 3,4	Manufacturing, Engineering, Technical and Consulting Services, Research and Technology Development	55	ASX listed (Aust)	Chairman	1992
EPC/EPCM provider 1	Tier 1	International provider of technical, professional, and scientific services, including engineering, architecture, construction, operations and maintenance	54000	NYSE listed (USA)	Country and Commercial Manager	1947
Business, Legal and Finance, Technical and Consulting Services provider	Tier 3,4	Provider of new business, markets, and competitive intelligence. Business, Legal and Finance, Technical and Consulting Services	3	Pty Ltd, ASX Non-listed (Aust)	Managing Director	1984
Environmental, Technical and Consulting Services provider	Tier 2	Integrated risk management and compliance company Environmental Services, Mining Services, Technical and Consulting Services	387	ASX listed (Aust)	National Resource Manager	2009

Global engineering and design services provider	Tier 1	International provider of engineering, architecture, environmental and construction services	8500	Pty Ltd, ASX Non-listed (Aust)	Business Development Principal, Major Tender Manager	1928
Resource supply chain consultancy services provider	Tier 3,4	Consulting in supply chain	1	Sole Trader (Aust)	Principal	2013
Engine and industrial air, oil and liquid filtration solutions service provider	Tier 1	International company providing engine and industrial air, oil and liquid filtration solutions		Other (USA)	National Manager	1915
Automation and control services provider	Tier 3,4	Engineering company specialising in integrated systems including industrial automation, robotics, and continuous process control.	14	Trust (Aust)	CEO	1990
Exploration and drilling services company	Tier 3,4	Exploration and drilling Services	26	Pty Ltd, ASX Non-listed (Aust)	Owner	2002
Large-size multifaceted industrial services provider	Tier 1,2	Multifaceted Industrial Services corporation	19000	ASX listed (Spain)	Business Development Manager	2003
Wireline services provider for the mining industry	Tier 2	Technical and Consulting Services	28	Trust (Aust)	Managing Director	2005
Hydraulics and pneumatics equipment and services provider	Tier 2	Hydraulics and pneumatics equipment and services	35	Pty Ltd, ASX Non-listed (Aust)	Sales Manager	1953
Business, Legal and Finance consultancy services provider	Tier 3,4	Business, Legal and Finance, Technical and Consulting Services	1	Pty Ltd, ASX Non-listed (Aust)	Principal Consultant	2015
Technical and Consulting Services to the mining industry	Tier 1,2	Technical and Consulting Services to the mining industry	169	Pty Ltd, ASX Non-listed (Aust)	General Manager, Adelaide	1983
Multifaceted engineering and design company	Tier 1,2	Multifaceted engineering and design company	100	Partnership (Aust)	Manager Industrial	1982