Australian Story - The Formation of Australian Mining Technology Services and Equipment Suppliers.

A Pilot Study for the United States Studies Centre, University of Sydney

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The Formation of Australian Mining Technology, Services and Equipment Suppliers.

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Acronyms
AusIMM Australian Institute of Mining and Metallurgy
Austmine Australian Mining Equipment, Technology and Services
Austrade Australian Trade Commission
ABARE Australian Bureau of Agricultural and Resource Economics
CAMESE Canadian Association of Mining Equipment and Services for Export
CSIRO Commonwealth Scientific and Industrial Research Organisation
GFROs Government Funded Research Organisations
ICT Information and Communications Technology
JKMRC The Julius Kruttschnitt Mineral Research Centre
MCA Minerals Council of Australia
MTEC Minerals Tertiary Education Council
MTS Mining Technology Services
MTSAA Mining Technology Services Action Agenda
NMITAB National Mining Industry Training Advisory Board
SME Small to Medium sized Enterprise
VET Vocational Education and Training
Executive Summary

This study focuses on a specific issue – the development of the mining technology, services and equipment sector in Australia. It aims to outline the recent development of the sector, to assess the significance of the sector, and to identify the major factors that promote or impede its continuing development. As it is a pilot study, some important issues are raised but not systematically assessed.

A wider perspective informs the study. The resource boom that is reshaping the Australian economy is one aspect of that perspective. Does Australia have the policy settings to avoid the ‘Dutch Disease’ and ensure that, after the resources boom, it will be better positioned for economic development? In assessing the policies that can help to ensure the economy has more options and more capabilities for an uncertain future, what might be the role the ‘demand side’ – ie of stimulating and responding to new and challenging demands for new goods and services?

Minerals are not simply economic resources with a value independent of the capabilities to identify, exploit and process them. The history of the United States and other countries show that developing those capabilities, and leveraging resource development for wider industrial development, requires strategy and investment that are not the outcome of market forces alone.

With those issues in mind, the study is motivated by two questions:

• To what extent is Australia capturing the dynamic opportunities arising from the demand-side of the resource sector growth and related investment to develop new firms and new competitive strengths?

• To what extent does the Australian business context provide a supportive environment for new venture formation and growth in this area?

Several countries, including the United States, Canada, Sweden and Finland, have leveraged resource development for industrial and technological transformation. A brief review of those histories indicates opportunities that can be pursued and signals some of the issues that need to be addressed for those opportunities to be realised. They point to the importance of capability development in industry, the role of coordination (through strategy and sectoral organisations), positive externalities and facilitating the wider processes of cluster evolution.

Rising global competition, accelerating technological change and more open markets have two unavoidable implications that are highly significant but poorly understood. First, countries need to more actively build their ‘comparative advantage’. Hence, the mechanisms through which comparative advantage is built, strengthened and renovated are of central importance to any economy. Second, new ventures play a key role in exploring areas of new opportunity and new approaches to value creation – they are the business experiments which signal profitable paths for investment. The mechanisms and capabilities that stimulate and support new venture development, particularly in innovative areas, are vital and their importance in an economy is increasing. Only some new ventures are likely to sustain
growth. To do so firms usually need to transform their capabilities and systems and enter a process of business engineering, often involving acquisitions and new product/service and market development. Understanding the factors that shape each stage of development, including the availability of finance and talent, is of great significance for the longer run. The literature relevant to these issues is vast and rich. Drawing on a range of recent studies, the report develops a basic analytical lens, and a set of specific analytical questions. These questions concern the formation and development – the evolution - of firms and the overall sector.

The mining industry is booming. It currently accounts for about 8% of GDP, at $138 billion annually more than 50% of Australia’s exports, but employs only around 200,000 people (2% of the labour force). With investment at over $50 billion per annum, and the expenditure on inputs for exploration, production, processing and transport, that level of demand is an opportunity for local and international suppliers. The issue of local content has long been contentious. The information available provides a mixed picture with possibly declining local content in major oil and gas projects but high local content in mineral projects.

The relationship between the mining industry and the Australian Mining Technology, Services and Equipment (MTSE) sector is shaped by three primary factors:

1. The mining industry is consolidating and is increasingly dominated by such global firms as Rio Tinto and BHP Billiton. This has often meant that a supply relationship in Australia becomes a global relationship.

2. As in many industries, mining companies, are outsourcing more activities, opening a diverse range of opportunities for new suppliers.

3. The business of mining is becoming more complex and knowledge-intensive. Investment by mining firms in R&D - close to $4 billion - accounts for almost 25% of total business investment in R&D.

There is a strong mining-related research base in Australia and mining firms are engaged in significant levels of research collaboration with many public sector research organisations. The growing role of IT throughout exploration and mining has led to new patterns of demand for equipment and services – types of demand not dominated by the long established global suppliers. These new patterns of demand are the most important factor stimulating the development of internationally competitive Australian MTSE suppliers. Calling mining quarrying and Australia a quarry fails to grasp the reality of mining and the opportunities it brings.

However, the combination of those three factors is a substantial challenge for the future evolution of the MTSE sector.

There is no standard specification for what constitutes the MTSE sector. One restrictive specification emphasises firms with specialist technology, while a more inclusive approach includes the many suppliers of contract mining and construction services. Based on the
narrow definition, the sector employs at least 30,000 people, has total sales of at least $9b, exports over $2.5 billion and invests at least $1 billion in R&D. The more inclusive specification identifies a sector employing over 80,000, with total sales near $30 billion and exports of at least $6 billion. The restrictive specification identifies a sector substantially larger and with much more international activity than the wine industry. From the inclusive specification the sector is substantially larger, much more export active, growing more rapidly and almost certainly more prospective than the heavily subsidised automotive sector.

Most MTSE firms were formed by entrepreneurs from the mining industry or their suppliers. They typically began and developed through close interaction with the mining firms, often around problem solving. Spin-offs from research organisations, venture capital-backed start ups, and innovation supported by government grants have played a minor role in the development of the sector. Many of the leading firms in the sector are internationalising rapidly, through exports and particularly through opening offshore offices and subsidiaries – often at an early stage in their life.

Sustaining growth as customer expectations rise and internationalisation increases is a challenge for many MTSE firms. There are signs that consolidation is underway in the sector. Some Australian firms have acquired local and international firms (often with support from private equity investors) and some leading Australian firms have been acquired by offshore firms. More MTSE firms are transforming from the early entrepreneurial stage to a greater emphasis on professional staff and business systems. Many MTSE firms are also deepening their investment in capability development, often collaborating with mining firms. Some of the leading MTSE firms also collaborate with universities and to a lesser extent, CSIRO.

The Mining Technology, Services and Equipment (MTSE) sector is a significant ‘new’ sector of Australian industry, developed largely by entrepreneurs with engineering or technical training and prior experience in the mining or closely related industries. Many Australian MTSE firms are global leaders in their niche.

The emergence and growth of the MTSE sector arose from the combination of the challenges faced by mining companies and the capabilities of Australian firms to develop solutions to those challenges. In particular Australian firms have been at the forefront of the applications of IT to almost all aspects of mining. Through pioneering this new frontier of innovation they have been able to develop global competitive strengths.

Today the MTSE sector is at a key stage of evolution. Many firms, including relatively small firms, are internationalising rapidly, through exports and particularly through opening offshore offices. At the same time many firms are transforming their strategies, structures and organisational arrangements to support growth. A greater awareness of the strengths and performance of the sector would assist firms in attracting investment.

While a vigorous process of entrepreneurship has developed a diverse population of MTSE firms there is little evidence that the public policies designed to support new venture formation or the formal ‘commercialisation’ infrastructure, have significantly assisted.
Moreover, the growth and development of firms has been constrained by difficulties in attracting capital and by shortages of high level personnel, including engineers, managers, and IT and marketing professionals.

This pilot assessment suggests that the research infrastructure related to mining has not been designed, or evolved to support the development of the MTSE sector.

The development of the MTSE sector demonstrates the significance of harnessing the ‘demand side’ for industry and technology development in Australia. In particular it clearly shows the importance of discontinuities in the knowledge base as a basis for new paths of value creation and entrepreneurship. The MTSE case also reminds us that it is competence and entrepreneurship in industry that is essential and which cannot be substituted by high level capability in research organisations. This is a challenging area for policy, particularly as an emerging sector is likely to be populated by small firms, but it appears there is a lack of policy and support mechanisms to address this challenge.
Introduction The Resources boom and the development of Suppliers to the Mining Industry

The rapid development of the resource sector has the potential to transform Australian industry – positively or negatively. Mining exports in the year to mid 2011 were worth over $150 billion contributing over 50% of the value of Australia’s total exports. Investment in resource projects currently exceeds $40b per annum - of which about half is in mining.\(^1\) However, direct employment in mining is only about 220,000.

Resource booms present challenges for public policy. The role of major resources projects in industry development has a long history in Australia, with particularly strong debates around the Bass Strait and North West Shelf Projects.\(^2\) One of the challenges arising from major resource booms is due to the ‘Dutch disease’. This refers to the consequences of large increases in foreign currency income due largely to resource booms.\(^3\) These consequences include: pressures on government to increase expenditure by using additional tax income for transfers to lagging industries/firms and social groups, possibly leading to structural budget problems in the future; relative price increases in the non-traded sector relative to the trade-exposed sectors, and, in particular, the possibly severe competitiveness problems for the non-resource trade-exposed sectors that arise due to a rising exchange rate and the shift of capital and labour to the resource sector. Concern about the impact of the Dutch disease on manufacturing is based on the view that:

• the loss of market share in manufactured goods markets may not be reversible;
• the loss of manufacturing may lower the longer run growth prospects for the economy, because manufacturing is assumed to be more knowledge and R&D intensive than resource sectors and to create a relatively stronger demand for highly trained personnel.

The apparent observation that many resource-based developing economies have grown more slowly than those without such natural assets has been termed the ‘resources curse’.\(^4\) Among the various explanations for the ‘resources curse’ are a number of factors that can combine to diminish the longer run development impact of the resource-based sectors. One factor, also related to the ‘Dutch Disease’, arises where little of the investment and production inputs required for the resource-based sectors are sourced from the domestic economy. The lack of ‘backward linkages’ leads to the development of technological ‘enclaves’ with few opportunities for local capability development.\(^5\) A good deal of the wider literature on the

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\(^1\) ABS (2011)
\(^3\) The term was coined in 1977 by ‘The Economist’ first used the term ‘Dutch Disease’ in 1977 in reference to the negative impact of the exploitation of the Netherlands’ natural gas resources (‘The Economist’, The Dutch disease, 26 November 1977, 82–83). See also Frankel, 2010, Heinrich, 2011; Corden & Neary, 1982; Corden, 1984; Gregory, 1976.
\(^4\) A very extensive literature discusses the occurrence and explanations for the ‘resources curse’, for example among the more recent are: Ross (1999), Frankel (2010), Hausmann and Rigobon (2002).
\(^5\) Arnold, E. et al. (2011).
‘resources curse’ concerns the causes and impacts of the frequent public policy failures: “The failure of states to take measures that could change resource abundance form a liability to an asset has become the most puzzling part of the resource curse.”

**Beyond the Resource Curse**

However, several studies of the role of natural resource exploitation in the development of countries such as the United States, Finland, Sweden and Canada bring another perspective. This is a perspective which emphasises the potential for resource-based industrial development – if the required strategies are pursued. There are two aspects to this perspective:

- First, mineral resources are not simply natural endowments. They require investment **before** they are valuable. Such investment requirements have become larger, more complex and more knowledge intensive over time. Substantial research may be required to support exploration, mine development and efficient processing: “Because extending the ‘knowledge frontier’ can extend a country’s effective resource base, it is entirely possible for resources sectors to lead an economy’s growth for extended periods of time.”

Hence, the exploitation of a country’s mineral base can develop along with economic growth and technological progress. Indeed mining is (an increasingly) knowledge intensive industry. The discovery of resources requires a range of advanced technologies and investment, as well as the regulatory regimes that encourage that investment – Australia’s overall mineral resources have been increasing, despite two centuries of mining. The efficient exploitation of a mineral resource may be dependent on new processes to enable mineral extraction in addition to investment in production and transport facilities – many ore bodies are of no economic value until innovations provide an economic means to extract the mineral. As will be discussed further in Section 3.2 the decline in ore grades, the rising cost of energy and the increasingly stringent environmental and safety regulation, are driving innovation in all aspects of mining.

- Second, mineral development can stimulate wider industrial and technological development. The United States provides a powerful example of linking mining development with broader industrial development - by 1913 the US was the leading producer of most of the major minerals of that time. Similarly, Smith suggests that the experience of Canada, Norway, Finland, Sweden, the Netherlands, New Zealand and Australia) with significant resource bases shows that the resources curse can be avoided with appropriate policy. In the cases of the US, David and Wright (1997) show

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7 Wright & Czelusta, (2002) p. 20
8 Smith, (2007)
that minerals development in the US grew in parallel with the rise to leadership in manufacturing but that the inter-industry linkages strongly supported wider industry development\(^9\). David and Wright show that in the development of the mining industry in the US, three factors were vital:

- A supportive institutional environment, particularly the legal regimes clarifying ownership;
- Public knowledge infrastructure – particularly the vital role of the US Geological Survey which provided a rich base of information to guide exploration\(^10\), and
- The development of specialised education and research centres – by 1890 the US had 20 universities granting degrees in mining, some of which were the leading international centres of research and education in mining – and the problem solving and innovation that supported exploration, mining and processing.

More generally they argue that the development of a competitive mining industry involves a learning process at all levels, which leads to the development of technologies, capabilities, research and education organisations, knowledge (some of which is highly location-specific) of the paths for profitable investment, appropriate regulations etc\(^11\):

“..what matters most for resource-based development is not the inherent character of the resources, but the nature of the learning process through which their economic potential is achieved.”\(^12\)

These evolutionary processes are at the core of cluster development – discussed further in Section 2.2.

**Policy Foundations**

The opportunities arising from resource development are more likely to be captured, and the risks of the serious market failures due to the ‘Dutch disease’ are much more likely to be minimised, through a coherent strategy. While the policy priorities and mechanisms will vary with the context of place and time, a coherent strategy will include three broad dimensions\(^13\):

- Policies for upgrading capabilities in the resource sectors through investment in research, education and entrepreneurship.

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\(^9\) Cited in Wright & Czelusta (2002).
\(^10\) For an analysis of the role of public and sectoral infrastructure and institutions for minerals exploration in Australia see Scott-Kemmis et al. (2006). See also Connolly E and Lewis C (2010).
\(^11\) Most countries that suffer from the ‘resource curse’ are those that fail to ‘learn’, in the sense used here – i.e. they fail to develop the institutions, organisations, capabilities and technologies required.
\(^12\) Cited in Wright & Czelusta (2002). p.3
\(^13\) Smith (2007); Arnold et al (2011); Wright & Czelusta (2002). It is useful here to be reminded of the point made by West in his critique of the theory of comparative advantage: “..no nation has developed by applying the theory of comparative advantage, and they are aware that in the most important industries advantage is deliberately created.” West, J. (2010)
• Promoting the development through upstream (supply) and downstream (processing) industries.

• Investing in the overall national knowledge infrastructure to support innovation, productivity increase and new venture formation throughout the economy – the knowledge infrastructure here includes education and training, management capability, competencies in industry to innovate and implement new technologies and strategies, and hence may not involve major investment in public sector R&D.

Research Objectives and Focus

This study is motivated by two broad questions:

• To what extent is Australia capturing the dynamic opportunities arising from the demand-side of the resource sector growth and related investment to develop new firms and new competitive strengths?

• To what extent does the Australian business context provide a supportive environment for new venture formation and growth in this area – specifically, how do the characteristics of the entrepreneurship and innovation ‘ecology’ in Australia compare with those in the dynamic milieux of such regions in the United States as Silicon Valley and San Diego?

The study is a targeted scoping study, aiming to develop a sound overview of the sector and of new venture development, and to characterise the key features of new venture formation in the sector. Specifically, this scoping study aims to:

• Build a database of new ventures in the target areas.

• Develop a robust characterisation of the population of new ventures – segments, size, age, location, products/services, ownership structure and governance in the sector.

• Identify the key literature and studies relevant to the role of the business context in supporting or hindering the formation and development of new ventures in this sector in Australia.

• Locate the study in conceptual frameworks, through a selective review of relevant literature.

• Develop the methods appropriate for analysing the evolution of firms and of communities of firms and their supporting infrastructure in Australia.

• Identify the industry segments (eg equipment, services, software) in which new ventures have formed, grown and developed exports and international operations.

• Develop a well informed understanding of the formation and growth of firms and communities of firms through a combination of case studies, interviews with industry experts and selective surveys.

• Assess the main factors that promote and inhibit venture formation and development, based on the assessment of a sample of new ventures formed over the past 20 years.
Organisation of the Report

This report is organised in six sections:

Section 2 discusses the conceptual frameworks and prior studies which have been used to guide the approach and focus of the research. One area of relevant research concerns the development of upstream linkages between the users of equipment and services (and other inputs) and their suppliers. Work in this area has now largely been incorporated into the rich stream of studies on the development of industry clusters where the evolution over time of linkages and capabilities are studied. The second area of research on which the study draws concerns the formation and growth of new firms and industries. There is increasing awareness that as trade protection declines, new market opportunities grow and the pace of innovation increases, the capacity of an economy to support the formation and rapid growth of new ventures becomes more important. This section concludes with a summary of the specific issues to be pursued in the study.

Section 3 outlines the characteristics of the mining industry in Australia. It also discusses the changing patterns of demand for goods and services by the mining industry and the implications of those patterns for the Mining Technology, Services and Equipment (MTSE) sector. It notes the periodic concern about the ‘local content’ of resource projects.

Section 4 provides an overview of the Australian MTSE sector. It discusses the major segments of the sector and characteristics in terms of firm size, growth, export activity and investment in R&D.

Section 5 focuses on the key issues for analysis. It draws on a range of prior studies and original enquiry to assess the characteristics of new firm formation, growth and development. The discussion then moves to higher aggregations at the sector and ‘cluster’ level, and assembles some evidence for the level of development – drawing to some extent on comparisons with other countries.

The concluding section returns to the framing issues and assesses the evidence for whether:

- the Australian business context supports the formation and development of MTSE firms?
- the dynamic opportunities from resource sector growth are being captured to develop new firms and new competitive strengths?

2. Developing New Capabilities, Firms and Industries: Frameworks for Analysis

This section draws on a range of studies to develop the frameworks which shape the approach to this study. As noted above we are concerned with two specific issues and this section is organised around an exploration of the conceptual frameworks to address them. We introduce these themes before a more detailed discussion of each of them.
• **Harnessing the demand side for industry and capability development.**  
  The role of demand in innovation and new venture development has been increasingly recognised (for example, von Hippel\(^{14}\)). Demanding users who create early markets for innovative suppliers, and often contribute to innovation activities, have been shown to have been vital for the dynamism of clusters (eg in the work of Porter\(^{15}\)) and of highly entrepreneurial regions (for example in the work of Saxenian\(^{16}\)). The role of the military and other leading users in the development of the IT industry in the US and Israel is well known, if not systematically analysed (for example by Lerner\(^ {17}\) and Connell\(^ {18}\)). The role of the offshore oil industry for industry development in the UK and particularly Norway is also well recognised\(^ {19}\). Recently, awareness of the significance of the demand-side has influenced environmental policy. Almost all developed countries aim to harness environmental policy to industry development, specifically by encouraging the formation of firms to provide, for example renewable energy technologies, low emission engines, new battery technologies, recycled products, etc.

• **New venture formation and growth.**  
  Entrepreneurship and new venture development are vital for economic growth. Change in the demand and supply of new products, services and technologies, and in the use of new business models, is more rapid. As many of these changes involve high level of novelty and lead to new inter-firm and inter-industry relationships they are also more disruptive. A new venture is a business experiment. These experiments are at the core of dynamic economies. Consequently, the level and quality of those capabilities, activities and organisations that support the formation and growth of new ventures – which could be termed the ‘new venture development system’ – are of vital interest at the regional, sectoral and national level. While understanding of what constitutes a dynamic new venture development system remains limited, deepening this understanding is the focus of a good deal of current analysis.

2.1 **Demand Side Drivers– Backward Linkages and Clusters**

Many development economists who have emphasised the risks of a resource curse point to a lack of local linkages as one reason why resource booms may contribute little to local development. Where foreign investment is used largely for imported equipment and services and most profit is repatriated, few linkages develop (Ross, 1999).

Several studies have charted the evolution of upstream supply industries in response to the (increasingly sophisticated) demand from resource-based industries and from downstream

\(^{14}\) Von Hippel, E (1988)  
\(^{16}\) Saxenian, A. (2007, 1996)  
\(^{19}\) Arnold, et al (2011)
resource processing industries. A well known example is the forest-based sector in Finland where the evolution of the industry proceeded from producing lumber through to a diverse range of milled wood, pulp, paper, and furniture, and specialised inputs and diverse goods, as shown in Figure 1. This evolution increasingly drives, and its survival is dependent on, a deepening and diverse knowledge base and the organisations which acquire and diffuse knowledge and develop human resources – Figure 2.

**Figure 1: Development of the Forest Industry and Linkages in Finland**

![Graph showing the development of the forest industry in Finland](image)


Many countries, both developed and developing, have sought to link capability and industry development to major investment in resource projects. Several researchers have sought to identify the factors that shape the effectiveness of measures to harness resource investment for local industry development. The factors identified in a number of recent studies are summarised in Table 1
Figure 2: Development of Backward Linkages in the Finnish Forestry Industry

Table 1: Main Determinants for the Development of Domestic Technology suppliers

<table>
<thead>
<tr>
<th>Industry-Level</th>
<th>Supplier Firm Level</th>
<th>Industry and Institutional Context</th>
<th>Industrial Policy Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Competitiveness/Competence (position of established global producers, production and operations,)</td>
<td>Industrial context Financial and regulatory barriers to firm formation, inter-firm collaboration and division of labour</td>
<td>SMEs (innovation, venture and start-up capital, export promotion, training, technology and information transfer)</td>
</tr>
<tr>
<td>Demand (size, growth, diversification, novelty, the cumulative effect of other domestic demanding industries, the scale and technology-level required, the age and maturity of technologies worldwide and the distance to potential international suppliers) Customer behaviour and policies for collaboration</td>
<td>Level of technological interdependence or systemic links.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure (high concentration and instability have a negative influence on cooperation – rivalry favours innovation and bargaining power of technology suppliers, relationships/division of labour between large and smaller firms)</td>
<td>Entry strategy (acting on the competitive factors, capable entrepreneurs strategic management and cooperation), Mentoring Entry from suppliers to other industries, ‘spin offs’ from users, spin offs from suppliers, spin offs from research organisations Capability to attract risk</td>
<td>Industry organisations that support networking and policy lobbying</td>
<td>Linkages (territorial promotion, information transfer, coordination, local content requirements, linking dynamic sector with strategic but less dynamic ones, tax incentives, encouraging the institutional role of large buyer firms)</td>
</tr>
</tbody>
</table>
The Formation of Australian Mining Technology Services and Equipment Suppliers.

capital, development of customer relationships, role of networks

Geographical concentration (influences through transport costs, technological spill-overs, labor pooling, cooperation, trust, low risk and transaction costs, high specialisation, institutional role of buyers, and internationalisation, local external economies and development of shared culture

Growth Strategy
Entrepreneurial intentions
Dynamic capabilities research and development, absorptive capacity, management, financial factors, marketing and sales

Knowledge Infrastructure
Research organisations
Education and training organisations

Industry development support (credit subsidies, tax concessions, investment in infrastructure, building capabilities, coordination of activities and investments, public procurement financing of R&D, and technology support)

Developed from: Fuchslocher (2007); Fuchslocher (2010); Maloney (2002); Stevens (2003).

Clusters and Regions as the Context for New Venture Formation

The concept of cluster development is similar to that of backward linkages discussed above but takes into account a wider range of interactions (demand, competition, collaboration) and actors (firms, complementary goods and service providers, industry associations, government, research and education organisations, etc). Value creation from mineral resources involves at least three stages: exploration; exploitation and processing, and each of these stages includes the provision of capital, equipment, services (including financial, training and research services), technology, and some forms of infrastructure. The overall value creation from mineral resources will depend, in part, on the extent to which these stages, and the provision of inputs to each, are developed and sourced locally.

However, the key factor in cluster development involves far more than import substitution and local sourcing. It requires the development of positive feedbacks and increasing returns which drive an endogeneous process of capability deepening and upgrading among most actors linked through market and non-market relationships.

It is clear that resource industry development has leveraged wider industry development in several (now) advanced economies:

“.. in Sweden, Finland, the United States, Canada, and to a certain extent Australia, the natural resource sector evolved from a position of low ... to one characterized by highly-skilled, knowledge intensive and export-oriented activities. Such a growth strategy was based [on] increasing the domestic value added associated with such
natural resources by prompting the development of those activities which naturally tend to ‘cluster’ around resource-based processing and extraction industries. These included industries supplying critical ‘side stream’ inputs (such as capital equipment, consulting services, and consumables), and activities engaged in the further processing .. of the outputs (‘downstream’ industries). Clustering not only enhanced the productivity of the workforce, but also resulted in increased income distribution in the local population and rapid economic growth. More significantly, it prompted a shift to a more dynamic and sustainable growth trajectory.’’  

The recent improvement in the terms of trade for mineral commodities has stimulated renewed interest in the development of mining-related clusters and a good deal of research is underway in several countries (particularly Canada and Chile) and regions (including Africa and South America).  

Perhaps the first mining-based cluster was that in the Gulf of Bothnia and including firms from Sweden and Finland. The Bothnian Mining Cluster has been the context for the development of several of what are now leading global supplier firms, as shown in Table 2.

**Table 2. Bothnian Mining Cluster**

<table>
<thead>
<tr>
<th>Suppliers for Mining</th>
<th>Segment</th>
<th>Swedish</th>
<th>Finnish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td>Hagby, Craelis, Flexit</td>
<td>SMOY, Kati</td>
<td></td>
</tr>
<tr>
<td>Mine Structures</td>
<td>ABB, Alimak, Indau, Jama</td>
<td>Sandvik, Wartsila, Ahlstrom, Robit</td>
<td></td>
</tr>
<tr>
<td>Drilling</td>
<td>Wassara, Atlas Copco, Tamrock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blasting</td>
<td>Dyno Nobel, Kimit</td>
<td>Normet, Kemira</td>
<td></td>
</tr>
<tr>
<td>Loading</td>
<td>Sandvik</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hauling</td>
<td>Tora, Volvo</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Suppliers for Processing**

<table>
<thead>
<tr>
<th>Segment</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral preparation</td>
<td>Metso, Sandvik</td>
<td></td>
</tr>
<tr>
<td>Physical separation</td>
<td>ITT Flygt, Grindex, Alvenius</td>
<td>Outotec, Metso, Tamfelt</td>
</tr>
<tr>
<td>Chemical Separation</td>
<td>Outotec, Kemira</td>
<td></td>
</tr>
</tbody>
</table>


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22 Noras, P. (2009)
Figure 3: Development of Backward Linkages in the Finnish Base Metal Industry (TEKES)

Source: Noras, 2009

An assessment of the evolution of the Bothnian Mining Cluster has provided the basis for ‘suggestions on the formula or necessary conditions for cluster creation’ in other countries.23

- Macroeconomic equilibrium;
- Trade openness;
- Industry policy supporting business growth and investment with strong support for education and innovation;
- Development of ‘cluster’ strategies at the sectoral and whole of government level;
- Strong national innovation system with a long term strategy for relevant capability development;
- Networking among individuals;
- Critical mass;
- Whole of value chain approach and encouraging growth and diversification to supply other industries;
- Marketing support for small firms;
- R&D projects with the sectors technology leaders.

Similarly, Ritter has explored the development of the mineral cluster in Canada, particularly in North Ontario, and detailed the evolutionary development of an increasingly diverse range of upstream and downstream industries, linked to mining – as shown in Table 3.

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### Table 3. Activities Linked to Mining: The “ Mineral Cluster in Canada”

<table>
<thead>
<tr>
<th>A. Mineral Machinery, Equipment and “Consumables”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exploration:</strong> Drill rigs, drill steel and bits;</td>
</tr>
<tr>
<td>Aerial exploration equipment;</td>
</tr>
<tr>
<td>Exploration instrumentation;</td>
</tr>
<tr>
<td>Instruments and equipment for laboratories</td>
</tr>
<tr>
<td><strong>Mine Development:</strong></td>
</tr>
<tr>
<td>Construction materials, for mining, processing, personnel and related activities;</td>
</tr>
<tr>
<td>Infrastructure and related building materials and equipment;</td>
</tr>
<tr>
<td><strong>Underground Mining:</strong></td>
</tr>
<tr>
<td>Drill rigs, steel, and bits;</td>
</tr>
<tr>
<td>Explosives and blasting equipment;</td>
</tr>
<tr>
<td>Continuous mining equipment and conveyor systems;</td>
</tr>
<tr>
<td>Shaft sinking and tunnelling equipment;</td>
</tr>
<tr>
<td>“Shaft furniture” and Hoisting Equipment;</td>
</tr>
<tr>
<td>Underground transport systems, rail or wheel;</td>
</tr>
<tr>
<td>Equipment for ventilation, electricity, water-removal;</td>
</tr>
<tr>
<td>Mining instrumentation</td>
</tr>
<tr>
<td><strong>Open Pit Mining:</strong></td>
</tr>
<tr>
<td>Drill rigs, bits and steel;</td>
</tr>
<tr>
<td>Explosives and blasting equipment;</td>
</tr>
<tr>
<td>Excavators and front-end loaders;</td>
</tr>
<tr>
<td>Off-road trucks and “wheel loaders;”</td>
</tr>
<tr>
<td><strong>Concentrating, Smelting, and Refining Equipment:</strong></td>
</tr>
<tr>
<td>Bulk Handling Equipment;</td>
</tr>
<tr>
<td>Environmental and Safety Equipment;</td>
</tr>
<tr>
<td>Personnel Equipment;</td>
</tr>
<tr>
<td>Specialized Transportation Equipment, for Road and Rail.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Mineral Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exploration Services:</strong></td>
</tr>
<tr>
<td>Aerial essaying, remote sensing, and cartographic services;</td>
</tr>
<tr>
<td><strong>Analytical Laboratories,</strong> geophysical and chemical analysis;</td>
</tr>
<tr>
<td><strong>Consultant Services:</strong> geological, exploration, mining, processing, management, financial, environmental; accounting;</td>
</tr>
<tr>
<td><strong>Mine-Site Construction;</strong></td>
</tr>
<tr>
<td><strong>Contract Mining and Drilling Services;</strong></td>
</tr>
<tr>
<td><strong>Maintenance and Repairs;</strong></td>
</tr>
<tr>
<td><strong>Communication Equipment, Underground and Surface;</strong></td>
</tr>
<tr>
<td><strong>Transportation,</strong> for mineral ore, concentrate, machinery, and inputs;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Other Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research:</strong> Geological, Exploration, Mining Systems and Processing;</td>
</tr>
<tr>
<td><strong>Aviation Services:</strong> For personnel, at mine-site and for fly-in: fly out mining</td>
</tr>
<tr>
<td><strong>Education</strong> of specialized personnel: Universities, Colleges, Trades training;</td>
</tr>
<tr>
<td><strong>Financial Services,</strong> including the stock exchanges</td>
</tr>
<tr>
<td><strong>Specialized Mineral Cluster Press;</strong></td>
</tr>
<tr>
<td><strong>Legal Services</strong></td>
</tr>
<tr>
<td><strong>Marketing and Export Consultants</strong></td>
</tr>
</tbody>
</table>

Source: Ritter, 2000

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The major MTSE ‘cluster’ in Canada is in North Ontario. The formation of this sector was stimulated by the downsizing of the mining industry in the region in the 1980s. The termination of employment of a skilled and professional labour force along with an increase in outsourcing led to the formation of many small firms. The Sudbury and Area Mining Supply and Service Association (SAMSAA) facilitates links between the many SMEs, as does the Ontario Mining Industry Cluster Council (OMICC). Technology development is supported by the Northern Centre for Advanced Technology (NORCAT), the Centre for Excellence I Mining Innovation (CEMI) and the Mining Innovation, Rehabilitation and Applied Research Corporation (MIRARCO). At the Laurentian university there were thirteen mining-related research institutes or centres and five research chairs related to mining by 2004 (Robinson, 2004).

A study of the formation of MTSE firms in the Sudbury area found that most had been formed since the mid 1980s. Network linkages among the MTSE firms were largely customers, and associations with research institutions rather than direct contact. The key factors in locating in the Sudbury area of Ontario were, in order:

1. Presence of key suppliers and/or customers?
2. Physical transport, communication infrastructures?
3. Supply of workers with particular skills?
4. Specialized research institutions and universities?
5. Specialized training or educational institutions?

A recent study for the Ontario North Economic Development found that the sector:

- includes about 500 firms and organisations with at least 50% of their business from supplying the mining industry;
- had 2010 sales of C$5.6b and employs about 23,000; and
- was overwhelmingly domestic market focused (81% of sales) and most firms were dependent on one or two customers for the majority of their business.

The study surveyed about 150 firms and organisations in the sector, and on this basis concluded that the sector needed to grow through diversifying markets and products. In particular the study identified a growing demand for ‘integrated mining solutions’, rather than ‘merely parts and equipment’, and for this reason that a sector growth strategy also required an innovation strategy, including a substantial increase in the investment in R&D. The study proposed a more active role by government and more collective action by the sector, to ‘raise awareness of sector capabilities’ and support marketing, through industry organisations.

More recently there has been significant development of a mining technology ‘cluster’ in Chile, particularly around Antofagasta. A study in 2003 found strong evidence of enterprise development, growing local content and some exports. But the study concluded that further

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26 Doyletech, (2010)
capability deepening was impeded by the small size of most firms, the lack of vision at the sectoral and government level and a passive role by universities. A more recent assessment of mining-related cluster development in Chile suggested that the level of government focus on mining supplier development had increased, as had the support for innovation. This assessment also found that the development of the sector had progressed with some suppliers beginning to diversify into supplying other industry markets as well as export more widely.

Frameworks for Cluster Development

One influential approach to general industry cluster development is that of Michael Porter (1990, 1998) and colleagues who emphasise the role of four cluster dimensions:

- **Demand** – particularly whether that demand is specialised, unusual or ‘leading’, in that it anticipates patterns of demand that will be more widespread in the future;
- **Input factors** – The availability of high quality inputs of eg capital, labour, natural resources, infrastructure, knowledge;
- **Complementary and supporting industries and organisations** – which provide goods and services (including research and education) to different stages of the value chain;
- **Competition and rivalry in the core sector** – which drives competition and the ongoing search for sources of improved performance;

However, the analysis which informed Porter’s cluster framework was based on clusters formed largely before the era of more open markets and the growing internationalisation of trade, investment and innovation. This raises the question of the extent to which the processes of cluster formation and evolution will operate in more open markets where an increasing proportion of goods, services, investment and knowledge flows are dispersed globally. It also raises the related question of whether the strong emphasis in the cluster literature on the role of geographical concentration will remain as relevant. While these issues remain open, recent research on clusters in Canada (an economy with many similarities to Australia), among other recent cluster-related research, does emphasise two points:

- Geographical proximity remains important for the development of cooperation, where trust is often vital, and for effective knowledge diffusion, where direct and close interaction is vital for the transfer of tacit knowledge;
- However an increasing proportion of input-output flows (trade, investment and knowledge) in a cluster can be geographically dispersed as long as key factor (often

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28 Cereceda, (2008)
the local pool of talent) shaping the dynamics of linkage and upgrading anchors the cluster to a location (Malmberg & Power, 2006; Wolfe, 2008).

Chance events can trigger the beginnings of these processes of accumulation, but the initial conditions must be favourable. A not uncommon such chance event has been the failure of a large anchor firm, liberating the managers and engineers they have brought to a location and spawning a high level of necessity-driven entrepreneurship – see the history of clusters in Ottawa and Calgary in Wolfe (2008). As a cluster develops the formation of a deeper local knowledge pool, the building of links with research and skill development organisations, the establishment of proven markets, technologies and business models and the formation of networks and sectoral and regional organisations, all contribute to ‘external economies’ which benefit all firms. These external economies lower the costs and risks of venture formation and innovation, encouraging further entrepreneurship and investment.

Drawing on an extensive research project, that involved detailed case studies of 26 diverse clusters in Canada, and on a review of prior cluster research, Wolfe (2008) identified six factors that shape the emergence and evolution of clusters:

3. **Entrepreneurship and Management**
   Through business experiments which explore areas of market, resource and technological opportunity, and through establishing new business models, entrepreneurs open new paths of profitable investment. Other entrepreneurs who replicate and extend these directions deepen and widen the cluster, extending the dynamic to further input sectors and new markets. These processes are central to the emergence of evolution of clusters. Novice entrepreneurs often benefit greatly from the support of other entrepreneurs and networking contributes to that interaction (Wolfe, 2008). In robust, knowledge-based cluster a high proportion of founding entrepreneurs of high growth firms come from existing firms, particularly innovative established firms or previous start-ups, ie many entrepreneurs build capability through forms of mentoring/apprenticeship/exemplars (Casper, 2007; Casper & Murray, 2004; Garnsey, 1998). At a later stage of evolution of a cluster management competency is vital to develop sophisticated business systems, strengthen the competitiveness of firms, manage growth and diversification and enter new markets. A lack of supply of professional managers can constrain the growth of clusters.

4. **Sectoral Knowledge Bases**
   One clear finding from the Canadian studies was that the processes of cluster formation and development have strong sectoral characteristics. Those sectoral characteristics are related to the sources of knowledge and the nature of innovation and capability development in sectors. In particular, many researchers distinguish between ‘analytical’ knowledge bases, such as those used by science-based industries working at the frontier of new knowledge, and ‘synthetic’ knowledge bases, such as those used by engineering sectors, where innovation typically involves the application and recombination of existing knowledge (Malerba, 2005; Asheim & Gertler, 2005).
5. **Geographical Proximity**
Most cluster analysis has focussed on clusters with a high level of geographical concentration and as a result there is a strong overlap between cluster studies and the fields of regional innovation systems and economic geography.

6. **Research Infrastructure**
The Canadian studies found no examples, outside of the few science-based sectors like biotechnology, of direct ‘seeding’ of cluster formation through spin-offs from research organisations. The presence of universities sometimes had a role in developing and attracting talent or major firms to a region. The contributions of research organisations to problem solving research, responding to rather than leading local demand, was often a contributor to the momentum of development. On the basis of these Canadian studies Wolfe (2008) concluded that the emphasis on universities and research organisations as leaders of cluster formation is misplaced.

7. **Talent**
The role of a pool of capable human resources with relevant types and levels of knowledge has long been recognised in cluster studies. The Canadian studies found that the talent base of knowledge workers was one of the most important factors in cluster formation and development, and a factor that can be shaped by public policy. Wolfe (2008, p20 concludes: “...policies which contribute to the development of a deep pool of highly skilled talent are ultimately the ones with the greatest long-term potential for cluster promotion.”

8. **Sectoral and Cluster Organisations and Institutions, and Social Networks**
Firms located within geographical clusters tend to have higher innovation, growth and survival performance than ventures not in clusters. [Gilbert, et al, 2008]. But the emergence of new ‘clusters’ involves institutional innovation, and hence experiment and learning, to develop policies and organisations that are effective in specific national and regional contexts (Saxenian, 2007; Feldman et al, 2005; Lester, 2003; Thornton and Flynn, 2003; Casper and Kettler, 2000; Haeussler, 2010; OECD, 2010).

The early stages of cluster development often involve the formation of sectoral or regional organisations that foster inter-firm or industry-research networking and collaboration. Such organisations, typically industry-led also provide a mechanism for coordinated action to shape public policy at a regional or wider level. This can be vital when regulatory barriers to growth arise or when new public investments in infrastructure, research or education are required to support a higher level of performance. Social capital based on inter-personal networks and shared values and perspectives is often seen as an important element of cluster development (Wolfe & Nelles, 2008). These networks can function within industries, but also between many different components of a cluster (leaders from different industry sectors and from public sector organisations) in a region. Based on the Canadian case studies, Wolfe (2008, p.28) concludes: “Many of 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.”

The Canadian studies also found that the dynamics of clustering processes and the priorities for public policy interventions varied with the stage of life of a cluster. Four stages were characterised, as set out in Table 2.

Table 4: Cluster Life Cycle Stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>Key processes</th>
<th>Coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent</td>
<td>Development of key resources, strong foundation of human resources, market or knowledge-based opportunity</td>
<td>Loose networks and informal coordination</td>
</tr>
<tr>
<td>Developing</td>
<td>Entrepreneurship, Growing specialisation in research and education, Finance and the ‘buzz’ from exemplars and information support new ventures</td>
<td>Linkages &amp; collaboration, Development of sectoral, cluster/regional organisations</td>
</tr>
<tr>
<td>Established</td>
<td>Investment attraction, growth in firm size and sophistication, Diversifying entrepreneurship, Established firms the incubators for new ventures, Strengthening positive feedbacks</td>
<td>Growing role of cross sectoral organisation to address shared interests.</td>
</tr>
<tr>
<td>Transforming</td>
<td>Investment, entrepreneurship, exploration of new directions, role of business angels and VC, Established firms, organisations and research/ education organisations as platforms for initiatives</td>
<td>New leadership to support new organisational and policy directions</td>
</tr>
</tbody>
</table>

Source: Based on Wolfe, 2008.

One of the conclusions of the several studies of the development of mining-related clusters is the importance of institutions that enable cooperation across industries, between industry and government and between industry and education and research organisations:

“One of the reasons for the successful [resource-based industrialisation] process in Sweden, Finland, Canada and the United States was that development occurred
within a context of commitment and cooperation at the national and local level, which proved an essential ingredient in ensuring the sustainability of the ‘virtuous cycle of innovation’ in the final stages of ... Moreover, cooperation between the public and the private sectors in the shaping of national science, technology and innovation policy has provided a foundation for a committed and coordinated approach to the long-term development of knowledge and skills in these countries.”

This brief discussion raises several issues to consider in the following survey of the development of mining technology, services and equipment suppliers in Australia. In particular, to what extent:

- does the wide geographical dispersion of mining activity in Australia limit the formation of clusters, or perhaps lead to smaller nodes in some areas;
- have strong links and mechanisms of coordination developed between supplier firms and the education and research sectors;
- does the overall shortage of skills limit the supply of talent for the development of the suppliers sector;
- have sectoral organisations and networks developed to champion and support the development of the supplier sector?

A particular challenge for detailed analysis is that much of what constitutes the real dynamism and development power of clusters is not easily ‘visible’ and certainly not reflected in available statistics - see Figure 4. In the following sector we focus on an additional issue – the role and mechanisms of new venture formation.

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2.2 Entrepreneurship Studies Perspective on New Venture Growth

Entrepreneurship and new venture development are vital for the economic health of nations and regions. This is increasingly recognised and has led to a strong interest in frameworks for more effectively promoting commercialisation and the development of regional entrepreneurship ‘systems’ and networks. In the 1980s and 1990s many countries sought to build their equivalent to Silicon Valley by emulating what were seen to be the necessary (and sufficient) pre-requisites. There have been very few successes, and none approaching the scale and significance of Silicon Valley.

Many recent studies show that success in commercialisation and industry development involves a range of evolutionary processes with strong interaction and feedback. A range of recent research has begun to focus on the dynamics of these processes and to assess the scope for policy to augment, or at least reduce the impediments to, their development. That work has led to a better understanding of the development of ‘social capital’ in sectors and regions, and also to the development of research tools to analyse these patterns.


31 van der Valk, T. & Gijsbers, G. 2010 provide a recent overview of the use of social network analysis in innovation studies. See also The Council on Competitiveness, 2006.
One approach, the regional and sectoral innovation systems perspective, has recently focused on the patterns of emergence and early evolution of clusters or sectors, through the processes of firm formation and growth and the related development of linkages. This approach has also led to the development of useful analytical tools based on the key functions or dimensions of an emergent innovation system and the factors that can enhance or impede these innovation and enterprise-related dimensions of performance. The analysis of the early stages of cluster development has also drawn on the complex adaptive systems frameworks.

For the development of clusters and sectors a focus on firm formation must be complemented by a focus on growth. Why do some new ventures grow and others don’t? Drawing on prior studies, Gilbert et al. (2006) estimate that of the 700,000 new ventures started each year in the United States, only 3.5% grow sufficiently to actually evolve into large firms. In general, firms that remain small are less likely to survive than those that grow – viability increases with age and size (Gilbert, et al., 2006).

Gilbert et al. (2006) have drawn on an extensive range of prior studies to identify the major factors that contribute to the growth of new ventures. They identify ten key factors:

• **Aspiration - Growth intentions**
  Growth is the result of intentional actions and hence a decision to grow. That decision is shaped by the goals of the entrepreneur and their perceptions of the scope to grow, the risks in doing so, and their own capacities to manage growth (Baum & Locke, 2004; Orser et al, 2000).

• **Entrepreneur Characteristics**
  Relevant prior experience, and particularly the knowledge that provides of information sources and the access to such sources through inter-personal networks, has been shown to be important for new venture growth. Such experience, whether of an individual or of a team (especially a team of diverse experience) can contribute to greater insights into opportunities and better decisions regarding strategy (Mullins, 1996; Gilbert, et al, 2006).

• **Internal Human Resources**
  The capabilities of employees are one of the vital resources for new ventures and the type of human resources required changes as the venture evolves.

• **External Human Resources**
  Access to advice and information through mentors, networks and boards of directors has also been shown to contribute to growth (Ostgaard & Birley, 1996; Lee et al, 2001).

• **Financial Resources**
  Firms with higher levels of financial capitalisation are more likely to grow.

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financial resources enable more time to develop effective strategies and to invest in measures that support growth. But firms with more innovative (growth enabling) technologies are more likely to attract capital from external sources (Bollingtoft, et al, 2003). Firms that through networks have links to banks and potential investors are also more likely to attract finance and to grow (Lee, et al, 2001).

• **Location**
Some locations provide a rich context that supports the formation of new ventures through, for example, a ready supply of capable human resources, and access to advice and risk capital (Saxenian, 1990, 1994; Porter, 1995) – ie through high levels of the factors that support firm formation, survival and growth. Firms located in clusters are also more likely to be influenced, in the decision to found a venture and the strategies adopted, by the exemplars around them.

• **Strategy**
Gilbert et al (2006) acknowledge that the research in this area is unsatisfactory and has not adequately dealt with the contingent (ie context-specific) nature of effective strategies. Nevertheless, they find strong evidence that ventures with a strong focus, a unique product or service, or differentiation through innovation and quality, but also with relevant resources to pursue such a strategy at entry and during growth (strong internal capabilities, investment in R&D, adequate capital and external alliances), showed higher levels of growth (Chandler & Hanks, 1994a, 1994b; Lee et al, 2001; Bruton & Rubanik, 2002). However, after a point an alternative or complementary strategy is that of growth through acquisition. In the case of firms pursuing this strategy, the key internal capabilities are those of ‘business engineering’ rather than technological capabilities. Whichever strategy is pursued it must be aligned with the specific resources accessible to the venture (Edelman et al., 2005, Zahra et al., 2000)

• **Industry Context**
Not surprisingly, growing and emerging markets, particularly where new niches are arising (including those due to new technological opportunities), provide more opportunities and more tolerance of strategic mistakes than slow growing markets. Where the industry life cycle is at a mature stage, with a ‘dominant design’ and many established suppliers high levels of competition, and limited scope for differentiation, the scope for new entrants to take market share is limited – unless the needs of customers change or new technologies enable significantly different approaches to the supply of goods or services. New markets, or those significantly disrupted by new needs or new technologies, will often have lower levels of direct competition and also often have lower levels of capital requirement for initial entry (Christensen & Bower 1996; Christensen & Raynor, 2003)

• **Organizational Structure and Systems**
As firms grow the division of labour and the coordination and decision making systems – typically informal systems with a leading role by the founding entrepreneurs - that
were effective in the early stages become less so. Continued growth will normally require a transformation to higher levels of functional specialisation and more formal process for planning (Kazanjian & Drazin, 1990; Ensley, et al, 2006).

- **Internal or International Market Focus**
Whereas it has long been assumed that firms (should) internationalise only after firm establishment in the domestic market, it is clearly the case that many firms pursue an internationalisation strategy either from the outset (‘born globals’) or in early stages of life. Internationalisation strategies can involve different combinations of direct exports, use of agents, joint ventures or direct investment through acquisition or greenfield investment. Firms pursuing niche or highly-focused product or service specialisation often have a higher requirement to internationalise to pursue growth without losing focus (Baum et al., 2001). The (limited) available evidence suggests that, ceteris paribus, firms which internationalise at an early stage tend to outperform domestically-focused firms in terms of return to capital, growth of overall sales, and perhaps rate of capability development. However, the design and implementation of internationalisation strategies places high demands on management and prior experience (either internally or through advisors and boards) of international business is likely to be a critical requirement (Bloodgood et al, 1996, Coviello & Munro, 1995).

This comprehensive review raises a central issue that must be incorporated in the analytical framework – the firms that grow are those that aim to grow and that upgrade their capabilities, linkages and systems. Access to capital, to talent, to growing markets and often collaborative customers, to relevant sources of research services, and to supporting linkages with other firms, contribute to – or limit - growth and upgrading.

**Networks, Mentoring and the Re-use of Learning – the Evolution of Entrepreneurial Systems**

The discussion above has shown that entrepreneurship, and particularly the formation of potentially high-growth innovative ventures, is an important function in an economy, vital for the exploration of new opportunity and the discovery of new paths of growth. As the rate of change in technologies and in markets increases the processes of new venture formation become more important, and more critical, dimension of a regional or national innovation system. There is an increasing division of labour in the new venture development process with new actors (private and public, and various hybrids) creating an increasingly complex new venture ecology or system – for example, various forms of investor (angels, early stage investors, VCs); advisors (in almost all aspects of commercialisation); incubators of various types; and providers of innovation/commercialisation services.

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The new venture development process is highly knowledge, management, service and capital-intensive and is also high risk. The quality of knowledge, management and service inputs has a major bearing on the probability of success. A clear finding from previous studies is that the performance of entrepreneurs and entrepreneurship support organisations (technology transfer organisations, incubators) generally improves through experience – i.e. there is a learning process by all involved (Casper, 2007). With the increasing extent and importance of entrepreneurship and new venture development there is a parallel development of actors and institutions (regulations, policies, networks) that collectively form the main elements of a ‘new venture development system’.

Entrepreneurship is increasingly a collaborative process drawing on ideas, support, and services etc from an array of actors (entrepreneurial teams, innovative customers, funders of various types, advisors, incubators etc). Hence, it involves a range of actors who play complementary roles. More recently many of the resources and services required to develop a new venture (e.g. research, prototype development, trials, marketing) can be accessed from partners and/or independent external service providers under different types of commercial relationship (e.g. contract or equity). There are examples of ‘virtual’ commercialisation business models, where the ‘venture’ outsources as many functions as possible for as long as possible until investment in internal resources is necessary and justified. This virtual or distributed approach enables leaner, more capital efficient, commercialisation and more effective re-use of commercialisation knowledge. Increasing specialisation, along with the higher levels of interaction made possible by ICT and the internet, has led to a greater diversity of business models and of forms of collaboration among firms. These dynamics are also leading to more experimentation with commercialisation business models, particularly ‘lean’ new venture models where almost all functions are outsourced, except strategy and coordination.

There is also a good deal of evidence that, within a region, the entrepreneurial capacity (e.g. the capacity to create enterprise capital from technological or market-based opportunity) improves through the formation and growth of organisations that support new ventures, the increasing division of labour and hence specialisation and the learning in each of these actors. In some cases positive feedbacks lead to a strong growth in entrepreneurial activity and quality. Successful clusters (in biotech and in some other fields) have been characterised by social structures built on dense networks of scientists and senior managers, by labour market mobility which facilitates innovation and reduces the career risk involved in joining a start-up, by individuals and organisations with a diverse range of skills and experience, and by a strong

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34 Shane, 2004; Carlsson & Braunerhjelm, 2002; Cooke, 2000; Haeussler, 2010; Stead, 2010.

The Formation of Australian Mining Technology Services and Equipment Suppliers.
commercial orientation with a strong turnover of firms. The networks to which new venture founders and managers are linked have a vital role in the development, growth and survival of the venture. The combination of learning, specialisation, the scale and diversity of the talent market and the generation of new knowledge, and positive feedbacks that reinforce networks, can lead to an inflexion point in the evolution of the ‘cluster’ or ‘new venture development system’ after which there is rapid growth in the rate of firm formation and the level of growth of established ventures. The dynamics of this evolution encourage and support entrepreneurship, are summarised in Figure 5.

**Figure 5: Growing Incentives and Support for New Venture Formation**

Similarly, drawing on a wide range of previous studies (including Spilling, 1996 and Van de Ven, 1993) and on their detailed study of new firm development in Colorado, Neck et al (2004) also argue that regional economic development through new venture creation involves the interaction of many factors – an ‘entrepreneurial system’. They also conclude that the development of such a system is evolutionary. Due to these increasingly systemic processes and sequencing there is a high level of path dependence and chance in the development, such that the timing of events can be decisive in determining their impact. Neck et al (2004) identify several key elements of the entrepreneurial system they studied:

- Entrepreneurial support through incubators or other support mechanisms;
- Networks to access information and advice;
- Access to financial resources, particularly investment capital;

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• Access to knowledge and human capital – through a strong local talent pool and regional universities or research organisations;
• Anchor companies - that contribute to the vitality of the technology base and talent pool;
• Culture – shared values and optimism.

2.3 Key Issues for Analysis

Based on these four conceptual foundations, and focusing in particular on the key areas of convergence across them, this pilot study will pursue the issues set out in Table 5 and in the Key Issue Map.

Figure 6: Map of Key Issues

Table 5: Key Issues for Analysis

<table>
<thead>
<tr>
<th>1. New Venture Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The background of the entrepreneurs- links to networks, prior knowledge.</td>
</tr>
<tr>
<td>• Market entry paths – the role of market demand – type of opportunity (niche or wide, equipment, services, new need; level of complexity, exploration, investment or production stage), why open to a new firm?; the role of User – access to market, barriers to supply, assistance from customer, relationship with different types of user, prior links with user.</td>
</tr>
<tr>
<td>• Resources and support for market entry - role and sources of resources for entry – knowledge, credibility, capital; role of mentors and networks; Significance of access to talent/ capable human resources; role and significance of the knowledge</td>
</tr>
</tbody>
</table>
The Formation of Australian Mining Technology Services and Equipment Suppliers.

2. New Venture Growth and Development

- Venture development and internationalisation.
- Corporate development - the role of resources in development – knowledge, talent, professional management, capital; growth strategies – professionalization, and business engineering; barriers to development; entry to new markets – internationalisation, horizontal markets, source of competitiveness.
- Capability upgrading – extent, drivers and mechanisms; the role and significance of the knowledge base, talent markets and networks – links to other firms, research organisations; levels of absorptive capacity.

3. Industry Level Development (are cluster dynamics in evidence?)

- Development of knowledge infrastructure appropriate to the development of the sector/cluster.
- The significance of geography in linkages – does it matter?
- Development of industry – research organisation, and industry-education relationships.
- Cluster development and the development of industry level organisations for the promotion of shared interest, linkages, collective learning and advocating policy development.
3 Australian Mining Industry and the Demand for Goods and Services

3.1 Characteristics of the Australian Mining Industry

There are at least 300 mining companies, 600 exploration companies and perhaps 300 mines in Australia. Mining has a major role in the Australian economy. Among developed countries mining has such a key role only in Canada and Norway. Australia holds substantial shares of world minerals production and known resource stocks – Table 6.

Table 6 Australian Mineral Resources 2009

<table>
<thead>
<tr>
<th></th>
<th>Share of world production</th>
<th>Indicative life (yrs)</th>
<th>Share of world est. resource</th>
<th>World ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black coal</td>
<td>6%</td>
<td>100</td>
<td>7%</td>
<td>5</td>
</tr>
<tr>
<td>Iron ore</td>
<td>17%</td>
<td>70</td>
<td>17%</td>
<td>2</td>
</tr>
<tr>
<td>Gold</td>
<td>9%</td>
<td>33</td>
<td>12%</td>
<td>2</td>
</tr>
<tr>
<td>Copper</td>
<td>5%</td>
<td>91</td>
<td>13%</td>
<td>2</td>
</tr>
<tr>
<td>Nickel</td>
<td>12%</td>
<td>145</td>
<td>35%</td>
<td>1</td>
</tr>
<tr>
<td>Zinc</td>
<td>11%</td>
<td>45</td>
<td>25%</td>
<td>1</td>
</tr>
<tr>
<td>Uranium</td>
<td>16%</td>
<td>125</td>
<td>46%</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Geoscience Australia

The mining industry accounted for about 5% of Australian GDP through the 1990s to 2004, rising to over 8% by 2011. In 2009-10, the value of minerals exports was $138 billion\(^{40}\). Minerals exports currently account for around half of Australia’s total exports of goods and services with coal and iron ore alone making up one third\(^{41}\). Mining investment has risen from $12 billion in 2003-04 to an estimated $56 billion in 2010-11. In 2008-9 new capital investment by the Australian mining and petroleum sector was about A$38b, of which about A$10b was for plant and equipment\(^{42}\). With increasing demand the level of investment is rising and by the end of 2010 mining industry (ie minerals sector only) planned capital investment stood at $131.2 billion\(^{43}\). Employment in the minerals industry was at almost 190,000 by the end of 2010.

Expenditure on exploration is less concentrated than investment in mine development and junior mining companies, which may sell identified resources to larger firms, account for a substantial share (in some years more than 50%) of exploration expenditure. Minerals exploration expenditure has grown strongly since 2000, with over 2008-9 due to the global financial crisis.

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\(^{40}\) Grant et al (2005); Australian Treasury (2011), 2011

\(^{41}\) Minerals Council of Australia (2011) 2011-2012 Pre-Budget Submission. MCA

\(^{42}\) Tedesco & Haseltine, 2010.

\(^{43}\) ABS (2010a)
Surprisingly, multifactor productivity (MFP) in the mining industry has declined by 24 per cent between 2000-01 and 2006-07. Assuming that the methodologies used for assessing productivity are sound, the major causes of this apparent decline appear to be the declining quality of resources and the delayed impact of investment in new mines and the expansion of existing mines.\textsuperscript{44}

Mining industry investment in R&D grew strongly through the 2005-2009 period. By 2009-10 R&D expenditure by the mining sector was $3.7b (22\% of business expenditure on R&D), a slight decline from 2008-9.\textsuperscript{45} The Australian Bureau of Statistics (ABS) surveyed 1,650 firms in the mining industry in 1998 to assess the levels of technological innovation over the previous three years. The survey showed that whereas 26\% of manufacturing firms had undertaken technological innovation over this period, 42\% of the minerals businesses had. The focus of innovation effort is on process improvement.\textsuperscript{46} This survey also sought information on the overall level of investment in innovation. The findings emphasise that R&D is a small component of such expenditure: 5\% in the case of coal mining and 8\% in the case of metal ore mining – Figure 7 – and hence that R&D expenditure is of limited value as an indicator of innovation activity in this industry.

![Figure 7 Innovation in Mining in Australia: Types of Expenditure](image)

Source: ABS (1997)

The major mining companies have long been among the largest business investors in R&D. Significantly, the growing role of minerals production in Australia and the (partial) reflection

\textsuperscript{44}Topp, et al (2008). See also ABS (2101b)
\textsuperscript{45}ABS (2010a)
\textsuperscript{46}ABS (1997)
of this in the development of research infrastructure led to Australian mining research accounting for a growing share of global mining research. This was both because of the sustained investment in Australia and the declining investment in mining research in Europe and the United States through the 1990s (Upstill & Hall, 2006). In a submission to the Productivity Commission in 2007, Rio Tinto claimed that the decisions over the location of R&D investments were driven primarily by “the existence of a critical mass of world class research facilities and researchers supporting basic science, with which we can establish strong relationships”.  

The major mining companies operating in Australia, by mineral type are shown in Figure 8 companies account for 75% of the market value of the mining companies listed on the Australian Stock Exchange (ASX): BHP Billiton Limited, Rio Tinto Limited, Newcrest Mining Limited Woodside Petroleum Limited, and Fortescue Metals Group Ltd. The first three of these are majority foreign owned. Some of the major companies operating in Australia are not listed on the ASX: Xstrata, Anglo American, Peabody and Newmont. Hence, the level of foreign ownership of the Australian mining sector is high. 

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3.2 Mining Industry Development and the MTSE Sector
The growth of the mining industry in Australia is the key driver for the development of suppliers of equipment and services. The heavy mining equipment sector is dominated by long established global suppliers, and the barriers to entry into those segments are formidable. The major international suppliers are listed in 98.

**Figure 9: International Mining Equipment Suppliers in Australia**

![Diagram showing suppliers in Australia]

Local Content
The sourcing from local suppliers of equipment and services for major resource projects has been a controversial issue for over 20 years. For example, in 1998 a House of Representatives Committee report on Australian Participation in Major Projects updated an earlier Committee report, both focused on the North West Shelf oil and gas developments. Based on information provided by Woodside, the report estimated that overall local sourcing for the North Rankin platform, the Goodwyn platform and LNG trains 1, 2 & 3, was over 70% for investment project costs and over 80% for operational costs (totally about $10b) – these levels are very similar to earlier estimates in a 1992 Allen Consulting Group report. It is not clear, however, what proportion of the ‘local sourcing’ involved equipment although supplied by a local firm was actually imported.

The Department of State Development in Western Australia compiles detailed information on the sourcing of inputs for resource projects in that state. The findings of the most recent report are summarised in Table 7 and more detailed information is in Appendix 1.

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50 WA Department of State Development (2011).
The Formation of Australian Mining Technology Services and Equipment Suppliers.

Table 7. Sourcing of Equipment and Services for Resource Projects in Western Australia

<table>
<thead>
<tr>
<th>Year and Project Type</th>
<th>Western Australia</th>
<th>Other Australian</th>
<th>Overseas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Projects</td>
<td>80</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>New Projects</td>
<td>58</td>
<td>7</td>
<td>35*</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Projects</td>
<td>86</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>New Projects</td>
<td>61</td>
<td>8</td>
<td>31*</td>
</tr>
</tbody>
</table>

Source: WA Department of State Development (2011)

*For some major projects the proportion of total investment goods and services sourced offshore exceeded 50%.

This report concluded that project managers tended to use local suppliers for design, procurement and contract management, but that the level of local sourcing overall is declining due to:

- the increasing exchange rate;
- the growing capability of East Asian suppliers;
- low cost steel sourced from China;
- particularly in the case of Chinese investors, a closer links between project equity and sourcing;
- reader access to remote WA sites due to advances in transport and communication technologies;
- globalisation of supply chains and marketing arrangements;
- the greater use of modular construction technology for major capital equipment,
- the shift to offshore suppliers for design, procurement and contract management services; and
- the growth of specialist engineering procurement and contract management companies undertaking out-sourced service provision for project proponents.

The report concludes:

“As a result, the market supplying goods and services to resource projects has become more complex and competitive. Overseas competition is beginning to occur in areas previously serviced almost entirely by local businesses, such as accommodation, catering, concrete walkways and equipment maintenance. Production and services capacity and specialisation is increasingly concentrated in a few global hubs, and Western Australia does not feature strongly in these commercial linkages. These factors have been evident for several years, but competition has intensified sharply since the global financial crisis...Changing conditions have been particularly pronounced in offshore energy projects. Local industry participation has
fallen from a peak of 72% for train 4 of Woodside’s North West Shelf project to an estimated 45% to 55% for the Pluto and Gorgon projects”

Applications by investors under the Enhanced Project By-law Scheme (EPBS) provides some information on the significance of mining resource projects in overall major new project development. The EPBS enables tariff duty concessions for capital goods for major investment projects, but requires applicants to submit a plan for Australian industry participation in the project. Since the schemes inception in 2002 the majority of applications have been from the resources sector, by value: mining (39%); gas supply (31%); resource processing (10%). The scheme was reviewed by Access Economics in 2010, who concluded that the scheme was generally effective but needed to be more flexible, better linked to other industry support schemes and more forward looking. One of the schemes with which the EPBS links is the Industry Capability Network, which is sponsored by DIISR and State Governments and has state-focused offices within a national network. ICN assists project proponents to identify possible Australian suppliers of project inputs. The ICN also manages the Supplier Access to Major Projects (SAMP) Program for DIISR.

There are four paths of entry and development for new Australian MTSE suppliers:

- **Import substitution** through demand capture supported by government policy and support to acquire technology and build capability over time.
- **Supply chain repositioning** through entry at a low level where barriers to entry are low and local factors confer some advantages followed by incrementally increasing the firms role in supply chains through raising capability via investment and acquisitions.
- **Locational advantage** due to competitive advantage of proximity, for example in the supply of environmental management, mine safety and catering services and low value add fabrication services – some of these areas can also provide points of entry to global opportunities.
- **Responding to disruption** where capability discontinuities due to new frontiers of demand open the scope for new entrants, typically based on innovations in products, services or processes.

Several aspects of mining industry development in Australia shape the opportunities for MTSE sector development:

**Consolidation and Globalisation**

There are four major international mining companies operating in Australia: BHP Billiton; Rio Tinto; Xstrata and Newcrest Mining. As illustrated in Figure 10, Mergers and acquisitions along with a widening international dispersion of exploration and mining have changed the

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52 Access Economics (2010)
structure of the mining industry. Globalisation also extends beyond mining activity to research and collaboration, which, with the emergence of major global players is also more widely dispersed and coordinated. Collaboration among several of the major mining firms led to the formation of Quadrem Supply Network in 2000 as a global e-business (B2B) platform for mining-related procurement.

Figure 10  The Global Mining Industry in 2001 and 2011

Source: Xstrata

See eg Upstill and Hall (2006).
**Costs and Complexity**

Competitive mining is becoming more challenging for a range of reasons:

- New resources are more likely to be in remote sites, buried more deeply and hence less evident from surface exploration, and hence exploration is increasingly difficult.
- The process of mining facing rising costs due to lower grade ores, greater concern with safety, rising energy costs and shortages of highly qualified staff.
- Processing technologies must also deal with lower grade ores and rising energy costs.
- Due to the location of mines and to increasing regulation water usage and environmental impacts need to be managed more effectively.

The increasing complexity of mining activities, from exploration to marketing and environmental management, is discussed by Upstill and Hall (2006). They emphasise that most innovation in mining is incremental and that more radical, step-jump, innovation can take many years to develop and implement, and involves substantial risks.²⁴

A recent survey of mining companies in North America, Latin America and the Asia Pacific confirmed the continuing emphasis on cost reduction, and found that the firms identified their most urgent challenges, in priority order, as:

- Optimizing/maximizing production effectiveness;
- Ensuring workforce safety;
- Recruiting and retaining a skilled workforce;
- Managing capital projects;
- Ensuring different departments work together; and
- Ensuring equipment operates reliably and predictably.²⁵

**Knowledge Intensity**

It appears that three trends are shaping the development of mining company – MTSE interaction:

1. The deepening knowledge-intensity of mining as the challenges of lower-grade ores, environmental and safety goals and skill shortages are addressed through innovation;
2. A higher level of outsourcing of that innovation as mining companies focus on ‘core competency’ and look to their suppliers to provide new approaches and ‘solutions’; and
3. A preference for ‘whole system integrated solutions’ so that the mining company can rely on a well established supply for a ‘wall to wall solution’ with whole of life support and upgrades.

While these trends open opportunities for new suppliers they continually raise the level of competency required for success.

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²⁴ Upstill & Hall (2006)
²⁵ Mincom Mining Executive Insights: 2011 survey – this study covered 256 companies.
The knowledge intensity of mining, from exploration, through mine development, mining, processing and site remediation, continues to deepen. While the rate of change if uneven it is clear that mining companies are increasingly looking to their major equipment suppliers to take on a more service-oriented role. This involves suppliers taking responsibility for the use of equipment, for example through maintenance and repair contracts. In some cases this trend has led to mining companies negotiating contracts to pay equipment suppliers not for availability of equipment ($/hour) but for minerals output by the equipment ($/tonne), shifting not only product support to the supplier but also the capital cost of the equipment\(^{56}\).

The challenges outlined above have led to and increasing demand for highly qualified personnel and to rising investment by mining companies in R&D. AusIMM commented:

\[\text{“In Australia we are able to increase our prospectivity through R&D and innovation that lead to better techniques and technologies for deep cover exploration, improved minerals processing techniques to render lower ore grades economic, more efficient mining methods to bring down costs, more sustainable practices to meet the conditions of the social license to operate and supporting services that increase efficiency and competitiveness.”}^{57}\]

In particular, the application of IT is now extensive and increasingly essential in Australian mines and more recently in mines throughout the world\(^{58}\). Applications of IT are increasingly diverse and systemic, and include visualisation of exploration data and mine layouts, underground communication, mine planning software, remote control, asset management, supply chain management, scheduling, automation, optimisation, and systems to support training and knowledge capture\(^{59}\).

However, a significant report in 2000 on innovation in the Australian mining industry recognised the increasing technological intensity of exploration, mining and mineral processing – particularly the growing role of IT. But the report expressed concern with the lack of private and public sector commitment to mining-related R&D, and to effective approaches to collaboration at that time:

\[\text{“..government policy needs to reflect the importance of the minerals industry within the national innovation system and has an increased role to play. This includes clear assessment of the present and future role of innovation in minerals, compared with other industries which it prioritizes and where the country does not possess such a history, research infrastructure and comparative advantage. Based on this recognition there is a need for more active promotion of longer-term research in the industry and greater coherence and cogency in its support for innovation in the minerals industry.”}^{60}\]

\(^{56}\) Gaete (2007 )  
\(^{57}\) AusIMM Submission to the National Innovation System Review. April 2008. P.5.  
\(^{58}\) Roberts (2010)  
\(^{59}\) Ovum (2003)  
\(^{60}\) Dodgson & Vandermark (2000) p. 7
The report went on to argue that ensuring the future competitiveness of the mining industry in Australia required a more pro-active approach to responding to the rising knowledge intensity:

“Australia has a comparative advantage in the minerals industry; an industry with a large and historic base. Future international comparative advantages will depend on building this base, creating what is a called an international ‘centre of technological competence’.”  

Drawing on evidence provided by a report drafted as part of the Minerals Technology Services Action Agenda process, a report to government claims that “...much of the 200 per cent increase in minerals industry productivity over the past 20 years can be directly attributed to the implementation of [mining technology services sector] innovation.”

Rio Tinto has a substantial Technology and Innovation Group, with several technology centres. Rio Tinto’s Mine of the Future strategy emphasises improved exploration, greater automation of mining, and improved recovery of more challenging deposits. The automation goals are being implemented through their Remote Operating Centre in Perth, which controls some mining operations in mines in the Pilbara. Importantly, Rio Tinto aim to develop a higher degree of collaboration with suppliers and researchers to pursue these goals, and a substantial component of that collaboration is developing in Australia – although most of the supplier links are with international firms.

3.3 Entry and Development of Australian MTSE Firms.
The mining industry in Australia has faced a range of challenges that have driven a trajectory of increasing knowledge intensity. In addressing those challenges mining companies have drawn increasingly on specialist suppliers of services and equipment. This trend to greater outsourcing has been driven by the rising complexity of the tasks and by the shortages of specialist personnel. In such a context it appears that the changing role of innovation in the mining industry has provided a range of opportunities for new Australian MTSE firms. These challenges and opportunities begin with exploration in a terrain where potential mineral resources must be found under often deep regolith. As a result of sustained efforts to address those problems a number of Australian exploration equipment and service providers have developed capabilities which now provide the basis for entry to international markets. It has been both the international activities of the major Australian-based global mining firms and the increasing international exploration by the highly entrepreneurial ‘junior’ mining companies that have facilitated international market entry by Australian MTSE firms.

Many Australian MTSE firms have been pioneers in the application of ICT in mining. In particular, the increasing and pervasive importance of IT has led to many new trajectories of innovation in specific niches in which there are not established international suppliers. A study of IT applications in mining found that:

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61 Dodgson & Vandermark (2000), p.9
“ICT providers to the mining industry are typically much smaller in employee size and revenue terms than their clients, and generally pursue niche markets with one, or a small number of, specialised ICT products. Most ICT providers to the mining sector derive all or most of their income from the mining sector, and adapt their products for clients in other industry sectors only on an ad hoc or opportunistic basis.”

It also appears that, at least in the past, the mining industry has not been attractive to the major IT companies, such as Cisco and Siemens, and hence the scope for IT-based solutions for the mining industry has been an opportunity for small specialist firms. In addition, the relatively high levels of Australian research and education in mining-related areas provides at least the potential for support of local technology development. While decisions on major investment-related equipment and services are centralised the ongoing requirements for equipment and services (eg environment, safety, mine planning and management, mine site services) is often more localised providing opportunities for less established suppliers.

4. The Australian Mining Technology, Services and Equipment (MTSE) Sector

The industries that supply the Australian mining industry are diverse, as is the mining industry and its demands. The resource development activities of the mining industry range from exploration and resource assessment through investment in production facilities, the expansion and replacement of those facilities, the ongoing operation of mines, the processing and transport of ores, to the remediation of mine sites. The major segments of the sector are:

- **Equipment manufacture and supply** – including electric, electronic equipment and heavy machinery for exploration, mining and processing.
- **Specialist technology and related service supply** – including technologies for exploration, mineral processing, mineral assessment, mine planning and management software, mine communication and safety.
- **Consulting services** – geological and geotechnical assessment, surveying, environmental management, project management.

The Australian MTSE sector is comprised of many small companies (about 40% have less than 10 employees) and only about 7% of firms have more than 300 employees. About 50% of firms had at least one tertiary qualified staff member. The knowledge intensity of the sector is

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64 Ovum (2003) p.5-6

65 Interview with Mike Folleti, MineSite Technologies, May 2011

66 The scope of the MTSE sector covered by Tedesco and Haseltine (2010) excludes: finance, legal and management companies servicing the corporate side of the minerals industry; catering and related services; transportation and infrastructure; industry associations and professional institutes; wholesale trade companies and distributors; magazines and other publications; commercially available goods and services which are not specific to the minerals industry.
indicated by the fact that shortages of engineers were seen as an important issue by one firm in two. Several surveys of the Mining Technology Services sector have been carried out by the Australian Bureau of Agricultural and Resource Economics (ABARE) and these provide a valuable information resource – Table 8.\(^{67}\)

**Table 8: Key Statistics: Mining Technology, Services and Equipment Sector**

<table>
<thead>
<tr>
<th>Performance</th>
<th>1995-6</th>
<th>2003-4</th>
<th>2008-9*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Sales A$\text{m}</td>
<td>1,240</td>
<td>4,750</td>
<td>8,710**</td>
</tr>
<tr>
<td>Export sales A$\text{m}</td>
<td>467</td>
<td>1,110</td>
<td>2,490***</td>
</tr>
<tr>
<td>Export sales % of total</td>
<td>38</td>
<td>23</td>
<td>29</td>
</tr>
<tr>
<td>Total employment</td>
<td>~7,000</td>
<td>~17,000</td>
<td>31,300</td>
</tr>
<tr>
<td>R&amp;D expenditure A$\text{m}</td>
<td>382</td>
<td>339</td>
<td>985</td>
</tr>
</tbody>
</table>


** The MTSE sector for this year is defined as comprising establishments supplying goods and services that embody specialist technology, innovation, intellectual property or knowledge specific to the minerals industry. The definition of the MTSE sector in 1995-6 and 2003-4 did not include heavy machinery and equipment.

*** The mining industry magazine and information company, *HighGrade*, estimated that 2008-9 MTSE sales were A$27.5b and employment was almost 83,000 people. The ‘*HighGrade*’ definition of the sector included contract construction and mining services companies, with a small ‘technology’ component.

*** *HighGrade* estimated that the exports of the top 100 Australian owned MTSE companies exceeded $6b in 2010, of which almost 50% was due to Orica.

**Location.** MTSE firms are largely located in Western Australia, Queensland and New South Wales, and in each case the majority of firms are in or near the major cities- Figure 11 – although all of the larger firms have offices in several Australian locations.

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\(^{67}\) The ABARE-BRS Survey of 2009 (Tedesco & Haseltine, 2010) surveyed 1022 MTSE companies and received completed surveys from 156, a response rate of 15% from a stratified sample by type, location and size of firm.
Figure 11: Location of MTSE Firms by State

Sub-Sectors. In terms of the number of firms the major sub-sectors are Equipment and Machinery and Consulting Services – Figure 12. In terms of overall sales the Equipment & Machinery segment is even more dominant accounting for 38% of the sector’s sales- Figure 13. Consulting Services (with a technology component) accounts for a much larger share of firms (33%) than of sales (16%), suggesting that there are many small firms in the segment, whereas Contract Services accounts for a much larger share of sales (23%) than of firms (10%) suggesting that there are some relatively large firms in this segment. Firms with headquarters in NSW or Queensland account for the majority (approx 70%) of ‘Technology Applications’ and ‘Equipment and Machinery’ sales, but WA-based firms account for significant shares of ‘Consulting’ and ‘Contract Services’. As will be shown below, it is the Technology Application segment that is the most dynamic in Australia.

Figure 12: Components of the MTSE Sector – No. Firms by Segment

Figure 13: Segments of the MTSE Sector by Share of 2008-9 Sales.


**Firm Size:** Almost 30% of MTSE firms had sales of less than $1million in 2008-9, while 24% had sales of over $10m – the sector clearly has many small to medium size firms. Average sales per firm are increasing – Figure 14.

Figure 14: MTSE Sector- Distribution of Firms by Level of Sales.

Growth: As noted above (Table 8) the MTSE sector has grown rapidly, particularly over the past decade. Growth over the period since 2008-9 has been even more rapid as will be discussed in Section 5.2, below – see 15.

Figure 15: MTSE Sector Global Sales ($m) – 1995-6 to 2008-9


Exports: MTSE exports grew rapidly over the 2000s (Figure 16) and the available information indicates that this growth has been even more rapid over most years since 2008-9. Between 2006-7 and 2008-9 there was a decline in the number of MTSE firms that did not export, indicating an increasing export orientation- Figure 17. The segment with the highest level of export orientation in 2008-9 was Consulting Services, while Contract Services had a relatively low export orientation – Figure 18. While the Equipment & Machinery Segment continues to account for the highest share of MTSE exports (about 40% in 2008-9) exports from the Technology Applications and Consulting Services segments grew more rapidly over the 2000s. The Technology Applications segment has been estimated to have rates of over 30% per annum over 2006-2009. Over this period for all segments, except Equipment and Machinery, exporting was the main driver of growth. The most important export markets have been

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68 The data in Figure 15 is based on the more restrictive ABARE-BRS definition of the MTSE sector, one which emphasises firms with a significant technology component in products or services. The mining industry magazine and information company, HighGrade, using a broader definition of the MTSE sector estimated that 2008-9 sales were A$27.5b – more than twice the level estimated by ABARE-BRS. These definitional issues, which are related to the purpose of the two databases and surveys, are discussed in Tedesco & Haseltine, 2010.

69 The mining industry magazine and information company, HighGrade, estimated exports of the top 100 Australian owned MTSE companies exceeded $6b in 2010.
Africa (16%), Oceania, particularly Indonesia (15%), and North America (15%), but exports to Latin America and China have been growing rapidly.

**Figure 16: MTSE Sector Export Sales ($m) – 1995-6 to 2008-9**

[Graph showing export sales from 1995-6 to 2008-9]


**Figure 17: MTSE Exports 2006-7 and 2008-9- Distribution of firms by level of Exports.**

[Bar chart showing distribution of firms by level of exports for 2006-7 and 2008-9]

The Formation of Australian Mining Technology Services and Equipment Suppliers.

Figure 18: MTSE Exports – Share by Segment (2008-9)

![Bar chart showing MTSE Exports by segment.]


Figure 19: MTSE Exports - Export Revenue ($m) by Segment 2006-2009

![Bar chart showing MTSE Exports by segment.]


**Research and Development (R&D):** In 2008-9 almost 75% of MTSE firms claimed to be carrying out some form of R&D and 15% were investing over $1m per annum in R&D – Figure 20. The Technology Applications segment, while accounting for only about 25% of MTSE sales, accounted for over 50% of the sectors R&D expenditure – Figure 21⁷⁰.

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⁷⁰ However, the ABARE-BRS survey included some research organisations in the survey coverage and these were included in the Technology Applications segment – the implications of this are not clear.
While this segment was estimated to have the highest level of R&D expenditure it had the lowest proportion of external expenditure.
5. Development of MTSE Firms

The leading suppliers to the global mining industry are from the United States and Scandinavia, although all are now global companies, and almost all were founded in the late 1800s. These are largely equipment or materials (eg explosives) suppliers, although several also provide services along with their products.

However, the growing technological complexity of the mining industry has been one factor that has stimulated the continuing development of new equipment and service providers to the mining industry. The majority of these suppliers are focused on the national markets of their country of origin. The conjunction in Australia of vigorous demand for improved performance in mining and increasingly capable new suppliers has led to the growth of the MTSE sector. These firms have often led innovations, particularly in the application of IT to mining, and have rapidly deepened capability. As their major customers have increased investment in exploration and mining offshore the suppliers have often followed, stimulating rapid internationalisation and deepening capability.

In order to assess the development of the sector this pilot project has drawn on a wide range of sources. To assist the assessment a set of 21 firms were selected for closer analysis – Table 9. The firms are diverse in terms of sub-sector, age, location, and size. However, in selecting the firms there was and emphasis on strongly performing knowledge-intensive firms, both service and product firms.

Table 9: MTSE Firms Selected for Analysis

<table>
<thead>
<tr>
<th>Case Study Firms</th>
<th>Founding</th>
<th>State</th>
<th>Segment</th>
<th>Size in 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>AmpControl</td>
<td>1968</td>
<td>NSW</td>
<td>Eqpt</td>
<td>850</td>
</tr>
<tr>
<td>Ausenco</td>
<td>1991</td>
<td>QLD</td>
<td>Consult’g</td>
<td>2500</td>
</tr>
<tr>
<td>Benthic Geotech</td>
<td>1997</td>
<td>NSW</td>
<td>Tech</td>
<td>15</td>
</tr>
<tr>
<td>Consep</td>
<td>1988</td>
<td>NSW</td>
<td>Eqpt</td>
<td>60</td>
</tr>
<tr>
<td>Corescan</td>
<td>2000</td>
<td>WA</td>
<td>Tech</td>
<td>-</td>
</tr>
<tr>
<td>Gekko</td>
<td>1996</td>
<td>VIC</td>
<td>Eqpt</td>
<td>70</td>
</tr>
<tr>
<td>Groundprobe</td>
<td>2001</td>
<td>QLD</td>
<td>Tech/IT</td>
<td>200</td>
</tr>
<tr>
<td>Immersive</td>
<td>1993</td>
<td>WA</td>
<td>Tech</td>
<td>195</td>
</tr>
<tr>
<td>Inbye (now Nepean Longwall)</td>
<td>1998</td>
<td>NSW</td>
<td>Eqpt</td>
<td>100</td>
</tr>
<tr>
<td>Industrea</td>
<td>1987</td>
<td>QLD</td>
<td>Tech &amp; Eqpt</td>
<td>440</td>
</tr>
<tr>
<td>Intelecction</td>
<td>2003</td>
<td>QLD</td>
<td>Tech</td>
<td>0</td>
</tr>
<tr>
<td>Maptek</td>
<td>1981</td>
<td>NSW</td>
<td>Tech/IT</td>
<td>268</td>
</tr>
<tr>
<td>Micromine</td>
<td>1986</td>
<td>WA</td>
<td>Tech/IT</td>
<td>185</td>
</tr>
<tr>
<td>Mincom (now acquired)</td>
<td>1980</td>
<td>QLD</td>
<td>Tech/IT</td>
<td>1000</td>
</tr>
<tr>
<td>Mine Site Technologies</td>
<td>1989</td>
<td>NSW</td>
<td>Tech/IT</td>
<td>130</td>
</tr>
</tbody>
</table>

71 Main sources for this section: Tedesco & Haseltine, 2010 for sectoral information; HighGrade: www.infomine.com, interviews with MTSE firms for company level information.
5.1 New Venture Formation

5.1.1 The Prior Experience of Entrepreneurs

Most MTSE firms were formed by entrepreneurs from the mining industry (often in the firms that would be the first customers) or from firms supplying the industry. Among the 21 ‘case study’ firms almost 50% were formed by entrepreneurs who were engineers of other professionals or technicians in the industry; about a third were formed by entrepreneurs with industrial experience related to mining and about 20% by entrepreneurs from research organisations active in work related to mining. A 2005 study of five specialist service providers to the mining sector found that none were spin-offs from research organisations and all relied heavily on the technical and industry knowledge of the senior managers and other staff. Some MTSE firms are spin-offs from research organisations, but at this stage these are not major players in the sector.

5.1.2 Market Entry Paths

The entry to market of many products or services that are relatively low cost and easy to implement is often likely to be at the site of application. The mining site is often the locus of interaction with the customer and with the providers of complementary equipment and services, and hence a key focus of learning and capability development. More complex and more expensive capital items are much more likely to involve negotiations with company managers in headquarters offices. In all cases however a good relationship between the buyer and supplier is vital.

There appear to be three typical modes of market entry among MTSE firms:

- Among the case study firms the most common mode of entry was through collaboration with a mining industry firm, or a supplier, around problem solving, which led to a cumulative development of capabilities and technologies. In some cases this involved adaptations of imported core equipment to better meet local needs.
- A second common mode of entry involved engagement with a mining firm around problem solving which led to a substantial product or capability development which

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72 Thorburn (2005)
then formed the basis for the development of the firm (eg Gekko, Russell Mineral Equipment).

- A third mode also involved the development of a foundation product platform but through the commercialisation of a technology developed in a research organisation, although again often with close interaction with mining industry users (eg Scanalyse, Intellection, Benthic Geotech, GroundProbe).

In most cases the relationship with the first users and often their direct involvement in the initial trials was an essential element of the product/service development and subsequent market entry. Thorburn (2005) also found that customer feedback was a major driver of innovation in all of the six specialist service suppliers to the mining industry which she studied.

While recognising that mining firms are risk averse, particularly with regard to critical equipment, the level and quality of product support provided by Australian MTSE firms is a strong factor in market acceptance by mining firms in Australia and overseas. Reliability and consistent support are highly valued. The significance of the relationship with major customers is clearly indicated in the findings of the 2009 ABARE-BRS survey (Figure 22) which four of the top five issues for integration into supply chains concerned the relationship with the customer.

**Figure 22: Important Issues for Integration of Products /Services into Australian Supply Chains 2008-09 [% of companies rating issues as‘ very important’]**

<table>
<thead>
<tr>
<th>Issue</th>
<th>% of companies rating as very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aligned company organisational and supply strategy</td>
<td>21.1</td>
</tr>
<tr>
<td>Access to finance</td>
<td>31.3</td>
</tr>
<tr>
<td>Use of IT infrastructure</td>
<td>32.2</td>
</tr>
<tr>
<td>Good strategic partnership with customers etc</td>
<td>46.9</td>
</tr>
<tr>
<td>Efficient product / service delivery</td>
<td>49.7</td>
</tr>
<tr>
<td>Building and developing new customer relationships</td>
<td>56.7</td>
</tr>
<tr>
<td>Responsiveness to customer needs</td>
<td>58.7</td>
</tr>
<tr>
<td>Remaining ahead of the competition</td>
<td>70.1</td>
</tr>
<tr>
<td>Preferred supplier status</td>
<td>74.8</td>
</tr>
<tr>
<td>Long-term customer relationships</td>
<td>77.6</td>
</tr>
</tbody>
</table>

Source: Tedesco & Haseline (2010)

In many cases the supply of equipment and services is bundled and the capacity to support a product on-site (eg effective product use, problem solving and maintenance) is essential for
The Formation of Australian Mining Technology Services and Equipment Suppliers.

Market entry and survival. This is the case, for example, around software and computing systems, and measurement equipment of different types. Among other things, this trend toward product-service packages has lead to a greater demand for trained and capable personnel able to provide the on-site support. Information technology (IT) is clearly a product/service area of particular importance, both for mining firms where it has found application in a diverse range of areas and for suppliers of equipment, software and related services. The growing capability of IT-based hardware and software, of firms providing these products and services and of personnel in suppliers and mining firms, has coincided with increasing demands for addressing performance problems in such areas as:

- Efficient mining activities;
- Analysis of complex and diverse exploration data;
- Mine site safety;
- Scheduling of mine site activities.

In this regard a deepening range of mining-related challenges has interacted with a deepening range of capabilities – ie in this wide interface of challenges and technological opportunities, specific problems have been focusing devices for innovation that have then led to product, service, capability and enterprise development. The MTSE firms were both users and suppliers of IT hardware, software and services.

As there are now a much wider range of suppliers to mining based on IT capabilities (in mining-related software, services and equipment), many of them Australian, it will be more difficult for new entrants in these areas – unless they have a distinctive product or service in a specific niche.

A study of the sourcing of ICT equipment and services in the mining industry found evidence of changing customer-supplier relationships:

"Increased globalisation of mining is likely to lead to greater centralisation of purchasing, and R&D activities. This will favour the more mature mining ICT markets and providers, as they will already have established a reputation and will have the resources necessary to undertake major R&D programs. For many Australian firms, increased centralisation could be a positive development, but the benefits will fall disproportionately across the sector. With greater centralisation, including the possibility of further relocation of corporate Head Offices overseas, mining ICT firms may find sales and marketing more difficult, particularly new entrants and those offering corporate, as opposed to individual mine site, solutions."  

5.1.3 Resources and Support for Market Entry

For most of the ‘case study’ firms the key resource for market entry was the capabilities of the founders and their relationship with the mining company. In about 20% of cases the application of knowledge from a research organisation (university or CSIRO) was vital and in

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73 Martinez-Fernandez, (2005)
74 Ovum (2003) p.6
less than 20% of cases funding came from some form of venture capital. Government grants had a small role and, among these cases, and was only important where the technology came from a research organisation and/or where venture capital funding had a role.  

Many links between mining companies and suppliers are initiated and developed up to a point at the site level. These tend to be for operational and problem solving expenditure, rather than major investment items. However, participation of larger projects relevant across the activities of the mining companies is managed at the corporate level and usually only involves the leading suppliers. This is in part because the mining companies are often seeking ‘total solutions’, where the supplier can integrate a range of technologies into an operating system. It is also because in more developmental projects the larger mining companies are seeking partners with deep technological capabilities.

This finding is similar to that of early studies. Martinez-Fernandez (2005), based on an extensive 2003 survey, found that customers were the most important source of ‘information, knowledge and skills’ for the firms, followed, in order of importance, by suppliers, parent companies, competitors and the internet. Again this emphasises the critical importance of the user interface and of the need to high quality personnel at that interface. Public sector research organisations were not seen as important sources by the majority of firms. Whereas the importance of customer interaction, for capability development, was increasing, that with public sector research organisations had remained at a low level. Thorburn (2005) found that all of the six specialist service suppliers to the mining industry which she studied had used internal capability for initial development and all continued to rely largely on in-house R&D.

5.2 New Venture Growth and Development

From the perspective outlined above it is not surprising that the 2009 ABARE-BRS survey found that the key strength of Australian MTSE firms, as perceived by the mining and MTSE sector, is that the firms are ‘innovative and technically advanced’ – Figure 23.
Figure 23: Competitive Strengths of MTSE Firms – Frequency cited.

<table>
<thead>
<tr>
<th>Strength</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listens to customer needs</td>
<td>3</td>
</tr>
<tr>
<td>Knowledge of Australian conditions and market</td>
<td>4</td>
</tr>
<tr>
<td>Lower prices than overseas MTSE companies</td>
<td>4</td>
</tr>
<tr>
<td>High level of customer service</td>
<td>4</td>
</tr>
<tr>
<td>World leaders</td>
<td>5</td>
</tr>
<tr>
<td>‘Get the job done’ approach</td>
<td>6</td>
</tr>
<tr>
<td>Close to markets and customers</td>
<td>7</td>
</tr>
<tr>
<td>Good business, financial and managerial skills</td>
<td>7</td>
</tr>
<tr>
<td>Local support, knowledge and domestic alliances</td>
<td>18</td>
</tr>
<tr>
<td>Mature Australian minerals industry which is...</td>
<td>13</td>
</tr>
<tr>
<td>Delivers quality products</td>
<td></td>
</tr>
<tr>
<td>Flexible and ability to customise</td>
<td>18</td>
</tr>
<tr>
<td>Skilled and experienced workforce</td>
<td>18</td>
</tr>
<tr>
<td>Innovative and technically advanced</td>
<td>30</td>
</tr>
</tbody>
</table>


The perceived weaknesses of Australian MTSE firms (Figure 24) were seen as those due to high costs – of labour, transport, manufacturing etc – further emphasising the extent to which competitiveness arises from capability and customer relationships. Among the issues considered by the firms to be less significant weaknesses of Australian MTSE companies, were:

- Limited ability to undertake research and development (time and money)
- Limited access to technology resources;
- Businesses do not think globally and poor understanding of international business cultures;
- Low level of influence on world market and lack of standing in the international business community;
- Lack of patience and confidence to expand business (domestic and international);
- Lack of major and technically advanced suppliers;
- Lack of technical understanding and narrow experience.
Figure 24: Competitive Weaknesses of Australian MTSE Firms – Frequency cited

Experience applicable only to Australian mining conditions
Lack of overseas experience and market penetration
Volutility and strength of Australian dollar
Language barriers for doing business in overseas markets
Lack of marketing skills for technology products/services and not aggressive marketers
Size of Australian MTSE sector is small with limited sales volume
Lack of financial backing (venture capital, other) and working capital
High prices of MTSE products/services
Shortage of skilled labour and high labour costs
High operating and manufacturing costs
Large distances and costs involved with doing business overseas


5.2.1 Internationalisation

One of the striking features of the past decade of development of Australian MTSE firms is the rapid process of internationalisation.

Australian suppliers now have a strong global reputation and many have built a position in many overseas markets with offices in the major markets. Austrade is widely seen as having played a valuable role in supporting initial market entry, through the provision of information and the organisation of exhibitions and delegations. By 2008-9 27% of firms had opened offices in offshore markets, with the most frequent locations being North America (19% of firms) and South America (15% of firms). Significant numbers of firms had opened offices in Oceania, Asia, Africa or Europe.

A 2003 study of the interaction between mining and the ICT industries suggested that: “In their overseas operations, some Australian mining companies have a pre-disposition in favour of Australian ICT providers, based on successful relationships in Australia. However, most adopt a pragmatic approach, selecting ICT that is fit for purpose, supported and easy to use in the overseas mining environments concerned.”

But Australian firms have learnt that it is important to endogenise, employ and develop local staff. It is often important to be seen as an insider in major markets. In some cases it is essential to redesign a product for a market, for example MineSite Technologies redesigned a product for China, reducing functions and lower the cost by 30%.

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76 Ovum (2003) p. 6
The 2010 ABARE-BRS survey and related interviews found evidence that the internet is playing an increasing role in marketing, and that many first contacts with customers began with being identified in an internet search\textsuperscript{77}.

Among the 21 ‘case study’ firms for which sound information is available the domestic markets accounts for on average only 53\% of turnover. Hence, international business, through exports and particularly through offshore offices, accounts for close to 50\% of business. For the major 100 Australian-owned MTSE firms the average level of offshore business in 2010 for firms from the services segment is 17\%, whereas for firms from the Technology Applications and Consulting Segment the average is 31\%\textsuperscript{78}. There is little evidence of a relationship between the age of the firm (Figure 25), the size of the firm in terms of sales (Figure 26) or the level of sales per employee (Figure 27) and the level of international business intensity.

\textbf{Figure 25: Exports & Offshore Business \% of Total 2010 Sales by Year of Formation of Firm}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{exports_offshore.png}
\caption{Exports & Offshore Business \% of Total 2010 Sales by Year of Formation of Firm}
\end{figure}

Source: Analysis of Firm Level Information from \textit{HighGrade}, 2011

\textsuperscript{77} Tedesco & Haseltine, (2010)

\textsuperscript{78} Analysis of firm level information provided in HighGrade Major Firms listing.
In many cases the entry into offshore markets was enabled by relationships developed with major mining companies in Australia. The rapid process of internationalisation through the 1900s and 2000s is illustrated by three cases:

Runge (Figure 28) was formed in the 1970s based on software for mine operations management. After widening the product range and organisational structures the firm...
expanded into North America, Africa, and Asia. By 2010 almost 50% of its business was offshore.

**Figure 28:** Development of Runge.

Mincom (Figure 29) was also formed in the 1970s and developed a suite of asset management operations management software. It built offshore operations even more rapidly, until acquired by a US firm and then ABB.

**Figure 29:** Development of Mincom.

GroundProbe (Figure 30) has built an international position even more rapidly. This spin-off from the University of Queensland established three offshore offices and began exporting to 10 countries within its first decade.
These cases and the history of other firms (discussed below) suggest that rapid international expansion is most often associated with a unique product or capability and a clear strategy, itself based on the professional development of the firm. Many firms are very extended with the rapid growth of mining in Australia and offshore. They have to be very selective in the opportunities they pursue. The availability of professional staff appears to be a constraint on growth.

5.2.2 Corporate Development: Transformation, Acquisitions and Investment

Many MTSE have head offices in the capital cities and branch offices closer to mining regions. According to O’Connor and Kershaw, in the late 1990s many MTSE firms had head offices in Sydney or Perth, with some indications that the rate of growth of the sector in Perth was particularly high. The growth of MTSE firms through the 2000s, and the need for capital to support expansion led both to a growth in listings of MTSE firms on the ASX and to an increase in private equity investment into the sector – four of the 21 ‘case study’ firms had received private equity investment. There is also evidence of consolidation in the sector – four of the ‘case study’ firms had acquired other firms as a mechanism of growth, one was acquired by another Australian firm and two were acquired by overseas firms.

While companies such as Austin Engineering, Bradken, Ausenco, WorleyParsons were significant acquirers of international companies, during the 2000s several leading Australian MTSE companies (Geologics, Jaques, Tritronics, Surpac Minex Aerodata, Warman, ANI Arnall, Cram, Prok, MIM Process Technologies, Elphinstone, Wheel and Rims Engineering) were acquired by overseas-owned firms.

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79 Cited in Martinez-Fernandez, 2005, p. 27-8
Several of the ‘case study’ firms were required to manage a process of transformation to support growth; transformation from the earlier more informal entrepreneurial stage to one with more structure with the recruitment of professional managers. In all cases this transformation was followed by a more vigorous expansion of the business For example: MineSite Technologies (MST) consolidated and brought-in additional capital to expand:

“The investment will enable MST to further reinforce its customer service offering in its current core markets of Australia, the United States and Canada and enable further expansion into rapidly growing resources markets including Africa, South America and China. MST has experienced strong growth in recent years and the investment from Macquarie will support the next phase of MST’s continued international and product expansion. Macquarie’s investment in MST gives us great confidence in being able to truly position ourselves as the leading global OEM of network and communications infrastructure for the world’s largest mining organisations. It will enable us to continue to roll out our proven sales and service support infrastructure in key markets and expand our sales capabilities to current and new customers across the globe.” Gary Zamel, CEO.

As mining has had cyclical trends in demand, and despite what many see an extended period of high levels of demand relative to supply, MTSE firms do need to prepare for market uncertainty. One report, noting the strong mining focus of many ICT-related MTSE firms, encourages the development of a broader range of business models:

“**ICT providers to the mining industry generally identify very strongly with the mining industry and generally seek to expand their businesses within mining, whether domestically or overseas. This alignment generates a high level of business cycle risk for mining ICT providers, risk that they cannot manage or mitigate without changing the business model that they have followed to date. Assistance may be required to provide best practice models for them to do this. Business model change may include moves to:**

- **Expand into other industries in which their ICT products and services may be deployed**
- **Expand research and development activity to stimulate product innovation and development**
- **Expand into consultancy incorporating the deploying of ICT products and solutions**
- **Merge with other firms to provide an enterprise with sufficient product coverage and critical mass to be able to expand into other industry markets in Australia and into foreign markets.**

The probable paths of horizontal diversification will be different for different segments of the MTSE sector. Hausmann analyses international patterns of industry co-occurrence and identifies transition paths based on ‘product spaces’.  

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5.2.3 Capability Upgrading – extent, drivers and mechanisms.

It is clear from the ‘case study’ firms that most invested substantial effort in continuously raising their capabilities, improving their products and widening their product/service range. Upgrading and innovation extends far beyond the technological dimension of capability and performance. It includes the development of task and personnel management systems and for most firms also the development of services\(^83\).

Figure 21 showed that the majority of MTSE firms claimed to undertake some R&D. About one third of the MTSE firms have at least one registered patent or trade mark and 5% have more than 20\(^84\). Figure 31, derived from the ABARE-BRS survey in 2009, suggests that only about a third of MTSE firms invest in external R&D, but at least some invest considerable sums in having R&D conducted by others. Most MTSE firms have collaborated with other organisations, particularly around innovation, and such collaboration appears to play a major role in innovation efforts\(^85\).

**Figure 31: External R&D Expenditure 2008-9 (Proportion of firms %)**

![Bar chart showing external R&D expenditure](chart.png)


Of those that do invest in R&D collaboration, the majority collaborate with exploration and mining firms – a feature that is not surprising given the importance of collaboration with customers for product and service development. The ABARE-BRS surveys of 2002, 2004 and 2010 (Tedesco et al, 2002, 2004, 2010) had all found that collaboration was an important

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\(^{83}\) Australian Government, nd. This report, based on Thorburn, 2005, emphasises the role of incremental innovation in service firms.

\(^{84}\) Tedesco & Haseltine, 2010.

\(^{85}\) Tedesco & Haseltine, 2010.
mechanism of capability development for MTSE firms. Customers were consistently identified as the most important collaboration partner. This survey data suggests that MTSE firms more often collaborate with universities than with CSIRO (Figure 32).

Figure 32: Research Collaboration Partners (% by collaborating firms 2008-9)


Among the 21 ‘case study’ firms almost 50% had some form of external collaboration, of which about half collaborated with either or both CSIRO or a university. As these selected ‘case study’ firms were almost all technology-intensive rapid growth firms their collaboration activity would not be representative. A range of prior surveys indicate that the majority of collaboration for the purpose of accessing external knowledge-based services (eg consulting, R&D, specialist support) is with other firms. According to a survey in 2003 the second most important source of ‘knowledge-intensive services’ purchased by Mining Technology firms was ‘universities or TAFE’, followed by CSIRO. That survey found evidence of some tensions between MTSE firms and CSIRO over IP issues. In a set of six cases studies of Mining Technology Service firms most acquisition of expertise from external sources focused on mining firms, suppliers and other MTSE firms - only one sourced expertise from universities. It is almost certainly the case that a focus on R&D collaboration underestimates significantly the level of technological collaboration that would not be characterised as formal R&D.

Such a perspective is supported by Figure 33 which provides some insights into what MTSE firms see as the key challenges in innovation. The issues are seen primarily in terms of in-house talent and links with customers. Nevertheless, access to professional staff is frequently

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86 Martinez-Fernandez, 2005
87 Martinez-Fernandez, 2005, p49
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identified as a constraint on growth and an increasing number of MTSE companies are recruiting staff from overseas. In fact, a survey of mining technology suppliers in 2003 found that collaboration was important for these firms, and that the majority of collaboration was informal and was with customers and suppliers and to a lesser extent consultancy firms. About a third of the firms surveyed had some form of ‘collaboration’ with universities or research organisations.

Figure 33: Importance of Challenges that affect Commercialisation and Integration of Innovation in 2008-09 (% of companies rating issues as ‘very important’)


The ABARE-BRS survey of MTSE firms in 2009 was supplemented by discussions with both a sample of MTSE firms and with mining companies (ie users) (Tedesco & Haseltine, 2009). One of the issues discussed with MTSE firms was the constraints which limit innovation. Access to finance was a key constraint, but few firms had been successful in attracting finance from the venture capital market. Some companies were aiming to attract alternative investors: ‘sophisticated investors’; or mining companies, with an interest in the technology as a solution to significant problems. Many MTSE companies have used one or more of the support programs provided by the Commonwealth or State governments, for example the R&D tax concession, R&D grants, Export Market Development Grants.

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89 Cited in Martinez-Fernandez, 2005. The survey sample was of 25 firms and may not provide a basis for generalisation.
5.3 Industry Level Development

5.3.1 Industry Development Initiatives
Over the period 2001-3 a Mining Technology Services (MTS) sectoral ‘strategy’ (or Action Agenda) was developed based on consultation within the sector and with related stakeholders, including mining industry associations and research organisations. The Action Agenda identified a range of challenges for the development of the sector:

- The diversity of the sector in terms of service categories and sizes of firms leading to a lack of wider profile and recognition contributing to limited attractiveness of the sector for investors;
- A lack of collaboration among MTSE companies and with research (although this was increasing) and education organisations;
- The importance of building positions in export markets, but the challenges in doing so for small firms, and of increasing cooperation between Austrade and Austmine; and
- The increasing demand for skilled human resources, particularly professional managers, engineers, geologists and IT professionals.

The proposed strategy, based on extensive consultations, focused on:

- A ‘vision’ of achieving Mining Technology Services exports of A$6b by 2010;
- Raising the profile of the MTSE ‘sector’ and increasing its attractiveness to the investors;
- Strengthening cluster relations, including collaboration among firms and with research organisations, and the depth of innovation and management capability in firms;
- Ensuring that most MTSE firms were fully competent in e-business;
- Attracting more graduates to careers in the sector and greater participation by the MTSE sector in influencing the supply of graduates. The Action Agenda stressed the need to improve the supply of high quality graduates in a range of mining and related areas, and to improve coordination among suppliers of education and training services and the mining and MTSE sector.

It appears that all of these issues are continuing challenges.

5.3.2 Knowledge Infrastructure
The infrastructure of mining-related research, and to a lesser extent, education, organisations in Australia is a key factor in the continuing competitiveness of the mining industry. This

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90 Strategic Leaders Group (2003) There is considerable ambiguity regarding the definition of the sector. The surveys by ABARE, which were carried out to support the development of the Action Agenda focus on firms providing services based on ICT or ‘or products that incorporate other scientific, technical or engineering based technologies, as well as services that provide expertise within these technology areas’ whereas the industry association (Austmine) uses a more inclusive definition that includes suppliers of equipment and other services to mining such as contract mining and catering.

91 The report noted that the issues of human resource shortages had been raised repeatedly, for example in Minerals Council of Australia’s (1998) Back from the Brink report and the Australasian Institute of Mining and Metallurgy (AusIMM) - Department of Education, Science and Training (2001)
infrastructure is largely focused on the mining industry rather than on suppliers to mining and has encouraged at least Rio Tinto to establish components of its global R&D in Australia. As shown in Table 10, there is an extensive array of organisations that conduct research in mining-related fields.

**Table 10: Australian Mining-Related Research Infrastructure.**

<table>
<thead>
<tr>
<th>Research Organisations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• CSIRO (Centre for Advanced; Exploration and Mining, Minerals and the ICT Centre)</td>
</tr>
<tr>
<td>• GeoScience Australia</td>
</tr>
<tr>
<td>• National ICT Australia (NICTA)</td>
</tr>
<tr>
<td>• Australian Nuclear Science and Technology Organisation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>University-Based Research and Consulting Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sustainable Minerals Institute, University of Queensland:</td>
</tr>
<tr>
<td>➢ Minerals Industry Safety and Health Centre</td>
</tr>
<tr>
<td>➢ WH Bryan Mining and Geology Research Centre</td>
</tr>
<tr>
<td>➢ Centre for Water in the Minerals Industry</td>
</tr>
<tr>
<td>➢ Centre for Social Responsibility in Mining (CSRM)</td>
</tr>
<tr>
<td>➢ Julius Kruttschnitt Mineral Research Centre (JKMRC)</td>
</tr>
<tr>
<td>• University of Tasmania’s Centre for Ore Deposit Studies</td>
</tr>
<tr>
<td>• Western Australia School of Mines</td>
</tr>
<tr>
<td>• University of South Australia's Ian Wark Research Institute,</td>
</tr>
<tr>
<td>• James Cook University School of Earth and Environmental Sciences</td>
</tr>
<tr>
<td>• Australian Centre for Minesite Rehabilitation Research. Brisbane</td>
</tr>
<tr>
<td>• University of Sydney, Rio Tinto Centre for Mine Automation (RTCMA)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collaborative Research Centres</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cooperative Research Centre for Mining</td>
</tr>
<tr>
<td>• CRC for Infrastructure and Engineering Asset Management (CIEAM)</td>
</tr>
<tr>
<td>• CRC for Optimising Resource Extraction</td>
</tr>
<tr>
<td>• Parker Cooperative Research Centre for Integrated Hydrometallurgy Solutions</td>
</tr>
<tr>
<td>• Deep Exploration Technologies CRC</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Previous Relevant Cooperative Research Centres</th>
</tr>
</thead>
<tbody>
<tr>
<td>• CRC for Mining Technology and Equipment (CMTE) (now CRC Mining)</td>
</tr>
<tr>
<td>• GK Williams CRC for Extractive Metallurgy</td>
</tr>
<tr>
<td>• CRC for Australian Mineral Exploration Technologies</td>
</tr>
<tr>
<td>• Australian Geodynamics CRC</td>
</tr>
<tr>
<td>• CRC for Landscape Evolution and Mineral Exploration</td>
</tr>
<tr>
<td>• CRC for Advanced Computational Systems</td>
</tr>
<tr>
<td>• CRC for Welded Structures</td>
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<tr>
<td>• CRC for CAST Metals Manufacturing</td>
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<table>
<thead>
<tr>
<th>Research Intermediaries</th>
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</thead>
<tbody>
<tr>
<td>• AMIRA International</td>
</tr>
<tr>
<td>• Australian Coal Research Association (ACARP)</td>
</tr>
</tbody>
</table>
The CRC Mining, based at the University of Queensland, is supported by most of the major mining companies, including: Anglo Gold Australia, AngloGold Ashanti, BHP Billiton, Freeport McMoRan, Hamersley Iron, Newcrest Mining Limited, Peabody Energy, Rio Tinto, and Xstrata. It is also supported by several supplier firms, almost all of which are international: Caterpillar; Elphinstone; Computer Sciences Corporation; P&H MinePro Services; Wellard; and Herrenknecht Tunnelling Systems. The CRC’s website states:

“Typically, solutions are developed for large mining corporates and spin-off companies which then market the technology across Australia as well as globally.”

The website lists nine spin-off companies.

A Mining Technology Innovation Centre has been established in 2009 in Mackay (Central Queensland) to support capability development and innovation in SMEs that are suppliers to the mining sector. The Centre is part of the Enterprise Connect programs of the Department of Innovation, Industry, Science and Research, and provides management and strategy-related advice to firms.

5.3.3 Development of industry – research organisation relationships

In 2008-9 about 40% of the MTSE companies participated in some form of collaborative R&D. The majority of these collaborations were with Australian organisations. As shown in Figure 32 the great majority of these collaborations were with exploration and mining companies. Among that small proportion of MTSE firms that collaborated with an overseas-based partner (which may nevertheless have been a firm active in Australia) the majority were also with exploration or mining companies. Mining companies are reported to be open to R&D collaboration with potential suppliers in areas where problem solving is significant. Larger mining firms prefer to collaborate through arrangements that bring together a range of expertise and organisations, as for example, in a CRC or multi-actor research project.

The most common public sector research partner was a university (14.5% of external partners among MTSE firms participating in collaboration). According to the findings of the 2009 ABARE-BRS survey (Tedesco & Haseltine, 2010) CRCs and CSIRO were identified as much less frequent partners. There have been a number of CRCs in areas related to the mining industry, including the CRC Mining. It is widely recognised that the CRC model tends to be less appropriate where an industry, like the MTSE sector, is not characterised by a small number of large R&D active firms. An analysis in 2005 of six case studies of firms that provide knowledge-based services (largely exploration, technical and IT-related services) to the mining

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93 The information base for this section is particularly limited.
94 Tedesco and Haseltine, 2010
95 Ibid
96 AusIMM (2008.) p.6
97 Ibid p.11
sector found that, despite the technical nature of the work, few had close links with research organisations. In fact some saw R&D organisations as competitors for the services they provide.  

An alternative perspective, possibly very relevant to understanding MTSE-research relationships and the perception of competition, comes from the leader of one of the major mining automation research centres:

“[research projects]. have placed Australia at the forefront of robotic mining R&D. Substantial research challenges in areas such as sensing, data fusion, navigation and control, have helped established Australian researchers as leading players on the world stage. However, major mining equipment suppliers have been remarkably slow on the uptake, possibly because few major equipment manufacturers have research or development divisions in Australia. This has made the transition of technology from research into products of value to the Australian mining industry, sometimes a difficult and dispiriting process. So in Australia, a significant number of smaller technology-oriented automation companies have come to the fore, ranging from companies specialising in remote control, to those providing sensors, information processing, control and planning software. Many of these companies are spin-outs from various robotics research groups around Australia. A possible industry development scenario in Australia is that one or more of these companies will turn into a systems-engineering house for mining robotics, able to source and integrate individual items of equipment and technology into a fully supported automated mine. This draws on the view that the benefits of automation will only be fully realised through an integrated system, recognising the role that large Australian-based miners play in the global resource industry.”

5.4 Evidence of ‘Cluster’ development

It is widely recognised that the development of firms and sectors often involves the parallel development of supporting sectors, organisations and policies – ie a cluster of interacting organisations. The development of a cluster involves four processes, which reinforce each other: the entry or formation of more, and a more diverse range of, actors (suppliers, customers, intermediaries, sectoral organisations, research and education organisations etc); increasing interaction (user-producer, competition, collaboration) among these actors; increasing specialisation and capability upgrading within the actors (and through complementarity and cooperation at the level of groups of actors), and; the development of institutions, policies and shared priorities.

The discussion in Sections 3, 4 and 5 above, has focused on the formation and growth of MTSE firms and other cluster actors, which some see as important for the development of mining in Australia. In the Hunter region of NSW the closure of the BHP steel mill left many engineers and managers without employment. Many responded by forming new firms and by

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97 Thorburn, 2005.
98 From Hugh Durrant-Whyte, The Warren Centre’s 2010 Innovation Lecture.
99 “Clusters of technology and services firms are an increasingly critical part of the mining supply chain...” AusIMM (2008) p.14
The discussion above suggests that interaction with customers around problem solving is one of the key drivers of capability development in the MTSE sector. Rio Tinto appears to be increasing the level of their investment in mining-related innovation in Australia, developing a highly ambitious set of innovation goals, and strengthening links with research organisations and MTSE firms. There is little evidence that other large Australian-based mining firms have a similar level of engagement with research organisations and particularly with MTSE firms. However, as supply interactions are increasingly global, pursuing those opportunities provides a mechanism for Australian MTSE firms to build scale while remaining reasonably specialised. The evidence discussed above suggests that many MTSE firms are investing heavily in internal knowledge development. Linkages and collaboration among MTSE firms appears to be quite

There is some evidence for the development of nodes of cluster type activity in some regions, particularly the Hunter Valley, Brisbane and Perth, each with their own characteristics.

---

Footnote:

100 There is some evidence for the development of nodes of cluster type activity in some regions, particularly the Hunter Valley, Brisbane and Perth, each with their own characteristics.
limited in depth. Almost all of the other drivers of capability development identified in Figure 34 are constrained in one way or another, although acquisition activity is increasing.

The development of sectoral organisations is an expression of shared interests in an emerging sector, and is often essential to lobby for those interests where existing policy is not supportive. The 2004 ABARE-BRS survey (Tedesco, et al., 2004) sought information on the forms of collaboration used by MTSE firms and this showed that forms of exchange and cooperation facilitated by industry associations were highly valued for their role in market promotion, professional development and information exchange. Thorburn (2005) found that few of the six specialist service suppliers to the mining industry which she studied had links to an industry association for the purpose of innovation. The exception was a firm in the Hunter region of NSW that was actively involved in the regional industry group. However, the firms did see that industry associations did play a major role in ‘broader knowledge acquisition’.

Sectoral organisations can develop to play a range of roles in supporting sectoral development. Four roles that are perhaps particularly important involve representing the interest of the sector in relation to:

- The economic, industry and industrial relations policy arena;
- The coordination of research and research policy;
- Education and training policy;
- International, trade and investment arena, both governmental and private sector.

For each of these roles there are four levels of development:

1. Informal and ad hoc – no formal bodies, committees and processes.
2. Formal organisation – an organisation with membership, elected representatives and consultation processes exists.
3. A Secretariat of permanent staff exists.
4. The Secretariat includes a significant capacity to conduct research on issues to support the interests of the members.

Figure 35 aims to chart the current development of the primary MTSE sectoral organisation, Austmine, in terms of these roles. It indicates the organisation has a particularly limited role in two areas of substantial and growing importance: Education and training policy and coordination; and industry-research policy and coordination. Both of these areas were identified as priorities for action in the 2003 Mining Technology Services Action Agenda. A major and long standing issue for both the mining and MTSE sectors is the supply of human resources, particularly engineers and IT specialists. The mining industry has been concerned about emerging skill shortages while the commitment to maintaining or developing higher

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101 The MGB Group (2004) found an increasing concentration of firms near Perth but limited links among firms.

102 AusIMM Submission to the National Innovation System Review. April 2008. p.6
education programs has been declining\textsuperscript{103}. The concern extends to the development of research capacity and some industry bodies have drawn attention to the decline from 2000 to 2004 in enrolments in PhD studies in mining-related fields\textsuperscript{104}.

While AustMine is more active in supporting international trade and investment it is evident that the continued international expansion of Australian MTSE firms is vital and timely. There are almost certainly opportunities for AustMine to play a more active role in this arena.

\textbf{Figure 35: Dimensions of Development of a Sectoral Organisation}

6. Conclusions
This section returns to the focus questions: the context for new firm formation and development and the extent to which the demand side of the resource boom is being leveraged for industry and capability development.

\textbf{New Venture Formation and Development}
The Mining Technology, Services and Equipment (MTSE) sector is a significant ‘new’ sector of Australian industry. It has been formed largely over the past 25 years through the formation and often rapid growth of new ventures. The significance of this sector is underestimated.

\textsuperscript{103} AusIMM (2008). p.6. argues that part of the problem with the lack of development of higher education courses is the result of an unintended consequence of funding formulas which lead to universities restricting high-cost courses such as mining engineering.

For example, the total exports of MTSE products and services significantly exceeds that of the wine industry and by some estimates the motor vehicle industry. As many of the MTSE firms are also have substantial and rapidly expanding offshore business the overall significance is greater than indicated by exports.

Mining is an increasingly knowledge-intensive sector. The nexus of innovation and capability and industry-research links in Australia has attracted research from at least one leading global mining firm, Rio Tinto. The technological challenges facing mining, not least in terms of energy efficiency, using low-grade ores and environmental management are likely to increase. Consequently there are ongoing opportunities for MTSE firm formation and development in Australia.

Most of these new firms were formed by entrepreneurs with engineering or technical training and prior experience in the mining or closely related industries. A small proportion of firms have been spin-offs from research organisations.

Many Australian MTSE firms are leaders in their niche. Most MTSE firms have built their capability and products/services over time through close (problem-solving) working relationships with mining and/or exploration companies. These relationships have often been vital for market entry and ongoing product or service development. The sector is knowledge and export-intensive. Because of the nature of innovation, R&D expenditure is unlikely to be a useful indicator of the extent of innovation in the MTSE sector. While many MTSE firms are essentially service firms, the product sector / service sector differentiation has limited meaning where most equipment firms bundle substantial service support with their products.

The emergence and growth of the MTSE sector of 2011 arose from the combination of the challenges faced by mining companies and the capabilities of Australian firms to develop solutions to those challenges. In particular Australian firms have been at the forefront of the applications of IT to almost all aspects of mining. Information technology forms the basis for new paths of innovation in information acquisition and analysis related to many aspects of mining. Software and hardware improved over time and supported modelling of ore bodies, mine-sites and production operations. New sensing and communication technologies improved safety and productivity. Low-cost real time data-acquisition technologies supported greater automation and remote control. There remains substantial scope for IT to contribute to energy efficiency, greater safety, improved capital utilisation, and improved environmental performance. Australian firms currently provide a substantial share of the software used in the global mining industry – estimates vary but figures around 60% are cited\(^{105}\). Through pioneering this new frontier of innovation they have been able to develop global competitive strengths. The scale, diversity and innovative performance of mining in Australia have all contributed to the strengths of the MTSE sector. This assessment does not apply to the Oil and Gas sector which is outside the scope of this pilot study.

\(^{105}\)AusIMM Submission to the National Innovation System Review. April 2008. p.13

The Formation of Australian Mining Technology Services and Equipment Suppliers.
However, the MTSE sector is at a key stage of evolution. Many firms, including relatively small firms, are internationalising rapidly, through exports and particularly through opening off-shore offices. At the same time many firms are transforming their strategies, structures and organisational arrangements to support growth. Some are acquiring other firms to broaden their offering toward a role closer to ‘systems integration’ and the provision of ‘solutions’ to mining firms. This is likely to be an important trend that may reshape the sector. In some cases this stage of growth is supported by investment from private equity, in other cases firms have listed on the ASX to raise capital. As MTSE firms become larger and with deeper competencies they are more attractive partners for customers and research organisations. A greater awareness of the strengths and performance of the sector would assist firms in attracting investment.

Some MTSE firms are also beginning to develop products and services in other markets beyond mining. For example, some software and equipment firms have increased business in the defence and construction sectors.

The international expansion of MTSE firms is a high risk endeavour. It involves the development of new knowledge and capability and also generates significant externalities. These externalities include building the reputation of Australian industry in new markets and developing the international experience of Australian managers and engineers.

While there has clearly been a vigorous process of entrepreneurship that has developed a diverse population of MTSE firms there is little evidence that this has been significantly assisted by the public policies designed to support new venture formation or the formal ‘commercialisation’ infrastructure. The story is substantially one of new challenges in mining being addressed by dispersed and capable entrepreneurs, and being approached in a new way due to the technological opportunities arising from new generic, essentially IT, technologies.

**Industry-Level and ‘Cluster’ Development**

The growth and development of firms has been constrained by difficulties in attracting capital and shortages of high level personnel, including engineers, managers, and IT and marketing professionals. The discussion in this report emphasises the necessity for high level capability in firms and at the ‘coal face’ working with customers. The issues have long been recognised but have not led to a concerted response. It is clearly vital that impediments to the ongoing development of the sector are addressed. The formation of the Mining Technology Innovation Centre in 2009 in Mackay is a potentially useful initial step. Strengthening the

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106 The international expansion of MTSE firms is a high risk endeavour involving the development of new knowledge and capability and that generates significant externalities. These externalities include building the reputation of Australian industry in new markets and developing the international experience of Australian managers and engineers.

107 For example: Thorburn (2005b) p. 41.
capabilities and role of AustMine would also assist the visibility of the sector and the scope for collective action.

This pilot assessment suggests that the research infrastructure related to mining has not been designed, or has not evolved, to support the development of the MTSE sector. This is potentially critical as MTSE firms climb the technology ladder and require deeper engagement with research organisations and specialist expertise. Ideally, research in Australian public sector research organisations should be designed, and be assessed, in terms of three outcomes:

- Developing solutions to address the challenges of competitive mining in Australia;
- Developing competencies in mining firms and in mining industry suppliers to apply and develop knowledge;
- Developing Australian firms as suppliers to the mining industry.

In the long run there is little point in focusing public investment on developing competencies in research organisations and not in MTSE firms. Capability in the former cannot substitute for capability in the latter. This is particularly the case if the design of the research system limits opportunities for collaboration with MTSE firms and possibly displaces innovation-related links between mining firms and MTSE firms. This is an important issue and warrants further assessment.

The MTSE sector is geographically dispersed and there is a good deal of diversity among firms in terms of technology and market niche. There is little evidence of strong cluster development – although there are concentrations of MTSE firms in Perth and Brisbane. There do not appear to be strong interactions between the MTSE sector and research or education and training organisations. These relationships are likely to be more important in the future as the sector consolidates and deepens technological capability.

**Policy for linking demand, discontinuity and new firm development.**

It is vital that, after the boom phase of resource development, Australia has more options and more capabilities for sustaining international competitiveness. International experience indicates that that is unlikely to happen without a coherent strategy.

The development of the MTSE sector demonstrates the significance of harnessing the ‘demand side’ for industry and technology development in Australia. In particular this development shows clearly the importance, for the development of new firms, of discontinuities in the knowledge base. Without such discontinuities it is very difficult for new firms to challenge the competitive position of long established and usually large and well-regarded international suppliers. Many segments of mining equipment remain dominated by such international suppliers and without innovation that disrupts their position entry by new firms is unlikely. Information and communication technology are clearly enabling technologies with the continuing potential to disrupt established competitive positions in
many industries. This case and the story of many MTSE firms provide an important exemplar. To suggest that a focus on ICT is ‘picking winners’ would be to display a fundamental misunderstanding of economic development. A key issue for policy then is to identify other areas where there may be a highly prospective combination of challenging (and significant and sustained) demand, discontinuity in the relevant knowledge and competence base underpinning competitive performance, and at least nascent competencies in (or transferable to) industry in the new knowledge bases. The emerging technology areas of nanotechnology, biotechnology and new energy technologies may be areas of competence relevant to areas of challenging new demand. But the MTSE case reminds us that it is competence and entrepreneurship in industry that is essential and which cannot be substituted by high level capability in research organisations. Close links between research organisations and the ultimate users of new technology applications are of limited value if they do not promote capability development in an emerging supply sector. This is a challenging area for policy, particularly as an emerging sector is likely to populated by small firms. It appears that there is a lack of appropriate policy and support mechanisms to address this challenge.
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## Appendix

**COMPANIES OPERATING UNDER STATE AGREEMENTS LOCAL CONTENT REPORTS - CUMULATIVE OUTCOMES – 2009**

<table>
<thead>
<tr>
<th>Operating Projects</th>
<th>Percentage of contract</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WA</td>
</tr>
<tr>
<td>Adelaide Brighton Ltd (Cockburn Cement)</td>
<td>86%</td>
</tr>
<tr>
<td>Alcoa World Alumina</td>
<td>73%</td>
</tr>
<tr>
<td>Alinta Ltd (Pilbara Energy Project)</td>
<td>76%</td>
</tr>
<tr>
<td>Argyle Diamond Mines</td>
<td>93%</td>
</tr>
<tr>
<td>Birla Nifty Pty</td>
<td>81%</td>
</tr>
<tr>
<td>Dampier Salt Limited</td>
<td>59%</td>
</tr>
<tr>
<td>Goldfields Gas Transmission Pty Ltd</td>
<td>73%</td>
</tr>
<tr>
<td>Iluka Resources Ltd</td>
<td>90%</td>
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<td>Millennium Chemicals</td>
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</tr>
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<td>Nickel West Ltd</td>
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</tr>
<tr>
<td>Onslow Salt Pty Ltd</td>
<td>43%</td>
</tr>
<tr>
<td>Rio Tinto Iron Ore (Pilbara projects)</td>
<td>88%</td>
</tr>
<tr>
<td>Sharke Bay Resources Pty Ltd</td>
<td>61%</td>
</tr>
<tr>
<td>Simcoa</td>
<td>79%</td>
</tr>
<tr>
<td>The Griffin Coal</td>
<td>99%</td>
</tr>
<tr>
<td>Tiwest Joint Venture</td>
<td>93%</td>
</tr>
<tr>
<td>Westfarmers Premier Coal Limited</td>
<td>99%</td>
</tr>
<tr>
<td>Wespine Industries Pty Ltd</td>
<td>65%</td>
</tr>
<tr>
<td>Worsley Alumina Pty Ltd (operations)</td>
<td>61%</td>
</tr>
<tr>
<td><strong>TOTAL OPERATING</strong></td>
<td><strong>80%</strong></td>
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<tr>
<th>New Projects (including expansions)</th>
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<th>OS</th>
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<tr>
<td>Argyle Diamond Mines (Underground mine development)</td>
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<td>98%</td>
<td>2%</td>
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<tr>
<td>BHP Billiton Iron Ore</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RGP4</td>
<td></td>
<td>84%</td>
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</tr>
<tr>
<td>RGP5</td>
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<td>3%</td>
<td>16%</td>
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<td>21%</td>
<td>0%</td>
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<td>CP Mining</td>
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<td>11%</td>
<td>40%</td>
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<td>Australasian Resources</td>
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<td>24%</td>
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<td>76%</td>
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<td>Tiwest Joint Venture (expansion projects)</td>
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<td>75%</td>
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<td>Chevron (Gorgon)</td>
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<td><strong>TOTAL NEW PROJECTS/EXPANSIONS</strong></td>
<td></td>
<td><strong>48%</strong></td>
<td><strong>5%</strong></td>
<td><strong>47%</strong></td>
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</tbody>
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| TOTAL ALL PROJECTS                                       |                       | **58%**   | **7%** | **35%** |
### Operating Projects

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<thead>
<tr>
<th>Project</th>
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<th>ES</th>
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<td>Birla Nifty Pty</td>
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<td>22%</td>
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<td>Goldfields Gas Transmission Pty Ltd</td>
<td>100%</td>
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<td>Millennium Chemicals</td>
<td>88%</td>
<td>8%</td>
<td>4%</td>
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<tr>
<td>Nickel West Ltd</td>
<td>66%</td>
<td>34%</td>
<td>0%</td>
</tr>
<tr>
<td>Onslow Salt Pty Ltd</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Rio Tinto Iron Ore (Pilbara projects)</td>
<td>88%</td>
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<td>1%</td>
</tr>
<tr>
<td>Sharpe Bay Resources Pty Ltd</td>
<td>95%</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>Simcoa</td>
<td>76%</td>
<td>3%</td>
<td>21%</td>
</tr>
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<td>98%</td>
<td>2%</td>
<td>0%</td>
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<td>48%</td>
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<td>52%</td>
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<td>84%</td>
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<tr>
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<td>4%</td>
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### New Projects (including expansions)

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<th>ES</th>
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<tr>
<td>RGP5</td>
<td>85%</td>
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<td>Iluka Resources Ltd (expansion projects)</td>
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<td>4%</td>
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<td>CP Mining (Sino project)</td>
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<td>32%</td>
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<td><strong>TOTAL NEW PROJECTS</strong></td>
<td>53%</td>
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<td>41%</td>
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**TOTAL ALL PROJECTS**

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<th>ES</th>
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<td>61%</td>
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<td>31%</td>
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