



TECHNOLOGY GOVERNANCE

Working Papers in Technology Governance and Economic Dynamics no. 41

THE OTHER CANON FOUNDATION, NORWAY  
TALLINN UNIVERSITY OF TECHNOLOGY, TALLINN

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# Emergence and Development of Knowledge-Intensive Mining Services (KIMS)<sup>1</sup>

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June 2012

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<sup>1</sup> Research overview prepared for the World Investment Report 2007 - UNCTAD.

*During recent decades the global mining industry has experienced a significant technological rejuvenation process, which has been accompanied by an important change in its production organisation. The mining industry showed high rates of innovation and productivity growth and several functions, formerly performed within mining companies, were outsourced to independent suppliers.*

*In particular, an important emergence and development of specialized knowledge-intensive mining services (KIMS) suppliers has taken place. Many of these firms have gradually become international players, creating a new knowledge-based and globally organised industry.*

*This emergence and development has been uneven across mining economies. Indeed, an important number of KIMS suppliers – from mining countries such as Australia, Canada and South Africa - emerged and participated in the significant technological innovation process experienced by the global mining industry, and gradually achieved international competitiveness. Additionally, this process has been a key driving force behind the development of knowledge intensive “clusters” based on the mining industry.*

*In contrast, in Chile, also an important mining economy where mining has been experiencing a significant growth over the last two decades only a weak growth of locally owned KIMS firms have taken place. Chilean KIMS firms developed some strength at the local market, but were weak in developing international competitiveness. Accordingly, a major share of the significant growth of demand for KIMS derived from the rapidly expanding Chilean copper industry has been met by international KIMS suppliers.*

*This research analyses the dynamics of the emergence and development of internationally competitive KIMS suppliers over the second half of the 20<sup>th</sup> century. It focuses on the structure of the technological learning and innovation process that accompanied and underpinned the emergence and development of KIMS. It focuses mainly on contrasting the Chilean and Australian experience. However, other mining economies such as South Africa have also been analyzed but in lesser details.*

## **1. What are Knowledge Intensive Mining Services (KIMS)?**

KIMS refer to a wide range of services and products supplied to mining investment project and operations at every step of the whole mining process - from exploration to mine closure. KIMS comprises services such as exploration services, mine planning services, equipment design, project management, metallurgical process design, and environmental engineering services.

Table 1 shows a more precise segmentation of the supplier to the mining industry sector according to four broad categories, and highlights KIMS category (first column in shade). Each category is split in two depending on whether the firms supply to an investment project or to an on-going operation. The table also presents some illustrative examples of the kind of goods and services provided by each category.

**Table 1: Categories of Suppliers to the Mining Industry**

Categories of Suppliers and Examples of Product and Services				
	Knowledge- intensive services (KIMS) Consultants	Specialized Services Contractors	Capital Goods and Equipment Suppliers	Consumable Inputs Suppliers
Services and goods mainly for investment projects	<ul style="list-style-type: none"> <li>- Exploration services.</li> <li>- Investment project management.</li> <li>- Engineering services such as mine planning, process design, and metallurgy engineering.</li> <li>- Mine closure, reclamation and remediation design.</li> </ul>	<ul style="list-style-type: none"> <li>- Development and construction services.</li> <li>- Tunnelling services.</li> <li>- Shaft sinking.</li> <li>- Drilling services</li> <li>- Sampling services</li> </ul>	<ul style="list-style-type: none"> <li>- Heavy machinery and equipments such as: mills, crushers, and smelting equipment.</li> </ul>	
Services and goods mainly for ongoing operation	<ul style="list-style-type: none"> <li>- Mine automation &amp; optimisation.</li> <li>- Blasting engineering.</li> <li>- Equipment design and adapting.</li> <li>- Equipment maintenance and repairing.</li> <li>- Geological testing.</li> <li>- Metallurgical analysis.</li> </ul>	<ul style="list-style-type: none"> <li>- Drilling services</li> <li>- Shaft sinking</li> <li>- Laboratory Services</li> <li>- Mineral handling contractors</li> <li>- Education &amp; training</li> <li>- Mineral processing</li> <li>- Environment monitoring</li> <li>- Tailing dam operating</li> </ul>	<ul style="list-style-type: none"> <li>- Light machinery and equipment:.,</li> <li>- Replacements</li> <li>- Drilling equipment</li> <li>- Conveyors</li> <li>- Ventilation equipment</li> <li>- Excavators</li> <li>- Electronic equipment</li> <li>- Engines and generators</li> <li>- Trucks</li> </ul>	<ul style="list-style-type: none"> <li>- Explosives and blasting accessories</li> <li>- Chemical products.</li> <li>- Abrasives</li> <li>- Acids.</li> <li>- Drill bits.</li> <li>- Tyres</li> </ul>

KIMS are not just provided by ‘pure’ knowledge-intensive services suppliers, such as engineering consulting firms. Equipment and input providers have been gradually integrating KIMS within their range of products. Additionally, several engineering and project management suppliers integrate contractor services related to development and construction activities together with their KIMS services.

For instance, Orica (from Australia), the largest explosive supplier, offers explosives, initiating systems and explosive accessories, and besides these inputs, it also provides blast-based services, which include important blasting engineering and research activities. Also, Aker Kvaerner (from Norway) is a leading global provider that executes project development studies, followed by engineering, procurement & construction management (EPCM), direct hire construction, commissioning & start-up, and services for operating plants.

## 2. What has led to the rise of the KIMS sector?

The emergence and development of KIMS sector have been driven by the following two interrelated processes:

- a) *Restructuring the organisation of production of the mining industry:* Mining corporations such as Anglo America, De Beers, Rio Tinto, BHP Billiton and Noranda have been restructured by extending their global presence. Additionally, many functions, operations and services, which were formerly integrated within mining companies, were outsourced to independent specialized actors.

Mining companies opened the door for consulting engineering and knowledge based services to be involved in investment projects and operations delivering services, which were previously preserved for mining companies internal units. This outsourcing process has been driven by mining companies cost reduction pressure. Divesting the so called non-core functions and reducing engineering departments' overheads was seen at the time as a source of significant cost reduction.

Many of the highly specialised firms that emerged from this process were units spun out from mining companies. These firms were based on highly specialised team of experts and engineers that were trained and got their experience while working for mining companies and later started up their own business.

The new organization of production generated that mining companies can now choose among different competing service providers. Furthermore, the general availability of capacities which was previously maintained within the mining companies, can now be completely outsourced. Indeed, virtually every step of the mining process can now be outsourced.

- b) *The technological rejuvenation of the mining industry:* Up to about the 1970s the mining industry was considered a mature industry, i.e., an industry characterised by slow change, low innovation rate and based on highly standardized technology operated by unskilled labour. However, the mining industry gradually came to use pervasive new technologies, which together with new organisational arrangement increased the innovation rate, productivity and profitability. For instance, over the period 1986-2003 Australian mining industry productivity grew more than four times faster than the average productivity growth of all industries: around 130 percent compared to 30 percent.

A large number of technological innovations and continued improvements in exploration, mining and mineral processing were introduced to the mining industry, which has been driving the development of this industry. For instance, satellite imaging methods have reduced the costs of geological exploration, and also geographical information systems allow to accurately mapping geological parameters for exploration purposes with a dramatic reduction in cost. Also, information technology have impacted almost all the mineral production processes by the use of a vastly

larger amount of data to predict, design, plan and control operations and installations. Thus, the description of the mining industry as a low-tech and low-innovation industry that prevailed during the 1980s is outdated and inappropriate.

Large mining companies were key learning centres for building-up and accumulating within their own organisation substantial bodies of KIMS-related technological capabilities and expertise, which were a key source for the technological rejuvenation.

The result of these two processes has created an interaction mode that combines competition with regular cooperation. Suppliers and users work closely during product development, which speed up innovation and knowledge diffusion. Technological breakthroughs are now available to the entire industry and consultants build up a more diverse experience base. The reorganisation of production and technological innovation were mutually reinforcing.

### **3. Leading global KIMS suppliers**

The KIMS supplier sector is highly diverse and very fragmented. There is no clear picture about the structure of the KIMS supplier sector and how it has been evolving. While some groups of KIMS suppliers seem to be consolidating and a few large companies lead the sector at the international level, there are other groups of KIMS firms controlled by medium size firms (between 50 and 500 workers) that have also been driving innovation and have been expanding internationally at a significant rate. Cutting across this changing diversity, one can identify at least three general groups of supplies – excluding the KIMS emerging in association with contractors and suppliers of equipments and inputs:

1) Large international consulting firms that integrate engineering, project management, procurement & construction activities, such as:

- Kvaerner (Employees: 44,000; Operational revenue: US\$ 8.3 billion, 2006) a Norwegian known as the largest shipbuilder in Europe, is committed to a complete withdrawal from this industry, seeking to reduce its reliance on manufacturing. Kvaerner is orienting itself toward the provision of engineering and other technological services to become a major player in the growing market for large-scale engineering and consultancy services.
- Hatch (Employees: 7,000, 2006) is a Canadian leading global consulting, engineering, procurement, project and construction management, and start-up and commissioning firm. The company is dedicated to three sectors: mining and metals; energy; and infrastructure.

- Bechtel Group, Inc. (Employees: 40,000; Operating Revenues: US\$18.1 billion, 2005). This North American company is a leading construction and engineering firms in the world, building everything from roads and bridges, to dams and pipelines, to power plants, and even entire cities.

2) Medium size specialised engineering consulting companies, such as:

- SRK Consulting (Employees: 600, 2006) is a South African international consulting that provides focused advice and solutions to earth and water resource industries. For mining projects, SRK offers services from exploration through feasibility, mine planning, and production to mine closure.
- AMC Consultants (Employees: 100, 2006) is an Australian leading mining consultancy providing services exclusively to the minerals sector. Its main services include mining engineering, exploration, geology, resource estimation, geomechanics, mine optimisation, feasibility studies, expert reports and valuations.

3) Small to medium size mining and geological software providers, such as:

- Maptek, (Employees: 200, 2006) an Australian mining software firm that pioneered geological modelling software.

#### **4. The importance of KIMS suppliers to the mining industry**

KIMS supplier expertise can play a very important role in shaping the profitability or the cost of investment projects. In particular consulting firms and project management firms have played a very important role during the feasibility, conceptualization, engineering and design, and also during the development and construction stages of investment projects.

Although the feasibility, design and engineering and project management services account for only about 7% to 12% of the cost of investment projects, they can determine the project success. For instance, KIMS firms expertise and innovation capability have transformed unprofitable projects in profitable ones and have expanded the value of ore or mineral deposits of mining companies.

KIMS not only support investment decisions and the strategic and corporate planning of mining companies. Their project development expertise also plays a very important role in terms of developing projects on time and on budget, coping with challenges that emerge during project development. In many cases, KIMS firms have become the

reservoir of knowledge and problem solving experience associated with thousand of projects.

In the case of on-going operations, the importance of KIMS is fairly similar to what take place during the investment project stage. For instance, KIMS concerned with optimisation and operational upgrading services have raised the profitability of on-going operations and extended the life-time of facilities and mines.

There is a lack of accurate figure about the share of KIMS in total operational costs. However, casual fieldwork sources estimate this figure to be around 10%.

## **5. The importance of KIMS suppliers for developing mining countries**

Mining industry innovation and the development of innovative capabilities processes (learning processes) have become a network phenomenon. Most innovations are not carried out only by mining companies, but also by other actors – notably KIMS suppliers – and also importantly by the interaction between user-producer.

Innovative capabilities derived from KIMS activities and interactions are fundamental for the competitiveness and sustainability of the mining industry, contributing to major improvements in productivity, safety and environmental impact issues.

Thus, developing countries that have an important mining activity require the development of KIMS capabilities to underpin a sustainable development of their mining industry.

The KIMS sector is diverse and fragmented and has a significant growth potential. Developing mining countries would benefit by the development of a knowledge-based services sector that first serve the local mining industry and then gradually the regional and world mining industry.

Thus, a KIMS sector development could lead towards the development of stronger knowledge-based clusters, which are able to compete at international level. Besides supporting the competitiveness of the mining industry in developing countries, these clusters also support the development of a range of knowledge-based products and services that may go beyond the scope of the mining industry.

## **6. To what extent have developing mining countries been successful in developing domestic KIMS suppliers?**

The experience of developing domestic KIMS suppliers in the context of developing countries has been uneven. Chile and South Africa provide an interesting contrast. While the development of Chilean KIMS has been weak, the South African one has shown much stronger development.

Several interacting factors have created this contrasting evolution. Three issues have been particularly important:

i) Large mining corporations have played a key role in the development of KIMS suppliers. These organisations were very important learning and innovation institutions, in which a significant part of KIMS innovation capabilities was built-up.

- Up to the mid-1970s Chile lacked of mining companies that carried out locally advanced engineering and knowledge based activities, which led to high level of KIMS capabilities. Thus, Chilean KIMS emergence was fairly weak because the scarcity of mining companies capabilities to be spun-out.
- On the other hand, over the 20<sup>th</sup> century, South African mining houses, such as Anglo-American, built very important engineering and other KIMS capabilities, which later were the seed for the development of KIMS suppliers. They also kept interacting with mining companies and therefore perpetuating the innovation process.

ii) Several innovation and learning opportunities are opened-up according to the level and complexity of mining activities. In other words, the higher the number of mining investment projects and on-going operations and the related technological challenges, the higher the potential for innovation and learning.

- Up to the late 1970s-early 1980s, the growth of the Chilean mining industry was low and based on the exploitation of very few copper ore deposits of very good quality, which were highly profitable. There were few important technological challenges that push to innovate in order to keep cost and productivity at a competitive level..
- South Africa has a much diverse mining industry. It does not rely on just one commodity but on several (gold, PGM, diamonds, coal, vanadium, chromium, nickel, uranium, copper, among others). There is also a vast variety of ore deposits, which present different technological challenges to be addressed in order to either extract the mineral from them or to keep running the facilities an



operations that already exist. In other words, the pressure to innovate has been higher than in Chile.

iii) Barrier to entry and participate in mining industry's global value chain, which are significantly controlled by multinational mining corporations. Several mining companies before extending their international presence assisted and/or encouraged the development of KIMS suppliers at their home country. Later on, when their global presence was expanded, they were inclined to work with many suppliers with which they had built trust and a close relationship. Consequently suppliers' internationalisation was encouraged.

- In South Africa very strong engineering and technological capabilities were built over all the period that South Africa's mining industry was isolated. This process was led by big corporation such as Anglo American. Later on, as South African mining companies developed their global presence so did some South African KIMS suppliers, which were following their user firms.
- Before the 1970s, Chilean mining industry had a significant lack of technological capabilities. For instance, during the late 1960s – early 1970s, less than 5% of the engineering required in mining industry's expansion projects was hired locally. During the 1970s and 1980s, together with the creation of Codelco (the state owned mining company) and its expansion and upgrading projects, local KIMS capabilities were strengthened (e.g. during the late 1980s between 70% to 95% of the engineering required in Codelco's expansions projects were hired to local suppliers). Nevertheless, Codelco did not go international, and during the 1990s international KIMS suppliers arrived to Chile and commenced to get a higher share of the local demand of KIMS services.

Other issues include: shortage of engineers and highly specialised and experienced experts; weak user-producer interactions and collaborations; interaction with large international project management firms, which have increased their control of mining industry's global value chain.

## **7. Possible policy lessons**

- The technological activities of mining corporations are at the core of the innovation and learning systems of successful mining industries and KIMS emergence and development. Although the general and pervasive outsourcing process changed the organisation of production, mining companies still played an important role in training experts, carrying out innovations and integrating technologies (actually, it would be important to question whether the

general outsourcing process has gone to far). Thus, policies that encourage mining companies to strengthen their internal innovation systems allowing others to participate and use mining activities to innovate and learn, would benefit the country's innovation capability more widely as well as the competitiveness of mining companies.

- Internationalisation has become an important source of innovation. A continued access to new investment projects and operations of increasing complexity, wherever they are located, has become an indispensable factor - either to keep high innovation capabilities level or to build-up higher innovation capabilities. Hence, policies that encourage internationalisation also encourage innovation. A plausible path towards internationalisation is via entering to big corporation international activities and value chain. Additionally, assisting junior mining companies' feasibility and engineering studies could be an alternative strategy that leads towards the participation in international mining projects.
- Investment attraction policies should also consider an active or strategic technology transfer mechanism. For instance, foreign direct investments (FDI) usually use the best available technologies to get the highest profits of a mining project. Then, policies that link FDI programmes with training programmes in order to use investment projects to build higher capabilities at the local level, could generate benefit for both, multinational mining companies and an incipient local KIMS clusters.

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