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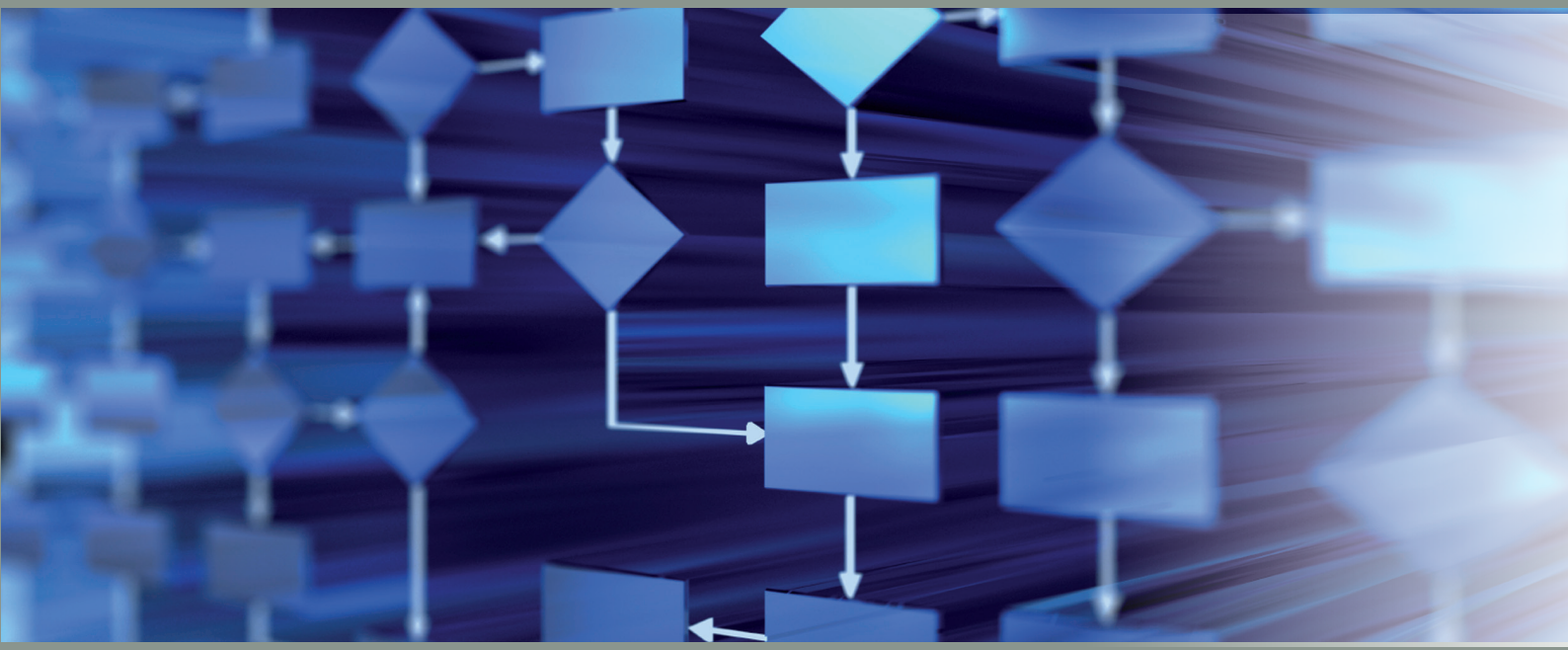

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Innovation and IP rights in the Chilean copper mining sector: The role of the mining, equipment, technology and services firms

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Abstract[‡]

This analysis of intellectual property (IP) protection practices among mining equipment, technology and services suppliers (METS) in Chile's copper mining sector adds to a body of literature that has hitherto focused on high-income countries. It is based on data collated from an online survey of resident METS and on semi-structured interviews of executives from mining companies and suppliers, including two universities. The main conclusion is that, although METS appear to be innovative in relation to the mining sector and the economy as a whole, only a few use intellectual property rights (IPRs) to protect their innovations. The main reasons for this finding appear to be the cost and expected complexity of the registration process. Another noteworthy finding is the view that Chile has the requisite legal IPR expertise, but commercial capabilities (expertise in IPR-based innovation management and business plans) are much less developed. In the last section, four case studies of product and process innovation by four mining suppliers add some interesting insights to the analysis.

JEL codes: L72, L78, O31, Q55, L24, O14
Keywords: Mining sector, Innovation, technology transfer, intellectual property

Disclaimer:

The views expressed here are those of the authors, and do not necessarily reflect those of the World Intellectual Property Organization or its member states.

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Introduction

The importance of the copper mining sector in Chile is unquestioned and is reflected in many production, international trade and fiscal revenue indicators. The sector, however, faces major challenges, namely deeper mines, scarcity of (and consequently more expensive) key inputs such as water and energy, lower-grade ores, concern for neighboring communities and respect for the environment. Innovation appears to be key to tackling these issues.

Given the well-documented causal relation between innovation and productivity gains[4], it is very important to determine whether there is also a correlation between intellectual property (IP) protection and innovation rates. Although this seems theoretically plausible (intellectual property rights are, in effect, temporary monopoly rights and thus incentives for innovation), there is little supporting empirical evidence.

This paper contains the findings of an online survey of 300 resident mining equipment, technology and services suppliers (METS) that are covered by EXPANDE, a public-private program on open innovation in the mining sector. The main survey objective was to collect information on the number of patents and other intellectual property rights (IPRs) filed, the firms' consideration of IP protection in their commercial strategies and the factors that underpin decisions on IP protection.

The survey analysis was complemented by semi-structured interviews of senior executives from a sample of 13 entities (four mining companies, seven METS and two universities). Four case studies on the firms interviewed have been selected because they interestingly reflect different types of innovation that should thus relate to different IP management strategies.

The literature on the subject has hitherto focused on high-income countries. Little, and rather anecdotal, evidence is available for middle-income countries (Hall *et al.* 2013). The only exception is the comprehensive report published by the National Institute of Industrial Property (INAPI) in 2010 and providing data on the patenting practices of companies participating in the Copper Mining Cluster Program from January 2000 to December 2009[5]. This paper complements and updates INAPI's 2010 analysis and raises new questions.

This paper differs from earlier endeavors by focusing on METS, while drawing on suggestions in the literature that they could play a major role in the mining sector's innovation patterns (Bravo-Ortega and Muñoz (2015, 2017), Navarro (2018), Meller and Gana (2016), Scott-Kemmis (2013) and references therein)). METS' innovative capabilities have been largely confirmed, but the findings show that they hardly rely on IP protection mechanisms[6]. Some evidence of the likely underlying factors is provided and policy implications suggested.

It must be stressed, however, that the information gathered yields only preliminary evidence on the importance of IP as a driver of innovation practices in the mining sector. The paper should generally be viewed as a starting point and an invitation to conduct new research in greater depth.

[4] See Bravo-Ortega and García (2011) and the references quoted therein, particularly Grilliches (1998) and Hall *et al*. (2010).
[5] See Navarro (2018) for a detailed analysis of this program.
[6] This may be so because only resident METS were considered; inclusion of multinational METS may lead to a different result.

The second section highlights the importance of the copper mining industry in Chile, while the third adduces some preliminary evidence on the sector's innovation capabilities, with particular emphasis on resident suppliers. The fourth section outlines the methodology and sources of information, while the fifth contains the main findings. The paper ends with the conclusion and policy recommendations.

1 The mining sector in Chile

The importance of the mining sector in Chile is reflected in many production, international trade, employment and fiscal revenue indicators. Chile holds 29.2 per cent of the world's copper reserves and accounts for 30 per cent of world output. The Chilean State owns the National Copper Corporation (Codelco), the world's largest copper producer, and the world's largest copper pit (Escondida, owned by Broken Hill Proprietary Company Limited (BHP) and Rio Tinto), is in northern Chile. Altogether, operations conducted in the country by BHP Billiton, Antofagasta Minerals S.A. (AMSA) and the State-owned Codelco account for 63 per cent of Chile's copper production and 21 per cent of world output.

Table 1 – Share of world output and reserves (%, 2015)

	Output	**Reserves**
Chile	30	29.2
Peru	9	11.4
USA	7	4.6
China	9	4.2
Russia	4	4.2
Australia	5	12.2
Canada	4	1.5
Zambia	4	2.8
Congo Democratic Republic	5	2.8

Sources: World Metal Statistics and Chilean Mining Council (based on COCHILCO and the US Geological Survey).

In 2016, mining production accounted for 11 per cent of gross domestic product (GDP), with copper production amounting to 10 per cent. These figures were stable throughout the 2013-2016 period. Copper exports accounted for 45 per cent of total exports in 2016[7]. The latter figure does give some cause for concern, as the high share of copper exports in total exports leaves the country extremely sensitive to the international business cycle.

Mining companies in Chile face challenges in a wide variety of areas, all of which are critical to productivity gains. Firstly, lower-grade ores and mines that are hard to exploit (the resources are at greater depth than in the past), the shortage of key inputs (mainly water) and relations with local communities (made more contentious, among other environmental problems, by air and water pollution) are all factors that raise production costs.

Moreover, the sector's total factor productivity (TFP) fell at an average estimated rate of 4.7 per cent per year between 1993 and 2015, according to a recent report by the Organisation for Economic Co-operation and Development (OECD, 2018). It also fell in other "mining countries", but the negative trend was sharper in Chile, as stressed in the report, and seemed to be the main factor of TFP stagnation in Chile's economy.

Owing to all of these factors, firms should become more innovative (Báez, 2015) and, for that reason, it is very important to understand the factors that can raise the sector's innovation rate. This point is addressed below.

[7] Source: Chilean Copper Commission (COCHILCO).

2 Innovation in the mining sector

2.1 Preliminary observations

As the factors that drive innovation differ from one sector of production to another, general innovation policies cannot be expected to be very successful, as suggested by Bravo-Ortega and Muñoz (2017). Drawing on industrial organization theories, these authors have conducted an analysis of the aspects that should be covered when considering innovation policy alternatives and they have, moreover, applied that framework to Chile's mining sector. A sectoral approach is taken in this portrayal of Chile's mining sector in terms of the ways in which mining companies and suppliers innovate and protect their innovations (provided that they innovate in the first place).

Interestingly, several authors have written that the sector (and extractive industries in general) is a canonical example of a non-innovative sector, at least in the case of big mining companies (Murphy, 2015). This view is consistent with the idea that it is more of a curse than a blessing for a country to be rich in natural resources (Sachs and Warner, 1995 and 2001), but it has been contested by Lederman and Maloney (2007), Bravo-Ortega and De Gregorio (2007) and Manzano and Rigobon (2007), among others. Suffice it to say here, without delving into the debate, that, other factors being equal, innovation seems to make a difference in resource-rich countries' reasons for taking differing development paths. It is therefore important to try to understand how innovation can be triggered in this sector.

The following issues appear to be critical in this regard: (i) development of linkages between end producers and input suppliers; (ii) collaboration by both end producers and input suppliers with universities and research institutes; and (iii) in-house innovation which, in the case of suppliers, is crucial to the development of knowledge-intensive mining services (KIMS) (for supporting evidence, see Chile Foundation (FCH) (2014), Fessehaie and Morris (2013) and Bravo-Ortega and Muñoz (2015)). In Chile, public and private efforts have been made under these three heads. Examples of collaboration between the public sector and private firms include the World Class Mining Suppliers Program[8], developed by BHP Billiton and Codelco (FCH, 2016), and the Alta Ley Mining Program, which is jointly administered by the Production Development Corporation (CORFO)[9] and the Ministry of Mining and is designed primarily to strengthen productivity, competitiveness and innovation in the national mining industry and to build national KIMS-exporting capacity.

Moreover, CORFO administers innovation and production development policy instruments that include incentives for innovation-boosting foreign direct investment and direct and indirect fiscal support for firms in the mining value chain, albeit not specifically tailored to them or their regions. Lastly, the National Commission for Research in Science and Technology (CONICYT) implements programs that provide incentives for companies to hire high-level human capital (CORFO, 2008 and 2009). Less attention has been paid to the role of IP regulation as a means of spurring innovation.

[8] For further details, see Navarro (2017).

[9] This is the national development agency and it is attached to the Ministry of Economy, Development and Tourism.

2.2 The role of specialized suppliers in Chile

Although the sector has been described as not very innovative, this might be an untenable view because it focuses only on end producers (mining firms) whereas most mining innovations seem to be actually developed by specialized suppliers rather than big mining operators (Murphy, 2015). Klevorick *et al*. (1995) point to the technological opportunities arising in various sectors as a major cause of poor innovative performance and conclude that metal production is indeed one of the sectors in which technological opportunities are low. Hall *et al.* (2013) reinforce this point and attribute Chile's low patent intensity partly to an industrial specialization pattern dominated by sectors with a low propensity to patent, such as the mining sector.

Suppliers have grown in importance as "innovation drivers", moreover, because mining firms are increasingly outsourcing non-strategic tasks such as transport, by-products, information technology (IT) services and equipment maintenance so that they can focus on their core business areas (FCH, 2014). According to FCH (2014), METS innovation rates are higher than recorded national economy and mining industry averages. Moreover, 25 per cent of the companies surveyed, by category, were classified as Essential Innovators, which are companies (METS) that have high levels of innovation and capabilities for new technology and equipment development.

Table 2 – Percentage of innovating firms (mining suppliers in relation to the industry and the economy)

Type of innovation	METS firms	Mining firms	National economy
Product	60	12	12
Process	41	35	16
Management	51	27	14
Marketing	31	10	10

Source: FCH (2014)

In terms of innovation capabilities and performance, however, this sample might not be considered very representative of the METS universe. As a matter of fact, the sample covered companies which had taken part in the World Class Supplier Program and which are characterized by being more sales- than mining-intensive and by having higher levels of professionalization and of innovation and export capacity than the average supplier.

Despite this likely bias, the findings have been largely confirmed by a recent report by the Industrial Mining Suppliers Association (APRIMIN) and the Chilean Copper Commission (COCHILCO) on the innovative behavior of 108 resident METS (APRIMIN/COCHILCO, 2017). According to the report, innovation is highly valued by companies, 75 per cent of which reportedly have an innovation budget, and there are no apparent differences between national and foreign companies, although foreign companies had higher innovation rates. Among other findings, most of the respondent companies (83 per cent) reported that they had experience of piloting, although there was scope for even greater cooperation with other competitors and research centers. Lastly, CORFO was most widely recognized as the institution that channeled public support for innovation activities.

According to FCH/PROCHILE (2017), Chile's resident METS export to a total of 39 countries in 2016 amounted to nearly 3 billion dollars. The main destinations were Peru (43 per cent), the United States of America (28 per cent) and Mexico (6 per cent). The supplier sector mainly exported mining design and engineering consultancy services, which accounted for 44 per cent of services exported in 2016. Original software design services ranked second at 25 per cent and IT consultancy services and technical support ranked third at 22 per cent.

Export capacity was high, despite the low copper cycle (prices), as local companies had maintained product development and international mining market share and had exported significant amounts.

2.3 IP in Chile's mining sector

As stated above, the mining sector faces major efficiency, productivity and sustainability challenges. Innovations leading to improvements in one or more of these areas may give a great competitive edge to firms and, to retain that advantage, consideration must be given to IP protection.

IP protection not only constitutes an effective tool for resolving appropriability issues[10], but also affords an opportunity to raise a firm's commercial value because IPRs are an asset that can be used strategically. For instance, patents can be licensed and even sold. This added value can also be used as fund-raising collateral. Codelco's experience illustrates this point. IP comes into play when Codelco develops mining equipment prototypes and enters into supplier agreements. Once tested, the prototypes are incorporated into Codelco's production processes. Under the agreements, Codelco transfers IPRs to its commercial partner in order to optimize product development. Moreover, IP plays a major role in a firm's network of alliances with various companies, research centers and universities (Báez, 2015).

Mining is one of the sectors that contribute most to patenting in Chile, together with the chemical and pharmaceutical sectors. Codelco and its technological division (Codelco Tech), both included in the sample of companies interviewed for this paper, are the leading patentholders (see Table 3). Box 1 covers Codelco's innovation and IP strategy.

Table 3 – Mining-related patents filed in the Chilean patent office

Year	Non-Residents	Residents	
		Total	Of which Codelco
2009	85	59	11 (19%)
2011	130	49	2 (4%)
2012	187	41	1 (2%)
2013	188	41	2 (5%)
2014	200	55	10 (18%)
2015	177	67	4 (6%)
2016	169	43	1 (2%)
2017	117	39	8 (21%)
Total	1,288	443	51 (12%)

Source: INAPI

In the preceding nine years (2000-2009), 1,090 patents were filed (INAPI, 2010). In the period under review, 1,731 patents were filed, an increase of 58 per cent. In 2000-2009, 41 per cent of the applications filed were national patent applications, which fell in the following nine years to 26 per cent but remained higher than the average for national applications within the economy as a whole[11]. Most national patent applications therefore originated in the mining sector.

[10] Trade secret and know-how are probably of some importance in mining, since many innovations concern process, rather than product, technologies (Murphy, 2015).
[11] The percentage was 14.5 in the 2000-2009 period (INAPI, 2010). Figures for the latter year are not available.

Table 4 – Major 10 non-resident (NR) firms filing patents in Chile, by country of origin

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	***Total***
United States	23	11	22	47	44	43	43	32	25	*290*
Germany	7	2	19	24	25	26	14	19	6	*142*
Finland	3	2	15	13	8	23	18	26	12	*120*
Australia	8	2	14	12	11	14	11	10	6	*88*
Switzerland	1	1	6	10	16	16	8	14	10	*82*
Canada	3	1	7	12	8	10	8	9	11	*69*
Japan	14	2	3	9	7	4	12	4	3	*58*
France	1	1	9	4	7	12	5	10	2	*51*
Brazil	3	3	2	7	7	7	4	2	8	*43*
United Kingdom		3	5	5	11	2	4	6	1	*37*
Total	*63*	*28*	*102*	*143*	*144*	*157*	*127*	*132*	*84*	*980*
(NR %)	*74*	*80*	*78*	*76*	*77*	*79*	*72*	*78*	*72*	*76*

Source: INAPI

Box 1. Codelco's innovation strategy (the role of Codelco Tech)

Codelco's importance to mining in Chile merits further examination of how the company is organized for innovation.
In 2016, Codelco merged its technological companies (IM2, BioSigma and Codelco Lab) into a single division known as Codelco Tech.
The new company is wholly owned by Codelco and has devised an open solutions development model that incorporates and promotes contributions by suppliers, research centers, start-ups and other entities.
Each of Codelco Tech's many units is tasked with seeking solutions in areas such as pyrometallurgy, hydrometallurgy, water, energy, underground mining, pit mining, biotechnology, automation, robotization, remotization, data science and new uses of copper, lithium, molybdenum, sulfuric acid and by-products.
The company has established an innovation management system in order to measure its impact over time in relation to a 2016 baseline.
By 2015, Codelco had filed 250 national and international patent applications, 134 of which have been granted in Chile and 21 in other countries[12]. The company has focused its innovation strategy on developing smart mining technologies for use at every stage of production in order to raise productivity and operational efficiency and achieve significant cost savings. These technologies include remotely controlled mineral-extracting robotic machinery that considerably reduce miners' occupational hazards, and new digital technologies for ever greater integration and automation of remotely managed processing operations (Source: Báez, 2015 and interview of senior Codelco Tech and Codelco executives).

According to INAPI (2010), in the 2000-2009 period, 93.3 per cent of applications were filed by firms domiciled in 10 different countries. Chile led the ranking with 41.4 per cent, followed by Finland (12%) and the United States of America (11%). The most recent data for the 2009-2017 period paint a similar picture, with the United States of America replacing Finland in second position. Table 4 shows the 10 countries that have filed the greatest number of patents in Chile in the last nine years.

[12] The difference of 165 is the number of patents pending.

2.4 INAPI's role

Several public policies in Chile have been designed to spur innovation in the private sector and collaboration among firms, universities and other research centers, while some innovation-boosting programs have specifically targeted mining suppliers. Many publications, academic articles and official reports have touched on these programs but not on policy efforts to regulate IPRs.

INAPI is Chile's IP Office. Its current policy agenda, of relevance to the mining sector, includes statistical data (Analiza)[13], capacity-building, awareness-raising, advice to small- and medium-sized enterprises (SMEs) and public policy. Under the first component, INAPI conducts surveys and issues reports on the current status of IP in the mining sector, as exemplified by the above-mentioned publication (INAPI, 2010), which complements other reports on mining issues.

The second component consists of training programs for mining sector entities, including operational and innovation management staff. The achievements of "INAPI in the field", a project, have been considerable in the north of the country, which is the predominant mining region. For example, INAPI provides training in IP strategies to member companies of the Antofagasta Industrial Suppliers Association that are at the technology-development and product-packaging stage (an advanced stage of the innovation pipeline).

Lastly, INAPI contributes to public policy formulation on the subject as a permanent advisor on CORFO-based programs that provide funding for large-scale and long-term innovation in mining sector projects. This is the case of the Innova Chile committee, the Technological Capabilities subcommittee and the Alta Ley Council, through which the major stakeholders (academia, suppliers and mining companies) meet to draw up a roadmap to solve industry-wide problems (the roadmap is used by CORFO in drawing up its technological support programs). On INAPI's recommendation, all beneficiary companies under CORFO-administered innovation support programs are required to have IP management strategies in place and to keep available technologies under technological surveillance. These rules are necessary because many mining industry technologies have not been protected owing primarily (if not only) to a lack of awareness of IP protection mechanisms and the myth about their costs and complexity (lack of knowledge leads naturally to immobility)[14].

As explained in the fifth section, the opinions collected from the semi-structured interviews and the surveys give some insights into the esteem in which mining firms, suppliers and academia hold INAPI and the scope for raising that esteem.

[13] https://www.inapi.cl/portal/publicaciones/608/w3-propertyvalue-12030.html.
[14] Interview of María José García (Deputy Director, INAPI Knowledge Transfer Unit).

3 Methods and Data

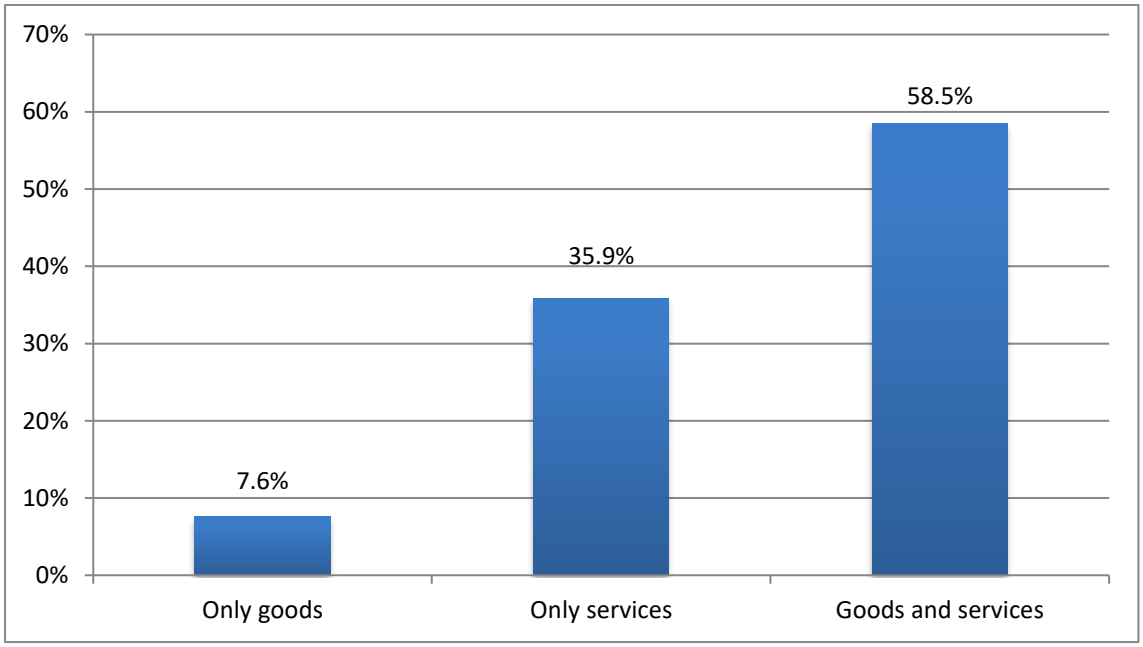
Inputs were gathered from three main sources, namely online surveys, semi-structured interviews and case studies. Each information source is covered below.

3.1 Survey: EXPANDE Program

An online survey was conducted of 300 resident suppliers that form part of EXPANDE, which is the first ever open-innovation mining program. Led by BHP, AMSA, Codelco and FCH, the program was established in 2017 and builds on the lessons learnt from the World Class Suppliers Program (2008-2016). EXPANDE seeks to link mining companies that require technological solutions not only to suppliers, but also to other stakeholders in the ecosystem such as investment funds, banks, export promotion agencies and international knowledge nodes.

The firms were interviewed about their innovation practices, their use of IP instruments (if any) and their opinion of the IP protection system in Chile. Basic corporate financial information, such as Gross Domestic Expenditure on Research and Development (GERD), exports and number of employees, was gathered. As Figure 1 shows, most firms produce both goods and services, followed by those which only produce services. A small proportion of firms (7.5 per cent) produce only goods.

Figure 1 – Types of firm surveyed, by products supplied



Source: Survey of EXPANDE firms. Notes: Of the 57 survey respondent firms, 53 answered this question.

Table 5 shows some descriptive corporate statistics. The sample was restricted to the 42 firms recorded in the database as having positive sales[15]. Although the standard deviation (Column 3) suggests that the firms are highly heterogeneous, closer examination shows that only a few "outliers" influence the result. The four biggest firms effectively account for 83 per cent, with a single firm accounting for 37 per cent, of total sales (Figures 2 and 3 illustrate the highly skewed distribution of the data on sales and number of workers).

[15] The full sample (57 firms) is considered in all tables except Table 5, as the remaining 14 firms answered all of the other questions and only omitted the "economic data" questions.

If the sample is narrowed down to 38 firms (excluding the largest four), the resultant statistics are those shown in the last three columns[16].

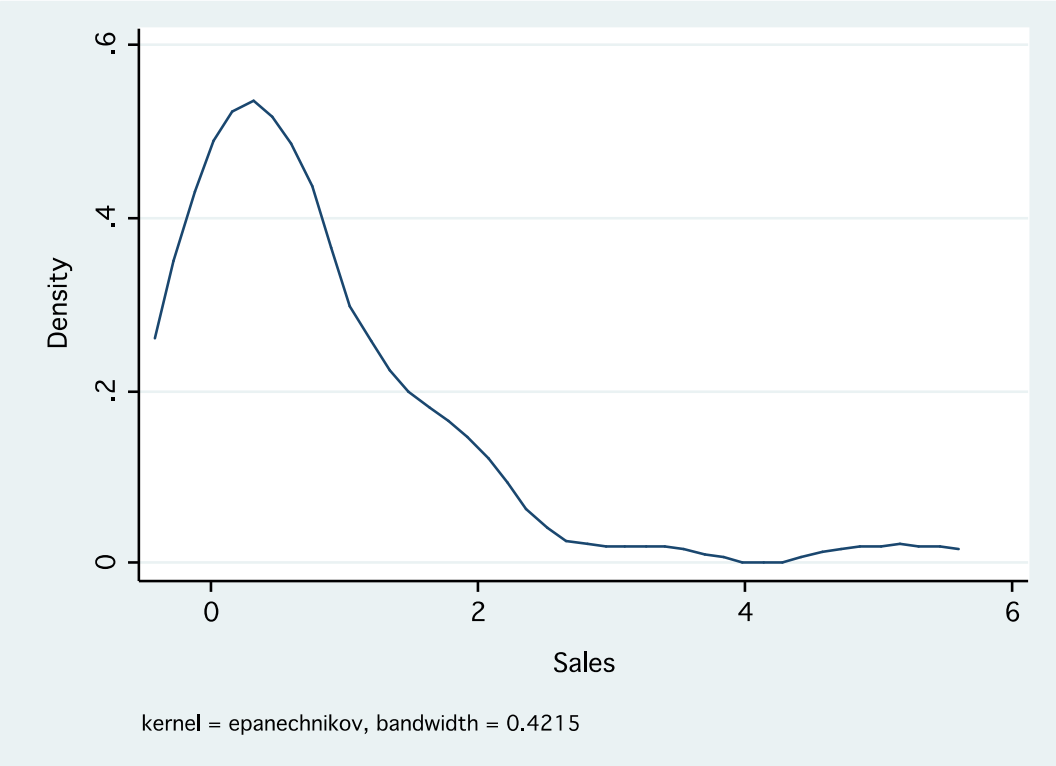
One result that does not significantly change from one table to the other is the GERD-to-sales ratio, which is higher than that of the mining sector as a whole and that of the general economy. This finding is consistent with the tendency for METS to be more innovative than other firms in the sector and in other industries.

Table 5 – Descriptive statistics (in US dollars)

	Full sample			**Four largest firms excluded**		
	(1) Mean	(2) Median	(3) St Dev	(4) Mean	(5) Median	(6) St Dev
Sales	4,100,835	463,333	11,723,221	775,133	425,000	1,023,938
Exports (*)	211,024	50,000	333,055	163,940	45,412	322,443
Workers	47	9	110	15	7	16
GERD	81,718	8,333	124,774	80,607	12,500	140,183
GERD to sales (percentage)	12	2.1	23.8	13.3	2.3	24.8

Source: Survey of EXPANDE firms. Notes: (*) Among exporters

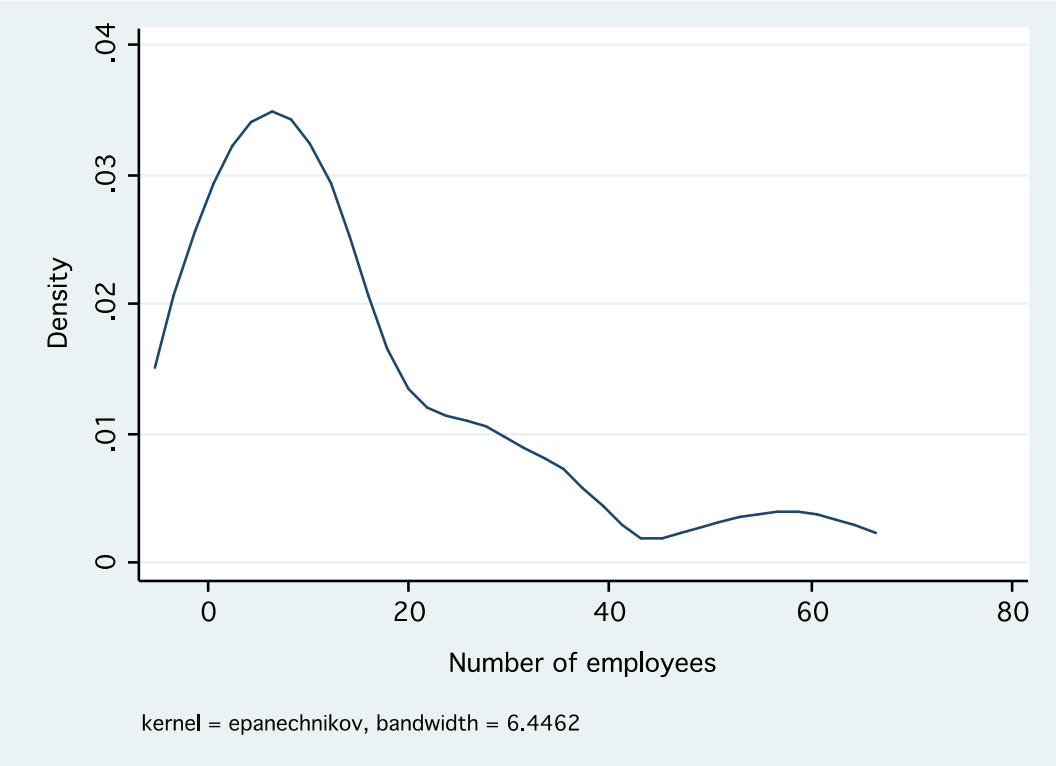
Figure 2 – Sales (frequency distribution, excluding the largest four firms)



Source: Survey of EXPANDE firms

[16] The mean values for sales and number of workers are very similar to economy-wide SME values, as reported by the National Bureau of Statistics and Chile's National Tax Agency.

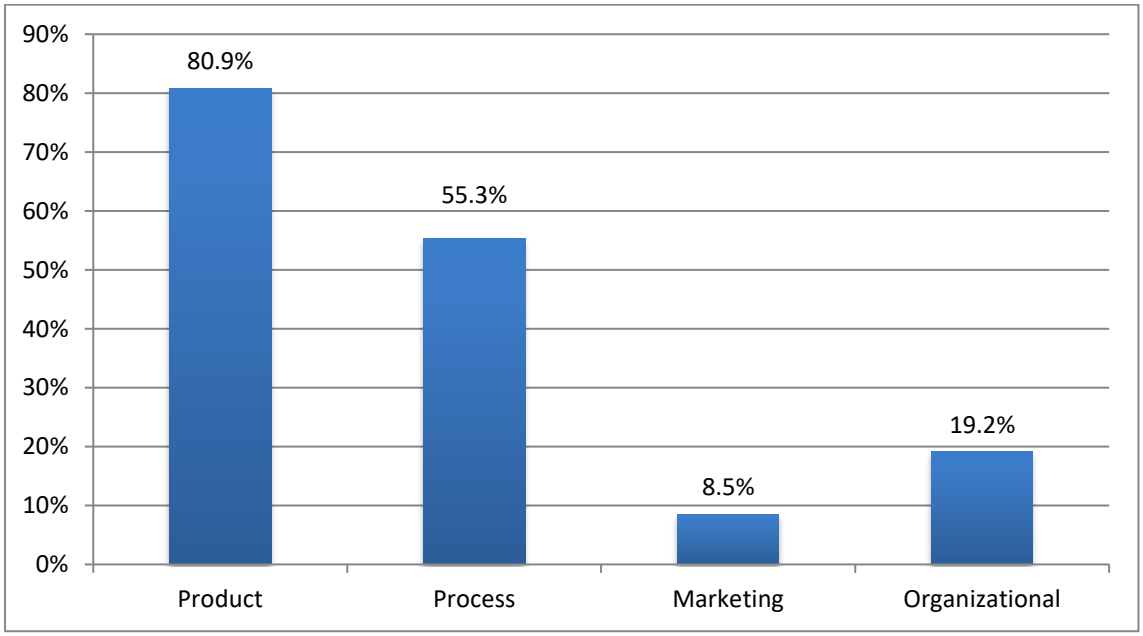
Figure 3 – Employees (frequency distribution, excluding the largest four firms)



Source: Survey of EXPANDE firms

Most respondent METS engaged in product innovation (81%) and process innovation (55%). Mining companies seem to require these types of innovation the most, as illustrated in the "Case studies" section.

Figure 4 – Type of innovation



Source: Survey of EXPANDE firms. Notes: Of the 57 survey respondent firms, 47 answered this question.

3.2 Semi-structured interviews

In an analysis of mining industry patents, Francis (2015), mindful of the wide array of technologies involved, classified patents applicants into three groups, namely miners, METS and major publicly funded entities such as universities. This classification was followed in conducting semi-structured interviews of senior executives from a sample of four mining firms, seven METS and two universities[17].

All of these organizations consider themselves to be innovative, have collaborated on innovation projects with universities or non-academic research centers at least once and are active users (beneficiaries) of public innovation-supporting instruments. As to IP protection mechanisms, most rely on patents, which they have registered both nationally and internationally through procedural formalities delegated to external lawyers[18].

The interview questionnaire contained questions designed to elicit information on these organizations' innovation and IP protection practices. The interviews usefully corroborated some survey findings. It is noteworthy, however, that although the sample is very small, the companies were not selected at random.

3.3 Case studies

Two case studies are similarly structured. They set out the innovation idea and its expected impact, any difficulties encountered during the innovation process and the way in which each organization has handled related IP matters.

The two METS were selected from the sample of interviewees. The case studies are particularly interesting because they concern different types of innovation for which different kinds of protection could be sought. The scope of application, too, varies: the first concerns a process innovation that is applicable to all copper mines worldwide, while the second concerns a product innovation that is tailored to the particular mine and could hardly be sold abroad.

4 Analysis

This section provides some preliminary ideas on the IP protection practices of the suppliers surveyed. The interviews yielded valuable complementary information.

4.1 Do METS rely on IP protection mechanisms?

As noted earlier, the METS surveyed considered themselves to be innovative. This has been borne out by their responses on the type of innovation and the average GERD.

The next question of interest was whether the firms protected their innovations. As shown in Table 6, the answer to this question is in the negative. METS do not protect the outcome of

[17] For further details on the companies and universities interviewed, see Bravo-Ortega and Price (2018).

[18] Only South American Management (SAMSA) responded that it did not hold any IPRs (this company had never applied for any IP protection). This is understandable because it is a mining prospection consultancy firm and, according to INAPI (2010), exploration does not require much IP protection and is one of the three areas in the mining value chain in which both resident and non-resident companies require the least protection.

their innovation efforts. Most firms have not filed IP applications either in Chile or abroad[19]. This is particularly true of industrial designs and utility models.

Table 6 – IP applications filed in the Chilean patent office and abroad, by instrument (%)

	In Chile			Abroad		
	0	1	2 or +	0	1	2 or +
Patents	52.9	26.5	20.6	60.9	17.4	21.7
Utility models	91.3	4.4	4.4	90.0	0.0	10.0
Industrial design	87.5	12.5	0.0	85.0	0.0	15.0
Trademarks	79.2	16.7	4.2	84.2	0.0	15.8

Source: Survey of EXPANDE firms. Notes: Of the 57 survey respondent firms, 41 answered this question. The likelihood of "self-selection bias" relating to this omission certainly cannot be ruled out.

Although most METS do not protect their innovations, nearly 90 per cent of them stated that they take IP issues into account when appraising new business opportunities, as Table 7 shows. The table also shows that most METS are fully aware of IP protection costs and regulations.

Table 7 – Questions on IP practices and regulation (%)

	Yes	No
Do you know the legislation that regulates IP in Chile?	74	26
When appraising new business opportunities, do you consider the IP involved?	88	12
Do your company's employment and supplier contracts contain any clauses on confidentiality and/or other IP ownership matters?	74	26

Source: Survey of EXPANDE firms. Notes: Of the 57 survey respondent firms, 50 answered this question.

4.2 Why do innovative METS not rely on IP protection mechanisms?

The literature suggests that the major reasons for this situation are patent costs, the perceived complexity of the patent system and some companies' preference for soft forms of protection such as trade secrets[20]. As shown in Table 8, the analysis has confirmed that this holds true for METS, as respondents have pointed to costs as the major reason for not protecting an innovation. It has also been confirmed by Figure 5, which shows that 69 per cent of respondents identified costs as a major factor in their protection decision, possibly because resident METS in Chile tend to be SMEs. Conversely, protection is standard practice (especially through patents) among large mining companies, as confirmed by some mining firms' senior executives during the interviews.

[19] The figures shown in this document concern filed IPRs only (as do details on granted IP mechanisms, but emphasis is laid on companies' interest in securing protection, which is measured by the percentage of firms applying for protection).

[20] See *Kalanje, Christopher. Role of Intellectual Property in Innovation and New Product Development. SMEs Division, WIPO. (*Downloaded on 17/09/17 from www.wipo.int/sme/en/documents/ip_innovation_development_fulltext.html) and the evidence quoted thereon).

Box 2. The likely impact of a patent box mechanism

If cost is a major protection-hindering factor, then cost-reduction policies could trigger IP protection practices. Alternatively, a policy could be introduced to raise the expected return on IP protection. As noted above, IP mechanisms can generate revenue, which has led policymakers in some countries to incentivize protection practices through tax reductions on IP-related revenue. One example of such incentives is the "patent box" system, which consists in reducing the marginal tax rate levied on net revenue from sales and licensing of intangible assets.[21] This incentive has been implemented in many countries (in particular European OECD countries), and one interview question elicited mining firms' and suppliers' opinion on the attractiveness of including the patent box in Chile's legislation.

The interviewees' opinions on the subject varied and depended largely on each company's business model. For instance, two large mining companies stated that they did not intend to sell their technologies but such incentives could still be of interest for, although they did not market their technologies, they were required to charge a "transfer price" to related parties for their companies' own mining operations that were conducted under a different legal number for tax purposes. For example, if AMSA transferred technology to Pelambres, one of its own pits, which has its own legal (tax) identification number and therefore counts as a "party related" to AMSA, under the current legal system, AMSA must charge a transfer price to Pelambres, thus accruing taxable revenue. Under such a scheme, the patent box would be interesting financially (cost savings).

Two of the METS interviewed considered that the patent box system would be a particularly powerful incentive for innovation and protection. It would essentially constitute new funding for research and development (R&D). As a matter of fact, some METS innovate and afterwards form a new company, in partnership with investment funds, to market newly developed technologies or goods. The new company must pay royalties to the developer, which thus accrues taxable revenue. The patent box would, in this case, be an additional source of funding for innovative METS. Other companies, on the contrary, ascribed less importance such an incentive because they file patents as a defensive strategy and do not intend to sell or license the technology.

This topic certainly requires analysis in greater depth.

Moreover, Table 8 shows that nearly one fifth of the firms surveyed lacked knowledge of IP protection mechanisms and utilization; this interesting finding casts light on the need for information and training policies in this area to be more effectual[22].

Table 8 – Innovating firms' reasons for not protecting innovations (%)

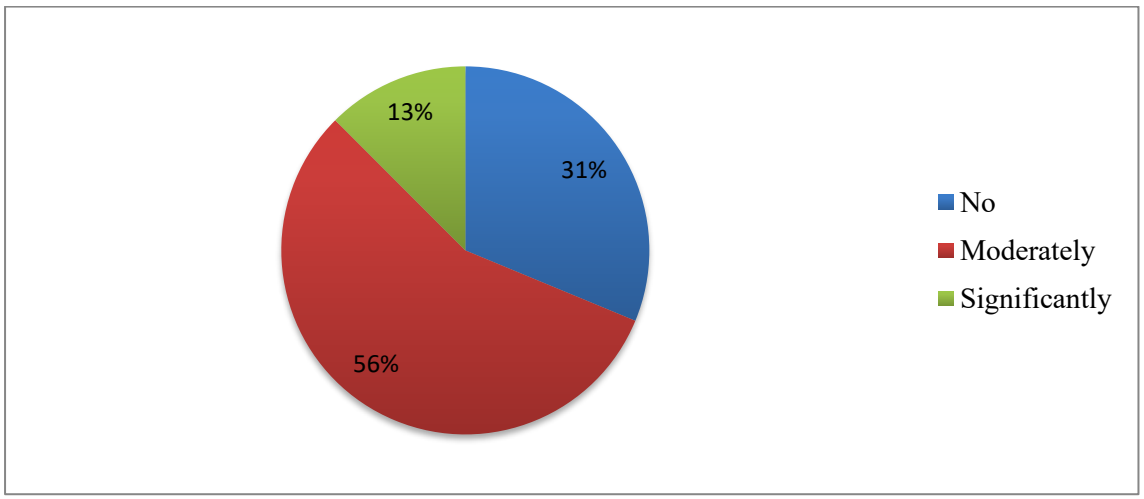
The cost (including money spent and time involved) is too high	40.0
Not applicable to this innovation (e.g., software)	33.3
Does not know of IP protection opportunities	16.7
Another (softer) type of protection (e.g., trade secret or copyright)	10.0

Source: Survey of EXPANDE firms. Notes: Of the 57 survey respondent firms, 31 answered this question.

[21] As patents are an outcome of R&D effort, the patent box constitutes preferential treatment of R&D investment (see Bellingwout *et al*., 2012 and Evers *et al*., 2014).

[22] Mindful of the importance of this activity, INAPI held two patent drafting courses in the preceding ten months (Source: interview of senior INAPI staff).

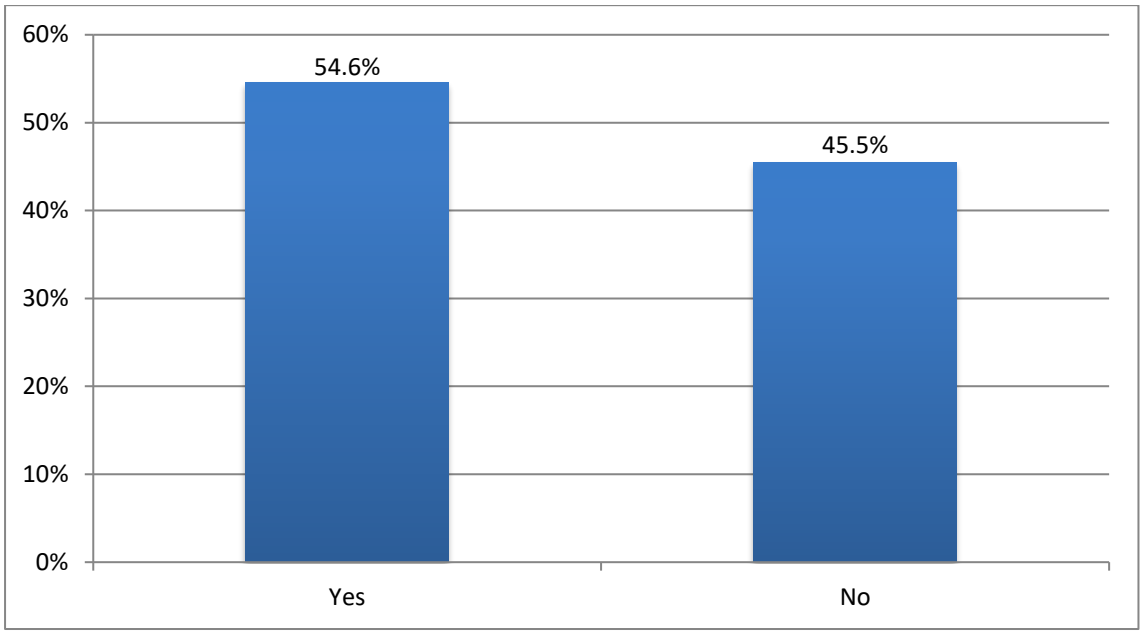
Figure 5 – Do IP registration costs affect protection decisions in Chile?



Source: Survey of EXPANDE firms. Notes: Of the 57 survey respondent firms, 48 answered this question.

As noted above, some METS preferred "softer" forms of protection. METS surveyed seem to rely on trade secrets as a form of soft protection. Figure 6 indicates that 55 per cent of the respondent firms actually have trade secrets.

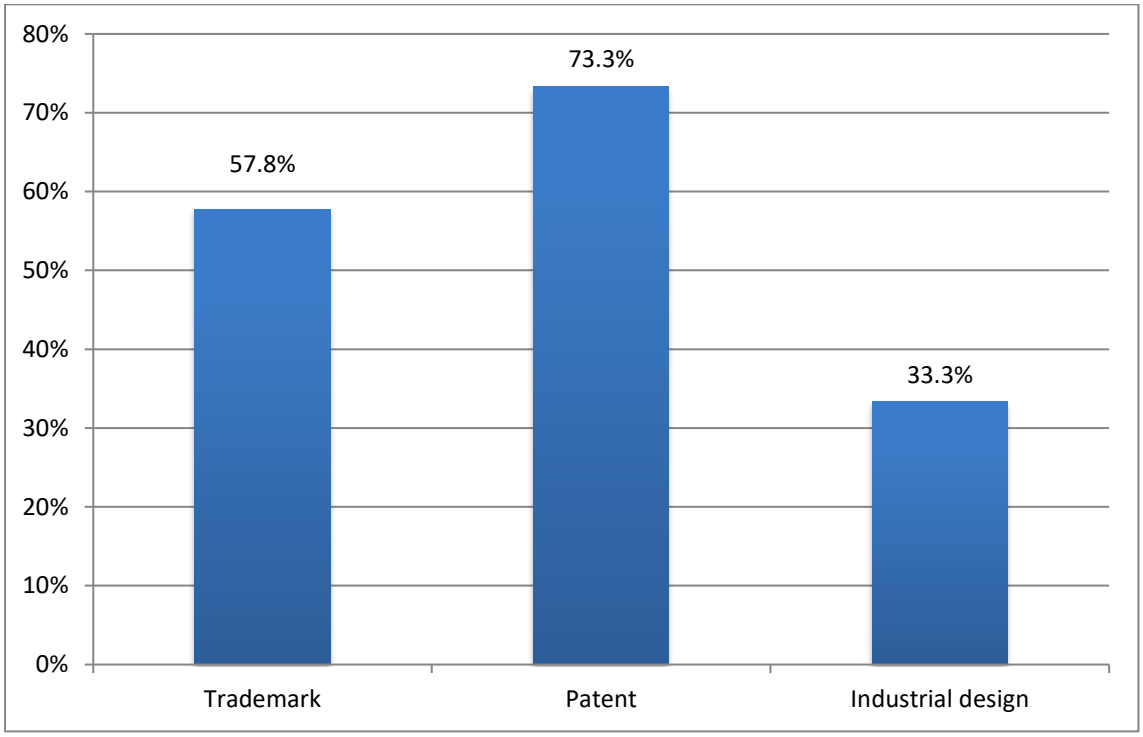
Figure 6 – Does your firm have trade secrets?



Source: Survey of EXPANDE firms. Notes: Of the 57 survey respondent firms, 44 answered this question.

Interest in IP protection differed among firms, depending on whether they were exporters and on their export intensity. The number of exporting firms is so small that this point could not be tested in the analysis. A survey question was nonetheless drafted to gather information on firms that intended to export goods or services. Figure 7 shows that most METS (73%) that wished to sell goods/services abroad were interested in filing for a patent through the international IP registration system and in other means of IP protection such as trademarks (58 per cent) and industrial designs (33 per cent). The importance ascribed to trademarks is consistent, moreover, with most respondent METS' tendency to invest in product innovation, inasmuch as the significance of trademarks becomes apparent when a new or improved good is to be marketed and a mark is to be devised for that purpose.

Figure 7 – IP instruments of apparent interest to potential exporters



Source: Survey of EXPANDE firms. Notes: Of the 57 survey respondent firms, 45 answered this question.

4.3 Firms' knowledge and opinion of INAPI

As shown above (Table 7), most METS surveyed (74%) knew of the legislation that regulated IP in Chile but, as it was not certain whether they knew specifically of INAPI and its mission, a question was crafted to address the issue specifically in the semi-structured interviews; the opinions thus collected might be useful to INAPI when it reviews its internal procedures, objectives and community service delivery. With regard to Table 9, interviewees requested that the name of their companies be withheld but, in truth, some firms held more than one of the opinions listed in the table.

4.4 Does the capacity for IP protection suffice?

The interviewees seemed to share the view that Chile's expertise for proper legal and technical advice on IP strategy management sufficed.

Some interviewees considered, however, that the country lacked the required capabilities to develop business models to take full advantage of the economic potential of IP assets and that IPRs should be regarded as assets which had a clearly defined life cycle and which must give a return on time. For instance, many innovators of process and product innovations should consider ways and means of finding new markets and/or of licensing or even selling their IPRs. Capabilities must be built to take up those challenges effectively.

Universities are a good example of the country's efforts to develop such skills and they are major stakeholders in the transfer of new knowledge and technologies to the production sector. They develop new knowledge, some of which is protected by IPRs. Engineers and managers with advanced knowledge of innovation business models are being recruited in order to take full advantage of those rights.

Table 9 – Interviewed firms' opinions of INAPI

Opinion/Recommendations	Frequency
As the process is slow in Chile, it is often better to register first in other countries and only afterwards in Chile. Four companies responded that they first approached INAPI only when they planned to protect their innovations only in Chile.	4
Three interviewees said that the INAPI website was not very friendly and provided much less information than foreign IP agencies' websites.*	3
Another MET called for major geographical decentralization and for the regulation to be amended to permit software protection.	1
Three interviewees considered that INAPI was a world-class agency. They welcomed the signing of the Patent Cooperation Treaty (PCT) by INAPI and the agency's active involvement in public policy discussions on IP and innovation.	3
Technological surveillance is difficult because INAPI has not digitalized the information that it holds. Even countries that are less developed than Chile have digitalized their data, as one interviewee stated, while another noted that INAPI had taken action to resolve the matter.**	3
One firm noted, interestingly, that law firms specializing in IP (as distinct from those having IP as one of a bundle of areas of expertise) were more trustworthy, with easier working relations, and that INAPI should make a public register of such law firms available to the sector (those law firms could, moreover, be certified by INAPI, if they met specific international standards).	1

Source: Survey of EXPANDE firms. Notes: (*) INAPI was resolving the matter while this research project was under way. The website was completely changed earlier in the year to be more user friendly. (**) INAPI had taken action while the survey was under way; it introduced electronic filing in January 2018.

Box 3. Universities and technology transfer – a note of warning

Only a few academics engage in applied research projects in Chile and have good connections with the production sector. This is partly due to the academic bias of focusing on papers (indexed publications) and the related impact index, with basic research being rewards more than applied research projects. Patents do not weigh in the balance when a professor is being promoted to a new position. Such bias is partly due to the preponderance of evaluation committees composed of academics only.

Public funding is, however, available to conduct applied research and reward IPR generation. One example is the Scientific and Technological Development Support Fund (FONDEF) Program (administered by CONICYT), which has led to improved IP management capabilities. For instance, at the University of Chile, there is an Intellectual Property Central Commission, and all IPRs in an innovation project in which one of the university's academics participates are owned by the university, which provides counterpart funding for registration (albeit restricted to Chile), as well as legal and commercial expertise.

Academics generally engage in such projects jointly with private or public firms, in which case IPR ownership must be shared in proportion to each party's funding contribution. FONDEF, which has generated a patent that is owned partly by Codelco Tech (33 per cent) and partly by the University of Chile (67 per cent), is a case in point and, interestingly, the patent and a trademark were registered in order to protect the commercial name of the marketed product.

There is room for improvement in this area. A good first step would be to acknowledge that complex universities must place the dual task of generating and transferring knowledge to society at the very core of their *raison d'être*, that they must therefore invest more resources and develop more capabilities in their technology transfer departments, and that they must reward professors on the basis of not only their indexed publication record, but also their IPR acquisition.

4.5 Case studies

The four case studies describe the product- and process-innovation efforts of four mining suppliers, the partners with which they have engaged, the difficulties that they have encountered and the IP protection strategies that each has implemented. The form of IP protection selected and sale or licensing intentions relate largely to matters such as the type of innovation and the market served.

4.5.1 iFlux (Innovaxxion)

Innovaxxion has excelled as a supplier of innovative solutions based on technology and applied engineering. It operates mostly in the mining sector, although it also develops applications for other industries (defense, energy and agro-industry). It has filed 15 patents in the past 24 months in the 10 countries in which the 20 largest copper operations are concentrated.

The firm has developed a knowledge creation model under which it generates and patents innovations and then forms companies to market the new good. It invites investors to enter into the ownership of the new companies, but it retains the controlling share.

This company's innovation model is based on the "design thinking" method, which relies on seven steps and five scales, from identification of the innovation challenge to hypothesis

testing. It works with other firms and with universities. Initial ideas undergo digital prototyping, which roughly 15 per cent survive and move to the next stage (three-dimensional prototyping). The idea that best meets requirements is selected, a real size prototype is made and large-scale testing (in an industrial environment) is conducted. If all is successful, a spin-off is formed and Innovaxxion outsources manufacturing to a "partner company". The firm usually files two patents – one to protect the specific solution (which has a clearly determined physical appearance) and the other to protect the formulation (i.e. the specific range of parameters); this is common practice in the pharmaceutical industry when laboratories protect new drugs[23].

Applying its innovation model, the company has devised and successfully marketed iFlux, an innovative solution that optimizes processes in foundry furnaces. iFlux is based on components that, under a briquette format, penetrate the surface of the bath inside furnaces and generate a series of chemical reactions to recover a higher percentage of copper than is usually possible in the smelting process.

The product is sold in sacks of different tonnages. Its proposed value also factors in expert professional services provided throughout the injection of the solution into smelting furnaces, as well as special industrial dosing equipment designed by the company to inject the product efficiently into the copper smelting furnaces.

The innovation was developed in response to a problem of competitiveness. Chile's foundries were in the last quartile of global industry in terms of unit costs and they even exhibited negative cash margins. Why were they losing money? This question drew the attention of Innovaxxion. As the innovation team noticed that copper recovery capacity was very low, thorough research was conducted into the state of the art. With its team of lawyers, the firm reviewed copper-recovery processes in foundries and found that the problem had not been properly addressed worldwide. It led the research for two years and the related applied R&D was performed by pyrometallurgy experts based at Federico Santa María Technical University (UTFSM), a Chilean university well known for the reputation of its Science and Engineering faculty.

iFlux is expected to increase copper recovery and to raise smelting efficiency (in initial testing, the percentage of "left over" copper fell from 38 per cent to 20 per cent and currently accounts for only 10 per cent of residue). iFlux could, moreover, lead to improved and cleaner operation of foundry furnaces.

The first difficulty was encountered at the beginning of the innovation process. Innovaxxion had applied for public funding, which had been denied; it therefore decided to risk its own capital. Secondly, owing to conflictual relations with academia, the innovation advanced slowly.

Potential customers to which Innovaxxion plans to roll out the solution include 19 smelters found in Chile, Peru, Brazil, Mexico, the United States of America and Canada, which have an overall output capacity of 3.4 million tons per year. Chile holds 50 per cent of that capacity. The project is currently in its first implementation stage in three Chilean furnaces. The objective is to serve the entire market in Chile by the end of 2018. The commercial model is to be validated in 2019 so that it can be launched internationally.

Patents (both national and under the PCT) are being filed for the product. Furthermore, the company expects to be granted a triadic patent (registered in the United States of America, Europe and Japan). It understandably wishes to protect this process innovation internationally because it seems to be applicable to all copper mines worldwide.

[23] In the pharmaceutical industry, these are known as primary and secondary patents, the former protecting an active ingredient and the latter protecting a range of related chemicals.

IP registration has been conducted ably both nationally and abroad. Lastly, the firm is open to the possibility of licensing or selling patents as an option conducive to developing new businesses abroad.

4.5.2 Intelligent Skids (RIVET)

RIVET supplies equipment and components to the mining sector. With more than 100 years on the market, RIVET is currently the main supplier of metal mesh to mining companies in Chile and has a leading position in the conveyor-belt business.

Conveyor belts are the most economical means of transporting ore. They can transport a large quantity of ore over long distances and great heights, while keeping energy consumption low. The spotlight here is on RIVET's work in this area, particularly in the manufacturing of one of the key conveyor-belt system components, the skids.

Skids must be reliable and durable because they bear the belts. The company manufactures skids to withstand extreme mining conditions in Chile, such as harsh environments, high tonnages and high speed. RIVET has launched a series of intelligent skids with integrated sensors that form part of a data analysis platform for ascertaining operating conditions and predicting failures[24]. Mining companies can thus save resources by reducing the number of unscheduled plant shutdowns.

As to the main innovation difficulties encountered, it is noteworthy that it was difficult to find the appropriate technologies and to train a suitable technical team. Data transmission technologies that met specific energy consumption and signal reliability criteria were required but were not available on the market. This hurdle could be overcome only by working with electrical engineers (RIVET specializes in mechanical engineering). Working relations with the initial team of expert engineers broke down owing to lack of agreement on ownership of IPRs in the innovation. A team of experts, with whom the innovation was developed, was ultimately found.

The potential customers are large and medium-sized mining firms. RIVET intends first of all to market this innovation in the countries in which it has operated with other products, namely Chile (where most of its output is sold), and Peru.

RIVET is at the final patent application stage. From the beginning, it seemed clear that it was a radical innovation and, for that reason, the firm opted for patent protection (rather than a utility model). RIVET, which first applied for a patent in Chile (INAPI), is now filing for PCT registration and plans to apply for protection in other countries. The company is very open to licensing the patent afterwards.

According to Mr. Enrique Celedón, the company's Chief Executive Officer (CEO), it was very difficult to draft the patent. "It is as if it were a new literary style", Mr. Celedón said. RIVET was therefore obliged to hire an engineer expert in patent drafting. Mr. Celedón has suggested that INAPI "organize and/or subsidize training courses so that firms can acquire the necessary patent drafting skills"[25].

[24] This technology is also known as "intelligent roller", "smart roller" and "smart idler". The original (commercial) Spanish term is *polín multisensor inalámbrico inteligente*.
[25] As noted above, INAPI is aware of the importance of this activity and held two courses on patent drafting in the past year.

4.5.3 Optibar (UDEC)

The University of Concepción (UDEC), a private university founded in 1919, is the university that holds the largest number of patents in the country and yearly competes for first place in terms of new patents. It is also the university that has the highest patent grant rate (ratio of approved to filed patents) and holds the highest number of metallurgical engineering patents. Moreover, Mr. Igor Wilcominsky, the metallurgical engineer holding the greatest number of patents in Chile, is a faculty member of UDEC's Engineering Department.

UDEC's Intellectual Property Unit relies on the "in-house patent model" and accordingly identifies, protects and, in close cooperation with the Technological Transfer Unit, transfers the (protected) results (inventions and innovations) to the production sector, unlike technological transfer offices and the surveyed companies, which outsource protection formalities to an external body or institution. The Unit is therefore a linchpin in the university's innovation system. It is in charge of marketing IP assets and has an incubator program that works closely with the students' innovation area.

Optibar is technology recently developed by UDEC researchers in order to reduce electricity consumption in the copper electrowinning industry – the largest consumer of this type of energy in Chile. It was one of the 14 mining and metallurgy innovations to be rewarded by the 2012 Avonni Awards, a contest that rewards innovation and entrepreneurship in Chile.

The project was implemented jointly with Barrick Zaldivar, the mining firm that has actually used the technology and found it to be an energy saver. "This company took the risk of innovating and believed in our capacity. To date, almost 100,000 tons of pure copper cathodes have been produced with the Optibar technology", says Dr. Eduardo Wiechmann, project director and a professor and researcher at UDEC's School of Engineering.

Dr. Wiechmann stressed that the innovation idea stemmed from the need to solve an operational problem. The challenge was to avoid (or at least mitigate) metallurgical short circuits that damaged electrodes and thus reduced output. "The Optibar project was developed with UDEC and Barrick working together. In short, we have shown that with this technology it is possible to save up to 100 kW per ton of copper produced in high purity cathodes. The potential national impact is enormous, since Chile produces 2,500,000,000 tons of copper cathodes per year", Dr. Weichmann pointed out.

The cost of energy has plummeted. The price of solar energy has fallen sharply and it currently costs less than 20 dollars per MWh, which affords an opportunity to use it intensively. Industrial processes must therefore be maximized during sunlight hours and be minimized at night. Energy production must be modulated in this way so that Chile's copper can be sustainable. Training, technical support and technologies are required in addition to strategic decision-making.

Optibar facilitates energy modulation in copper refining and electrowinning. Potential customers are therefore the electrorefining and electrowinning plants. On initial estimates, energy modulation could be increased by 30 per cent during the day and lowered by 20 per cent at night. The impact on productivity will be significant, as energy and carbon footprint costs will dwindle.

The main innovation difficulty encountered was cultural, namely fear of innovation and distrust. Fortunately, visionaries (such as Robert Mayne-Nichols, CEO of Barrick) supported UDEC by enabling industrial tests.

Optibar has already been patented. "The patent serves to avoid the crude and ill-made copy that would end up discrediting the innovation. Patenting in Chile was difficult because of the

rather limited examination expertise. UDEC's technical support was extremely helpful", Dr. Weichmann said. An agreement is being negotiated with New AncorTecmin, a Chilean company specializing in the development of electrowinning and electrorefining technologies for different metals, which can market the technology abroad (this is a technological process innovation with environmental benefits and a wide range of applications).

4.5.4 Puma P5SH Hammer (Drillco)

Drillco is a Chilean company founded in 1966, when it began to distribute the products of Stenuick Frères, the Belgian company that invented the Down the Hole (DTH) hammers. Today Drillco is a leader in designing, manufacturing and marketing rock drill hammers and accessories in Chile, Brazil and Mexico and it exports to the remainder of the Americas and to Europe. Drillco not only provides mining sector services, but also works for geothermal, petroleum and gas wells worldwide.

The company is engaged in a series of projects, together with Chilean and foreign universities and research centers primarily in order to raise the efficiency of DTH hammers in mining operations, including copper mining. The raw materials are all imported and Drillco adds value to the design of the hammers by endeavoring to improve their performance on different types of rock. It is precisely in design that efficiency gains (in terms of power and drilling speed) can be achieved and it is in this innovative area that the company has filed for patents.

Drillco currently holds five patents, after removing from its portfolio costly patents that brought rather limited benefits. The company now files patents only when it wants to compete and grow.

The P5SH has been selected as an interesting case study of a pneumatic drilling hammer for "competent rocks". The innovation idea arose from the need for rock drilling hammers that were more efficient, speedier and highly resistant to compression. As Drillco's traditional hammers were losing market share, the company started to seek ways and means of increasing drilling speed without changing air consumption.

That goal has been achieved. Perforation speed in competent rocks has been raised by 15 per cent. Drillco has positioned this hammer as the best among its competitors. This is already opening up new markets (quarries in the United States of America and pits where the rock is very hard, which holds true for geographical locations such as South Africa and Australia and for metals such as iron and platinum).

This is consistent with the company's innovation strategy. Drillco innovates in response to competition; it seeks to wrest market share from its competitors in new countries and, to do so, it must innovate because the rock differs in each country. If it does not innovate, it cannot seize business opportunities. In Chilean mines, for instance, the rock is rather soft.

Consistently with its innovation strategy, the company has focused on P5SH product design innovation. This hammer is the outcome of a wider innovation strategy implemented jointly with DICTUC Mechatronics Unit, a research center based at the School of Engineering of Chile's Pontifical Catholic University (PUC). The company began to implement the strategy in 1994, when Drillco recruited a professor of mechanical modelling at the PUC's Scientific and Technological Research Department (DICTUC) as an applied research associate.

The main innovation difficulty encountered consisted in expressing innovative design ideas in a physical design form that would support market demands for durability.

The company has initiated the national patenting process, which has been much slower than expected. It plans to file for patents in other countries where there are rock-drilling hammer manufacturers and/or consumers. It does not wish to license the patent because Drillco's business consists not only in designing, but also in manufacturing and marketing this type of hammer.

5 Conclusions, limitations and future research

This paper has provided information on the IP protection practices of METS in Chile's mining sector. The analysis was based on an online survey of approximately 300 mining suppliers that were covered by the EXPANDE Program. The information pointed to some preliminary conclusions, some of which were corroborated by opinions gathered from semi-structured interviews of executives from mining companies and suppliers, including universities.

Most of the firms are small and medium-sized (in terms of sales and number of employees). They consider themselves to be innovative and their self-reported opinions are consistent with both the GERD to sales ratio and earlier surveys and literature. Nevertheless, only a minority of these seemingly innovative companies relies on IPRs to protect their innovations. The most crucial factors that account for this finding are the cost and expected complexity of registration.

This paper reviewed four case studies of the product- and process-innovation efforts of four mining suppliers (including one university), the partners with which those bodies have engaged, the difficulties that they have encountered and the IP protection strategies that each has implemented. Some of the firms had established cooperation agreements with researchers based in universities or research centers, while one firm had relied mainly on its own research expertise. The form of IP protection selected and firms' sale or licensing intentions related largely to the type of innovation and the market served.

The paper is an initial attempt to study these matters empirically in a less-developed country. New research efforts should broaden the scope of analysis by drawing on better data. INAPI has compiled a comprehensive database that could be used to extend the analysis to all forms of IPRs and to perform multivariate statistical analysis. INAPI's database, however, only contains IPR-holding firms and individuals. In order to test new hypotheses for the entire universe of interest (i.e., those who protect innovations and those who do not), the sample could interestingly be widened to include member companies of APRIMIN and the Industrial Suppliers Association in the Antofagasta region (the largest mining region in Chile), as well as those already in the EXPANDE Program database, thus enriching the empirical analysis.

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Appendix 1 Questionnaire for EXPANDE firms

1. Data on the company and its respondent

Company name	
Company National Identification Number (RUT)	
Respondent's name	
Respondent's position in the firm	
Contact e-mail	

2. Economic information on the company

2016 sales, in pesos	
2016 exports, in pesos	
2016 number of workers (FTE)	
2016 GERD, in pesos	

3. The company offers (supplies):

Only product(s)	
Only service(s)	
Product(s) and service(s)	

4. If it offers product(s), what is the main product?

5. If it offers product(s), the main product is manufactured:

In Chile	
Abroad	
Partly in Chile and partly abroad	

6. If the company makes innovations, indicate which type(s)

Product innovation	
Process innovation	
Marketing innovation	
Innovation in organizational management	

7. IPRs (granted)

	In Chile	Abroad
Patents		
Utility Models		
Designs		
Trademarks		

8. IPRs (filed)

	In Chile	Abroad
Patents		
Utility Models		
Designs		
Trademarks		

9. This company has trade secrets (Yes/No)

10. IP legislation and practices

You know Chile's IP legislation	
When exploring new business opportunities, is the inherent IP considered?	
You include IP clauses in the contracts with employees and suppliers	
You know the costs of IP registration in Chile	

11. IPR registration costs in Chile affect (discourage) the protection decision.

12. If you innovate and do not protect the innovations, please give reasons.[26]

13. If your company is interested in applying for IP protection abroad in order to internationalize its goods and/or services, state which type(s) of IPR you would wish to file.

Trademark	
Patent	
Design	

Appendix 2 Mining companies covered in the analysis

Company	Description	Interviewee
Codelco	The National Copper Corporation (Codelco) is a Chilean State-owned company and the largest copper-producing firm in the world. It owns nine per cent of world copper reserves and it owns and operates several mines, including Chuquicamata (the largest open pit copper mine in the world). Other large mines are Andina, El Salvador and El Teniente.	Oscar Castañeda (Innovation Manager)
Freeport-McMoRan (FCX)	This international firm holds geographically diverse natural resources and reserves of copper, gold molybdenum, cobalt, petroleum and gas. Its head office is in Phoenix, Arizona, United States of America. It has many operations in the copper industry. In Chile, FCX operates El Abra.	Francisco Costabal (CEO)
BHP Billiton Copper	Part of BHP Billiton, a global Anglo-Australian company, with corporate head offices in Melbourne. BHP Billiton Copper has its head office in Chile and is the BHP unit tasked with administering copper-producing operations in Chile, Peru and Australia. In Chile, it operates two pits, namely Escondida and Pampa Norte.	Cleve Lightfoot (CEO)
Antofagasta Minerals S.A.	This is the largest private mining company in Chile. It ranks as the fourth copper producer in Chile and the ninth in the world. It has four operations, all in northern Chile, at Los Pelambres, Centinela, Antucoya and Zaldívar.	Nury Briceño (Innovation Manager)

[26] The question on firms' reasons for not protecting their innovations is quite important. Firms that market their knowledge may choose not to rely on formal forms of protection simply because there are other options, such as open source or creative commons which are increasingly important as soft forms of protection (file:///Users/juanjoseprice/Downloads/1425647105_032980800l425647105.pdf). As confirmed in the above-mentioned OECD report (file:///Users/juanjoseprice/Downloads/1425647105_032980800l425647105.pdf), patents are more effective as tools for large, rather than small, organizations; this view is consistent with recent survey findings by the Department for Business, Innovation and Skills (BIS, 2012).

Appendix 3 METS and universities covered in the analysis

Supplier	Description	Person interviewed
University of Chile	This is the largest public university of Chile. The interviewee, a professor from the Department of Geology, spoke of various applied innovation projects. The department's researchers have developed several mining process patents, often under collaboration agreements with other universities.	Brian Townley (Researcher, Department of Geology and Advanced Center in Mining Technologies)
University of Concepción	UDEC, a private university in southern Chile, has been, since its foundation in 1919, one of the country's best universities. It is the university that holds the greatest number of patents in the country and every year competes for the first place in terms of new patents. It is also the university that has the highest patent grant rate (ratio of approved to filed patents) and holds the highest number of metallurgical engineering patents.	Ximena Sepúlveda (Chief of the IP Department)
ENAEX	ENAEX, a private firm and subsidiary of the Sigdo Koppers group, produces, markets and distributes explosives and blasting agents and provides technical and logistical support. It has existed for 94 years and is the third largest producer of ammonium nitrate worldwide and the leading provider of blasting services in Chile. In the field of mining, it is the largest rock fragmentation services company in Latin America.	Miguel Angel Peña (Innovation Manager)
Innovaxxion	Innovaxxion designs and implements innovative solutions based on technology, processes and applied engineering. Most of its sales are in the mining sector, although it develops applications for other industries (defense, energy and agro-industry). It was rewarded in 2014 when it received the Innovative SME Award and was a mining category finalist for the 2014 Avonni Awards.	
Aguamarina SA	Aguamarina provides evaluation, control and research services in molecular biology and biotechnology. The company applies the most recent discoveries in these sciences to mineral extraction, while aiming to improve occupational safety and	Pamela Chávez (CEO)

	address environmental issues. It implements R&D projects on bioleaching and biocorrosion – two key chemical processes used in mineral extraction. It is a leading firm in Chile and has begun to extend its operations to the United States of America, Brazil and Peru. Aguamarina has been supported by the Chilean Government through CORFO, CONICYT and PROCHILE.	
Neptuno Pumps	A Chilean private company that designs and produces pumping solutions for the mining sector worldwide. It has supplied goods and services to the major mining firms in Chile and abroad. It is an example of the way in which innovation can contribute to greater productivity in an ecofriendly manner, particularly in terms of energy consumption and reuse of materials. It is precisely for these values that the company has been awarded a number of national and international prizes.	Petar Ostojic (CEO)
Drillco Tools	Drillco is a leader in the design, manufacture and marketing of rock drill hammers and accessories in Chile, Brazil and Mexico and it exports to the remainder of the Americas and to Europe. Drillco not only provides services to the mining sector, but also works with geothermal, petroleum and gas wells worldwide. This is an interesting example of product design innovation, and it is in this innovation area that the company has patented its innovations.	Gaspar Miranda (Innovation Manager)
Codelco Tech	Codelco's technological development subsidiary was formed after Codelco's three technological and innovation subsidiaries, namely Biosigma (biotechnological solutions in the mining field), IM2 (in charge of patenting advanced engineering developments) and Codelco Lab (enterprise incubator for new uses to copper), were merged. Codelco Tech operates on the basis of an open solutions development model that promotes collaboration with suppliers, research centers, universities and start-ups.	Felipe Merino (Innovation Manager)

South American Management (SAMSA)	SAMSA is a consulting firm specialized in the mining and construction industries. Its areas of expertise include prospection, mining development, financing, civil engineering and exploitation of water, mineral and energy resources.	Enrique Grez (CEO)
RIVET	This supplier of mining sector equipment and components has been active for more than 100 years on the market. It is the main supplier of metal mesh to mining companies in Chile and is a leader in the conveyor-belt business.	Enrique Celedón (CEO)

Appendix 4 Questionnaire for the case studies

1. What does this innovation comprise?
2. How did the innovation idea arise?
3. What problem(s) does it solve and what is its expected impact?
4. Main difficulty(ies) encountered during the innovation process.
5. Who are the potential customers?
6. How has the firm handled intellectual property?
7. Why has the company opted for patents rather than other forms of IP protection?
8. What steps were followed in the patenting process? Has the company licensed or is it willing to license or sell the patent?