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# Innovation and Competitiveness in the Copper Mining GVC: Developing Local Suppliers in Peru

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# Innovation and Competitiveness in the Copper Mining GVC: Developing Local Suppliers in Peru

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**Abstract**

Although Peru is one of the main producers of copper worldwide, the domestic industry has not yet taken fully advantage of the potential that the exploitation of this commodity offers. This paper explores the opportunities and challenges that Peruvian supplier face in their insertion into the mining global value chain. Our analysis is based on a mixed-methods approach, combining both quantitative and qualitative primary and secondary sources, including semi-structured interviews with key actors of the Peruvian mining sector. Our findings suggest that the weak presence of Peruvian suppliers in a sector dominated by few foreign firms is due to global industry dynamics as well as the underdeveloped capabilities of local firms operating in a fragile local institutional setting. However, opportunities for their insertion are primarily in areas where new solutions are required, which places a demand on the supplier's innovative capacity.

**Key words**
Mining; Peru; Copper; Global Value Chain, Innovation, Local Suppliers.

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## 1. Introduction

Peru is the world's second largest copper producer and exporter, and the sector largely drives the country's economy. The strength of Peru's copper mining sector is based on large reserves with low-cost extraction compared to the other global locations. Over the past fifteen years, this has raised the country's relevance to the global industry, and copper's importance to the local economy. By 2017, copper represented 50% of mining exports and 5% of the GDP (MINEM, 2019).

Global demand for the commodity is set to increase in coming years as a result of fundamental shifts in downstream industries, from rising demand for electric cars to electrification of national energy supply and rapid urbanization in the developing world. However, historically, the increase in demand or any price boost in commodities has not translated into substantial gains for the resource-rich economies. It has been very difficult for these countries - such as Peru- to capture the value of exploiting these commodities to drive growth and development. Much of the industry is operated by foreign firms in relative isolation to the rest of the economy, which has prevented the development of relationships between natural resource industries and "enabling sectors" that supply novel efficiency-enhancing products, which has been a core aspect in the economic development of countries such as Australia and Norway (Ville & Wicken, 2012). Thus, as functional upgrading into processing activities is no longer an attractive path, given that it offers only marginal value gains, host countries have sought alternative pathways to capture value from the sector. A key strategy to accomplish this is the fostering of backward linkages. Today, numerous host economies are promoting the development of local suppliers that can offer products and services to the mining sector.

Yet, supplying the sector is notoriously challenging. The copper mining market is concentrated by a small number of lead firms with mature global supply chains. Critical inputs are dominated by a few firms with strong relationships to buyers, while lower value inputs tend to be highly competitive and require significant scale. At the same time, risk adversity is high; buyers exhibit a strong preference for proven solutions, sourcing critical-systems innovations only from their trusted supply base. On the other hand, new suppliers are typically considered only for areas where miners are yet to implement any solutions. Establishing new solutions, however, is hampered by information asymmetry and limited opportunities to test and install new technologies. While miners rely on their suppliers to bring innovations to the sector – miners are poor innovators, in general - they simultaneously resist disclosing information about the areas where those are most needed and are constrained by high stoppage costs to pilot new solutions in operating mines.

The aim of this study is to explore how the country can leverage its strong position in the mining copper value chains to foster innovative activities and develop local suppliers, thus allowing the national industry to obtain benefits from participating in the global production. We base our analysis on the global value chain (GVC) framework. Several data sources were used for the analysis; these include the UN Statistics Division Comtrade, and Supply-Use Matrices from leading copper producing countries (Australia, Canada, Chile, Peru, and United States). Specifically, in Peru, firm-level production, investment and export data were analyzed from the Peruvian Ministry of Energy and Mines (MINEM), National Superintendence of Customs and Tax Administration (SUNAT) and the National Statistics Institute of Peru (INEI). Quantitative primary sources were complemented with research from secondary sources; these included a review of the existing academic, trade and policy literature as well as firm annual reports and private sector databases. In addition, over twenty interviews were carried out with

mining companies mining suppliers, government officials, and educational institutions/research centers in Peru.

Our findings suggests that, as it is dominated by leading multinational miners, Peru's copper mining sector reflects these broader global trends. There are only a few innovative suppliers providing value-added products and services to the industry; these are concentrated in services, consumable products, metal structures and niche capital equipment segments. Local supply has a comparative advantage in these segments, benefiting from proximity, high volume to value shipping costs and specific geological conditions. Many potential local suppliers in other areas lack the organizational capabilities, scale and scope to participate in the industry.

Moreover, the integration of more and higher value-added Peruvian suppliers in the copper mining industry is undermined by its still weak national innovation system. The suppliers that have successfully innovated in the sector have done so largely as a result of individual efforts rather than a concentrated national strategy. These firms have tapped into the small pools of human capital, training employees internally or abroad, and investing their own limited funds on research and development (R&D); furthermore, they have leveraged knowledge bases in foreign universities and with foreign suppliers to develop new products and services and gain access to the market. Peruvian copper mining policy has focused heavily on regulation, with little emphasis on the need to innovate and upgrade. With little guidance and commitment from government to the future of the industry, existing efforts are taking place in silos with little coordination and/or dialogue on how to increase the availability of qualified human capital, reduce the bureaucracy related to R&D financing, or increase effective collaboration between research institutes, universities and suppliers.

Our findings are relevant for several reasons, as they could be extended to lower-middle income countries, or countries with limited innovation capacity that do not use their geological resources to their full capacity. First, our findings provide a fully understanding of the external and internal challenges that limit the access of Peruvian suppliers to the copper mining GVCs. Second, this paper presents a clear pathway for these suppliers with the potential opportunities to develop backward linkages, e.g.: supporting the development of industry specific organizational skills for mining suppliers, as well as the growth of innovation capabilities of local firms. The paper also contributes by presenting a set of policy recommendations for Peruvian suppliers to gain access to the copper global value chain, focused on the institutionalization of the sector, increase the participation of suppliers, and incentivizing upgrading and innovation among them.

The paper proceeds as follows. In Section 2 we describe the global dynamics of the copper mining industry. This includes mapping the copper global value chain, analysis of the chain geography, the governance structures in the industry and how these influence procurement patterns of mining companies. Next, in Section 3 the focus shifts to Peru's evolving sector, identifying where and how local firms are successfully participating and innovating in the industry. Finally, a set of policy recommendations are provided in Section 4, focused on fostering increased participation and innovation by Peruvian suppliers.

## 2. The Copper Mining Global Value Chain

This section presents the global trends of the copper mining industry, from the global value chain (GVC) perspective, including a discussion of how the governance structures of the lead firms shape the procurement patterns of mining companies around the world.

Copper has become a key input for manufacturing and construction. Today, it is the third most consumed industrial metal after iron and aluminum (USGS, 2019). This is especially relevant for Latin America, as it is one of the regions with the largest reserves of the red metal. In the particular case of Chile and Peru, the mining industry is a significant contributor to their GDP, accounting for 10% and 5% of GDP respectively (MINEM, 2019; Banco Central de Chile, 2019). The region leads global copper production and exports, as Chile and Peru alone account for close to 44% of the world's output.

In recent decades, the price of copper has presented a significant fluctuation. However, demand has steadily increased, and there are strong expectations for growth in coming years as a result of fundamental shifts in its major end markets. Major structural changes of demand include a growing use of electrical vehicles -which use up to four times as much as internal combustion engine cars- and a shift into green energy, which is more intensive in the use copper than coal-generated power (Copper Development Association, 2018). In addition to this, an expected boost in construction due to a sharp increase in global urbanization is also likely to increase the demand of copper (Schipper, et al., 2018; Drzik, 2019). These trends in growing demand suggests that copper is entering a new upward cycle, which is a major opportunity for producer countries such as Peru to develop a more robust sector that would allow the insertion of local firms in the GVC.

Although the copper GVC feeds a large variety of downstream industries, from automotive, to construction and energy to healthcare and manufacturing, the sector upstream is relatively concentrated. The Latin America region (led by Chile and Peru) dominates the upstream stage chains of the industry, accounting for 44% of the copper production. Production in the upstream stages is highly concentrated because of the location and economic viability of reserves, as 50% of the world's reserves are located in just five countries, led by Chile and Peru, with the next five accounting for a further 25% (USGS, 2018).

Peru could be considered as one of the most important actors among countries focused only on copper extraction, rather than processing and refining. In these countries that primarily produce unprocessed copper ores and concentrates, over 75% of export revenues is generated from unrefined copper. These trends of growing demand could offer extracting countries such as Peru a major opportunity to develop their mining sector, in order to obtain greater gains from the industry.

### 2.1. What is the role of major mining companies in the copper GVC?

The copper mining GVC is dominated by a relatively small number of lead firms: Miners, engineering firms and major equipment manufacturers. The power dynamics between these firms greatly shape the potential for smaller firms to participate in the industry. The largest five miners account for 38% of production worldwide, with a very strong presence in Latin America, especially Chile and Peru (see Table A.1). Most of the major miners are engaged in all upstream and midstream stages of the value chain, from exploration to refining. In each of these stages these firms depend on a large number of input providers; outsourcing is as high as 60% in some countries.

Large miners tend to rely more on centralized global procurement strategies, while mine-specific companies[1]have their own procurement team. However, as procurement personnel is drawn from the companies that own the mines, these will tend to continue to favor their preferred suppliers.

In addition to miners, engineering firms play a major role in shaping industry dynamics and determining which suppliers may participate in the mine development stage of the value chain. These firms are engaged in all aspects of mine development, including facilitating the procurement of mining equipment and infrastructure. While these firms took on a particularly important role in mine development during the boom of copper prices -between 2003 and 2012-, in the following period of falling prices miners sought more control over the development process to keep costs down. As a result of this, procurement decisions were increasingly being taken by the miners themselves (Douglas, 2016); these trends are likely to ebb and flow according to the metal's price.

### 2.2. How are the mining companies supplied?

Procurement in the mining sector, of both products and services, is carried out by two key actors – mines and engineering firms. Despite the capital intensity of the industry, services account for approximately half of the operational spending in the copper mining sector. Services are dominated by high value activities; engineering services are the most important category of inputs, accounting for approximately one fifth of industry spending. This is followed by professional and technical services (8%), including IT, financial, and legal services amongst others. These services are provided by a wide range of suppliers and are mostly produced domestically.

Sourcing practices by these firms are driven by reliability, quality and safety. Miners tend towards strategic, long-term relationships with preferred suppliers on whom they can rely to deliver on these requirements. This has contributed to the consolidation of the supply sector around a small number of entrenched firms. Miners are typically very conservative in hiring new suppliers due to high costs of operational failure on cash flow and profitability, even when other more innovative solutions may be available (Deloitte, 2018).

As result of the global trends within the industry, with miners primarily sourcing from their established global supply base -and making little efforts to connect with local suppliers (Fessehaie & Morris, 2013; Katz & Pietrobelli, 2018)- host countries have placed a strong emphasis on promoting the incorporation of local suppliers into the value chain as backward linkages. Supplying inputs and services to mining companies located in the country, local firms would move to higher value activities in the GVC, which is key to increase the benefits from participating in global production.

Local suppliers typically face multiple challenges to entry because of both the nature of procurement in the industry and shortcomings in their local institutional context. The scale and capital intensity of the industry and the longevity of investments mean that miners tend to buy from large, established suppliers with broad capabilities, a global reputation and with whom they have existing relationships. Local suppliers in developing countries, on the other hand, tend to be considerably smaller in size, technically specialized and with lower access to finance

[1] These are companies formed through joint ventures of multiple miners and processors to operate a specific mine. For example, the largest global copper mine, Escondida, is a joint venture between BHP, Rio Tinto and other investors.

and organizational capabilities than their global peers (Katz & Pietrobelli, 2018). Furthermore, as new entrants to the industry, they lack the trust to gain access to mines to pilot their technologies/services (Pietrobelli, Marin, & Olivari, 2018). Even if the firms are capable of delivering the required product/service, they often are unable to comply with many of the guarantees and prerequisites to become preferred suppliers (Banchile Inversiones, 2016).

Numerous policies and programs have been implemented around the world over the past decade to help foster the insertion of local providers. Models to increase local procurement have ranged from those focused on promoting access through improved information availability to strict local content requirements (OECD, 2017). However, these policies have met with varying degrees of success. The next section explores the opportunities and challenges that the Peruvian copper sector face in the insertion of local providers into the mining sector.

## 3. Opportunities for Peruvian Suppliers in the Copper Mining GVC

Peru is the world's second most important copper producer, with significant unexploited reserves and a robust pipeline of potential investments in new mines. Over the past two decades, as the industry has grown, a local supply chain has emerged. However, this is dominated by foreign suppliers and there is very low participation of Peruvian suppliers in value-added inputs. The relatively weak presence of local suppliers in the industry is reflective of global industry dynamics combined with generally undeveloped capabilities of local firms. The opportunities for their insertion by the miners are primarily in areas where new solutions are required, which places significant demand on their innovative capacity. However, the still weak innovation system in Peru hampers the development of these suppliers.

With copper demand likely to continue to rise in the future, a renewed investment cycle is imminent in Peru and current procurement is likely to increase, as development of new mines would provide a significant boost in demand, for a range of services from feasibility to engineering and construction services, so as for products used as inputs for processing plants. This represents a significant potential opportunity for the country, however, neither the current local supply base nor the national institutions are not prepared to take advantage of this.

### 3.1. Methodology

This research paper follows the global value chain methodology developed by the Duke Global Value Chain Center. It used a mixed-methods approach, combining both quantitative and qualitative primary and secondary sources to understand the global industry dynamics, and how these may affect procurement patterns in the Peruvian mining sector. Additionally, multiple academic, trade and grey literature sources were analysed to cover private sector engagement in the industry. This included reviews of the annual reports of 12 leading copper mining companies (multiple years), review of both miner and supplier websites, sustainability reports, and private sector databases (e.g. Orbis), as well as a review of relevant industry publications, including the World Copper Fact Book, Mining.com, Mining Global, and Global Mining Review amongst others.

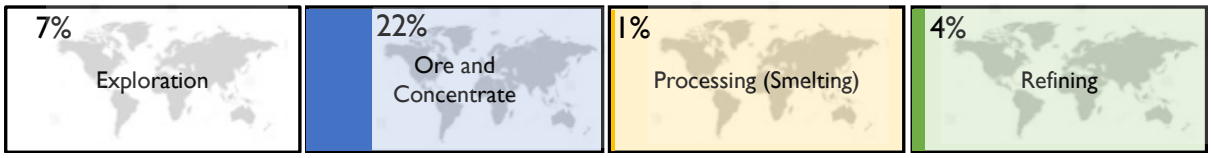
In order to identify procurement patterns in the Peruvian mining sector, as well as the challenges and opportunities that Peruvian suppliers face in their insertion to copper GVCs, more than 20 semi-structured, one-hour interviews were carried out between March and May 2019 with 1) mining companies in Peru, 2) Peruvian mining suppliers, 3) mining industry experts in Peru and Chile, 4) government officials (current and former) and 5) education

institutions. This information was supplemented with approximately 20 semi-structured interviews carried out between 2015 and 2018 to similar groups of actors, including key industry associations focused on the metal-mechanics sector. Both interviews carried out in 2019 and previously used the same structure allowing for comparability. Supplier interviewees were selected to include as wide a range of suppliers as possible, including both goods and services. An initial database of firms was drawn up based on the research team's past experience in the sector, this was complemented by a database supplied by the Inter-American Development Bank Peru office, and 'snowball' technique, having interviewees identify suppliers or peers.[2]

### 3.2. Peru in the Copper Mining GVC

A the world second largest exporter of copper ore and concentrate (UN Comtrade, 2019), Peru is a major actor in upstream stages of the copper GVC, with strong participation in exploration and extraction, and a presence in early mineral processing stages. The strength of Peru's copper mining sector is based on large reserves with very low cash costs. With 81,000M MT, Peru has the third largest copper reserves in the world after Chile and Australia (USGS, 2019). These reserves are relatively cheap to extract; at the country level, Peru's cash costs are the lowest in the world. It costs approximately US$1.10/lb in Peru, compared to US$1.48/lb in Chile, Australia and Canada and US$1.42 on average globally (BBVA Research, 2019). As a cheap destination with ample supply, the global growth in copper demand has thus spurred the development of the industry in Peru.

Figure 1. Peru's Position in the Copper GVC




Source: Authors based on (UN Comtrade, 2019).

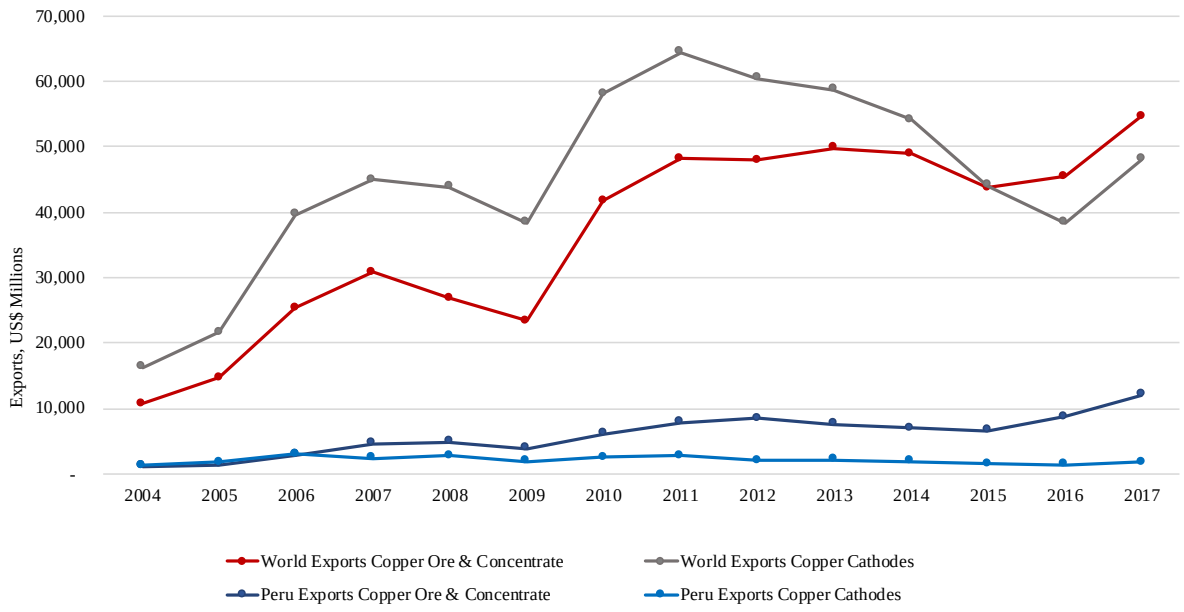
Peru's output has increased significantly increasing from 1.28 to 2.44M MT over the past decade, consolidating its position as the second largest producer of copper after Chile.[3] Peru's contribution to global production (12%) is aligned with its share of global reserves (11%). The low cash costs have allowed the country to rapidly increase its output where that of other producers has remained steady.

Almost all of Peru's ore and concentrate production is exported, with only a small share destined to the country's one operating smelter-refinery in Ilo. The majority of reserves currently exploited in Peru are sulphide ores, requiring flotation to produce concentrate. Only a few mines (e.g., Cerro Verde and Toquepala) extract oxide ores which can be directly processed using SE-TW to produce cathodes. The country thus is overrepresented in upstream stages of the chain accounting for 22% of global copper concentrate exports in 2017. This concentrate is destined primarily to Asia which accounted for 82% of copper exports in 2018. Chinese smelters absorb the majority (64%), followed by Japan (9%) and South Korea (6%) (UN Comtrade, 2019).

[2] In addition, the database of projects funded by Innovate Peru was reviewed. The keywords "mineria" and/or "cobre" returned 14 finalized projects and 10 projects underway.

[3] Despite this growth, it still produces less than half of the global leader in red metal. Chile produced 5.8 million MT in 2018.

Figure 2. Peru in the Copper GVC, Exports by value (US$M), 2004-2017




Source: (UN Comtrade, 2019).
Notes: HS02 260300 (copper ore and concentrate); 7402 (unrefined copper, copper anodes for electrolysis) and 740311 (copper cathodes). Peru/All exporters. Downloaded 23/05/2019.

Production is concentrated in a small number of large (>200KT) and medium sized mining companies (45KT<X<200KT). The top ten mines account for 96% of all copper produced. The three largest mines are world class mines,[4] owned by consortia of primarily foreign majors and operated by local mine-specific companies: Cerro Verde (US-Japanese-Peruvian), Las Bambas (Chinese) and Antamina (Australian-Swiss-Canadian-Japanese). Southern Peru Copper (Mexican-US) is the largest single firm mine operator in the country. Only one Peruvian firm has a significant position in Peru's copper mining sector, Buenaventura, which owns 20% of Cerro Verde and operates the medium sized, El Brocal, which accounts for 2% of national copper output. 70% of copper mining production is located in southern Peru (MINEM, 2019).

[4] Global top ten.

Table 1. Peru's Leading Copper Mines

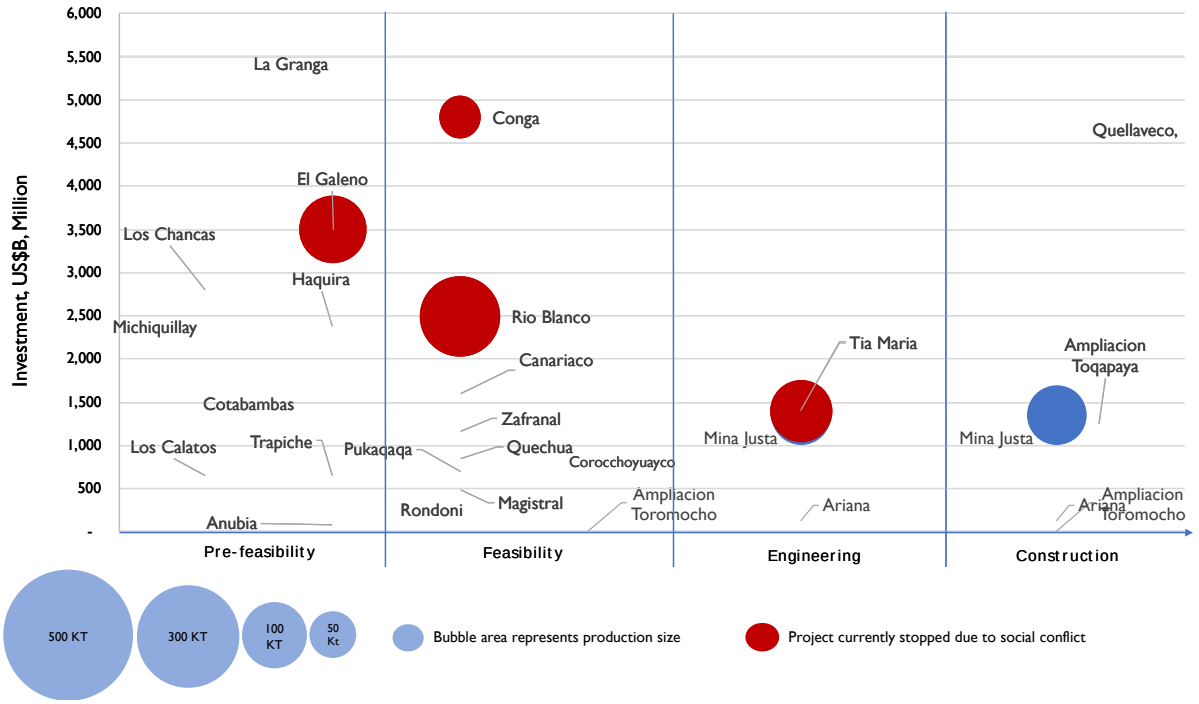
| Mines | Ownership | Processes | Output (MT) | |
|---|---|---|---|---|
| | | | 2017 | % |
| Cerro Verde | Freeport-McMoran, Sumitomo, Buenaventura | SE-TW | 501,815 | 21% |
| Las Bambas | MMG, Guoxin, CITIC Metal Co. | Flotation | 452,950 | 19% |
| Antamina | BHP, Teck Resources, Glencore, Mitsubishi | Flotation | 439,248 | 18% |
| Southern Peru Copper | Grupo Mexico | Smelting; Refining; SE-TW | 306,153 | 13% |
| Antapaccay | Glencore | Flotation | 206,493 | 8% |
| Toromocho | Chinalco | Flotation | 194,704 | 8% |
| Constancia | Hudbay | Flotation | 121,782 | 5% |
| Milpo | Nexa Resources | Flotation | 46,691 | 2% |
| Marcapunta-Norte/El Brocal | Buenavantura | Flotation | 45,778 | 2% |
| Cerro Corona/ La Cima | Gold Fields | Flotation | 31,460 | 1% |
| Other mines | | | 98,510 | 4% |
| **Total** | | | **2,445,584** | **100%** |

Source: (MINEM, 2019)

Large reserves have attracted considerably exploration activities. In 2017, Peru captured 7% of global spending on exploration in all non-ferrous metals (S&P Global Market Intelligence, 2018). Cumulatively, since 2008, approximately US$5.6B has been spent on exploration in the country. While exploration spending slowed following the decline in copper prices, it has reactivated, at US$412M up from a low of US$377M (MINEM, 2019). Leading copper miners have been active in the search for new mining sites alongside juniors.

Feasibility and mine development are led primarily by foreign firms; of the 26 projects in the copper portfolio, only three are owned by Peruvian firms: Trapiche (Buenaventura, 65,000MT), Mina Justa (Marcobre, 110,000MT), and Anubia (Arutani, 20,000MT). The remaining projects are owned primarily by majors and projects owned by Southern Peru account for 17% of projected new output. Consistent with a poor global pipeline within the next five years, only two projects are currently under construction. Quellaveco, jointly owned by Anglo-American and Mitsubishi is the largest new project nearing commissioning. It will produce 225,000MT at full capacity in 2022. Two others – Tia Maria and Mina Justa – are in the final stages of engineering design; Tia Maria, however, is still held up by social concerns and is awaiting construction permits (BBVA Research, 2019).

Figure 3. Key Investments in the Copper Mining Sector in Peru, by Stage of Mine Development




Source: Authors based on (MINEM, 2019)

New investment projects include a new smelting-refinery plant in Ilo by Southern Peru, which would double the country's smelting capacity. The investment is estimated to be US$1.35B. The plant is awaiting its production permit. There are also new projects that will produce SE-EW cathodes, including Tia Maria which would produce 120,000T of copper cathode.

### 3.3. Copper Mining Procurement in Peru

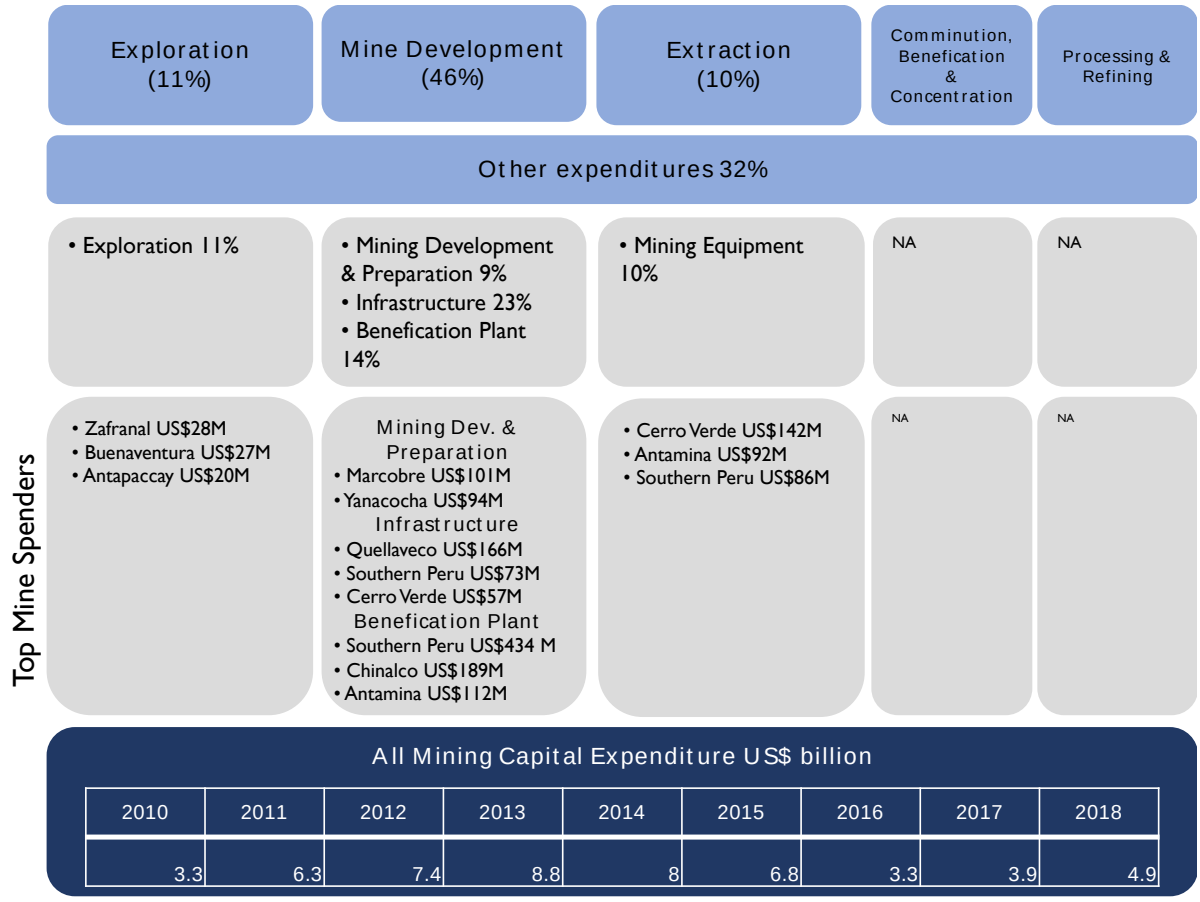
As a leading producer of various minerals including copper, expenditure in the Peruvian mining industry is considerably high. In 2017, for the sector as a whole, this reached US$9B in goods and services.[5] Goods spending was concentrated on fuels and utilities, followed by chemicals and explosives and capital equipment, which collectively account for 80% of spending. On the other hand, services spending is focused transportation and logistics, professional and technical services, and labour contracting (82%). Excluding categories characterized by oligopolistic supply (e.g. fuel, utilities), the approximate annual market size in Peruvian mining is US$2.3B for goods and US$4.4B for services. Copper is estimated to account for approximately half of this expenditure,[6] representing a considerable market for suppliers. See Table A.2. for details on the products and services purchased by mines in Peru.

Procurement, of course, varies by value chain stage driven primarily by variations in capital expenditure. Capital expenditure (CAPEX) is most significant during mine development and/or expansion (46% of the total procurement costs), with the building of mine infrastructure and

[5] This includes all expenditure for mining registered in the national current accounts, excluding that noted as gross fixed capital formation. This is comparable to spending in both Chile (US$12.2B, 2016) and Australia (US$20B, 2016).
[6] This is based on the following assumption: Copper mining accounts for approximately half of the output of the country, and is carried out by capital intensive global miners.

mineral processing plants collectively accounting for 37% of CAPEX in 2018. As the mine prepares for extraction, a further 10% is spent on the acquisition of mobile mining equipment such as drills, shovels and haulage trucks. As a result, annual CAPEX will fluctuate with the development of new mines. For example, the expansion of Cerro Verde (2015) which doubled its production, included US$4.6B in procurement (MINEM, 2019); Las Bambas (2015) mine development investment totaled US$10B;[7]and Southern Peru Copper invested US$1.2B in a major expansion underway at Toquepala (Gestión, 2017). Mining investment for new project development/expansion is projected to be US$21B between 2018-2021 and by 2028, US$58.5B (Millan Lombrana & Quigley, 2018). This expansion offers potential for more procurement, although new mine investment itself is dependent on a sustained copper price. Figure 4 illustrates mine procurement expenditures in 2018 by value chain stage, including the top mine spenders.

Figure 4. Mining Capital Expenditure by Value Chain Segment, 2018




Source: Authors based on Anuario Minería Peruana 2010-2018 (MINEM, 2019)

### 3.4. Mining Supply Chain in Peru[8]

While Peru's copper mining sector was initially supplied by foreign firms from global or Chilean headquarters, today, there is a relatively robust, and growing local supply chain (Field Research, 2019). In 2017, the leading ten copper miners directly imported just US$446M

[7] Direct imports by Cerro Verde of capital goods and construction materials – excluding those acquired from foreign subsidiaries in Peru - accounted for approximately 25% of that expenditure (Aduanas - SUNAT, 2017).
[8] This section is based primarily on field research with miners, suppliers and industry experts in Peru and Chile. Results were triangulated for veracity.

(Aduanas - SUNAT, 2017).[9] Several of these copper miners report procuring as much as 90% of their inputs locally (Field Research, 2019).[10] The local supply chain consists of three main sets of suppliers: (1) subsidiaries of global mining suppliers, (2) subsidiaries of Chilean mining suppliers and, (3) Peruvian suppliers. Foreign suppliers with operations in Peru include a strong presence of mining equipment suppliers and engineering firms. However, after more than two decades in the copper mining industry, there is a growing number of Peruvian suppliers.

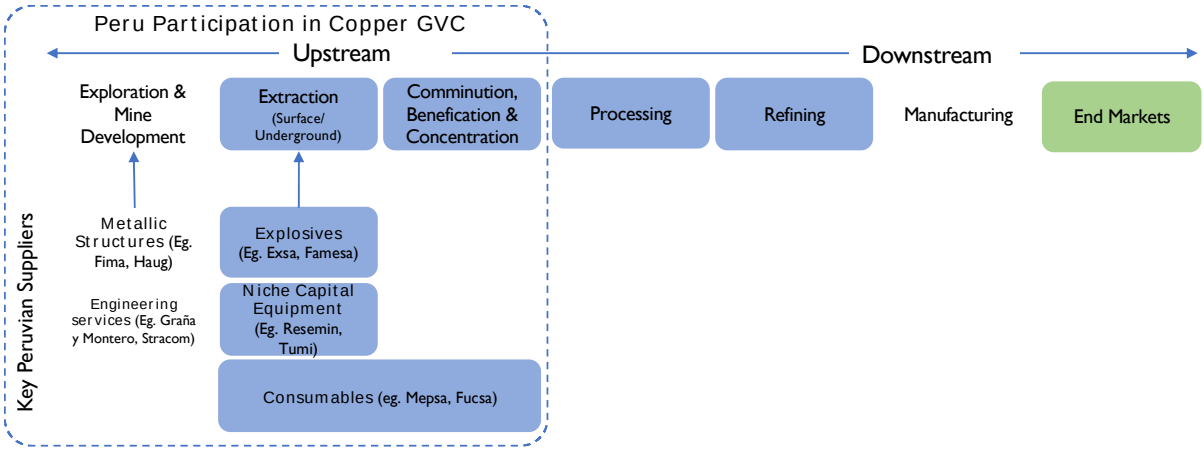
Peruvian suppliers are present in wide range of activities in the exploration, mine development and operation stages of the copper GVC, contributing both products and services to the industry. However, as a whole, their participation in the industry is limited and no strong area of focus has yet emerged. The strongest presence of local suppliers is in services, metallic structures, consumables, and niche capital equipment. Local supply has a comparative advantage in these segments, benefiting from proximity, high volume to value shipping costs and specific geological conditions. Overall, these firms are relatively small, typically subcontract with larger suppliers rather than directly with the mine, and only a few have successfully internationalized (Bamber, Fernandez-Stark, & Gereffi, 2016). Mid-size firms have tended to diversify across several markets, including oil and gas (in Peru) and infrastructure in order to reduce their exposure to the volatile commodity sector. Generally, it is very difficult for local suppliers to enter into the mining GVC due to their lack of scale and scope, access to finance and relatively weak organizational structure playing against them. In addition to this, reputation and past experiences are also key factors in the mining industries, resulting in big disadvantage of emerging suppliers against more experienced firms (Molina O. , 2017). Moreover, in some cases suppliers do not have formal channels through which they can offer their products. Therefore, they use indirect linkages to engage with the mining sector (Aron & Molina, 2019). Table A.3 details select suppliers that were analysed in the scope of this report.

Most local suppliers are producing standardized products and services, with limited impact on value-added in the industry, such as transport, catering and security. These are typically highly localized sourcing segments which are largely insulated from foreign competition. Nonetheless, approximately one third of local suppliers of the large-scale copper mining sector indicate that they have had to undertake some innovative activities and upgrade their products and services in order to compete in the sector (INEI, 2017; Aron & Molina, 2019). Within this group, there are a small number of firms that are undertaking innovation activities that directly contribute to domestic value added. The most successful of these innovations are those that have responded directly to the current needs of the industry; solely supply-driven solutions have had lower penetration amongst miners.

[9] This includes both operational and capital expenses. The largest import categories in 2017 were 8474 (15%, Machinery for sorting, screening, separating, washing, crushing, grinding and parts), 8704 (12%, off-road transportation equipment), 4011 (9%, off-road tires), 8431 (7%, parts for mobile equipment) and 8429 (5%, extraction equipment) (Aduanas - SUNAT, 2017). Comparatively in 2012, just 8 of these mines imported double that (US$906M) (Aduanas - SUNAT, 2012).

[10] For example, Hudbay's 2017 Annual Report notes "In Peru, our top 50 suppliers accounted for 84% of our spending, and 95% of our spending was with suppliers based in Peru." (Hudbay, 2017).

Figure 5. Peruvian Suppliers in the Copper GVC




Source: Authors

## Services

According to miners, services account for the highest number of local suppliers, although many of their operations are in non-value adding supportive services such as catering, accommodation and security. Services in the mining sector in Peru account for just 15% of value-added, compared to 21% in Chile and 26% in Australia (OECD, Unpublished). As seen in Table A.2 mine procurement in services in 2017 account for 50% of total spending. This figure is in line with the Chilean experience, in which services totalled 54% of the total mines expenditures. In terms of value-added activities, local firms provide a range of services for the pre-feasibility and feasibility activities within exploration and mine development stage of the chain, particularly with respect to environmental, social and geotechnical areas where local expertise is an asset. These include Proesmin, MinConsulting, and SRK Consulting among others. These firms have tended to expand their services offerings over time, for example, licencing and customizing foreign software. SRK Consulting went from providing environmental services to providing due diligence in site exploration.

In the operations segment of the chain, in addition to standardized services, such as labor contracting and equipment maintenance, there are several more innovative local suppliers which have been able to introduce new services to improve productivity. While some of these were suppliers that entered the sector with new-to-market innovations, others began with standardized services and upgraded their offerings once they had established their credibility amongst buyers. Renova developed a local retreading service which helped to reduce new tire consumption by 18% in Antamina (Antamina, 2017). NDT Innovation, on the other hand, introduced a new-to-market innovation with non-invasive technologies to offer preventative maintenance services. As more companies moved into the field, they then shifted from analysing steel-based products to detecting plastics failures – a technique which is unique in the global market. Several of these firms have successfully upgrading into international and industrial markets. NDT and Proesmin, for example, have projects in all major copper mining locations around the world as well as in a range of other industries. Serving multiple geographic locations has helped to further their understanding of how to tailor their services for specific contexts and gain reputation in the local market.

A second group of services suppliers are also emerging following the global trend of "servicification" of the mining industry. These product manufacturers are adopting a equipment-as-a-service (XaaS) business model. These include firms in a range of different activities. For example, Exsa, a leading Peruvian explosives supplier has moved towards a full-service model, whereby it manufactures the explosives, manages on-site storage and controls detonation in the mine. Qaira both builds drones for monitoring mine operations, and provides the monitoring service to miners. In addition to developing innovative business models, several of these firms have also steadily been working on new products. Exsa launched a new product Quantex in 2015, which helps reduce mine blasting costs by up to 20%. Qaira developed an autonomous charging station (Field Research, 2019).

**Products**

The presence of Peruvian suppliers in product supply is concentrated on metallic structures, consumables and niche capital equipment. Companies supplying metallic structure provide inputs for processing plants, such as flotation cells, ball and bar mills, classifiers and vibrators amongst others. These include Fabertek, Fima, Haug, Andes Peru and Mimco amongst others. These firms also serve multiple other sectors including construction, infrastructure, and oil and gas, as well as acting as suppliers for OEMs (Bamber, Fernandez-Stark, & Gereffi, 2016). As standard products for existing equipment, innovation amongst this group of suppliers is limited. Upgrading in these products has consisted primarily of improving product quality, factory processes and extending into regional markets. Collectively, leading foundries exported close to US$45M in 2017 to Argentina, Bolivia, and Chile, amongst others (IDB, 2018).

### 3.5. Peruvian Supplier Capability Development[11]

Peruvian mining providers utilize different strategies to develop their capabilities to offer products and services to the mining sector. These approaches can be grouped in two general categories: (1) internal capability development either through recruiting and developing human capital and/or in-house R&D departments; and (2) tapping into external expertise and knowledge, at local/foreign universities, foreign suppliers, or through strong relationships with buyers. While providers tend to focus on one of these strategies, it is common for companies to combine several approaches. For example, a company may have a strong internal R&D department but for some projects, it partners with a foreign university to acquire new knowledge. The use of these strategies among Peruvian suppliers is discussed below.

**Internal Capability Development Strategies**

Innovative mining suppliers tend to draw on highly skilled human capital to drive their capability base for innovation and upgrading. Numerous firms have employees with engineering, masters and doctoral degrees in technical fields. While this is particularly notable in services firms – Proesmin primarily employs engineers with masters - this also extends to manufacturing companies; approximately 15-20% of Resemin's staff are engineers. Employees are mostly Peruvian with degrees from local and foreign universities, although these employees are then trained in-house and/or are sent on work-rotations abroad to further develop their skills sets. For example, SRK Consulting places new employees in operations in Australia or the United States for up to two years. These employees may also undertake

[11] This section was based on interviews with suppliers and secondary research. Interview results were triangulated for veracity.

graduate degrees during this time, with financial support from the company. Exsa, likewise, invests in foreign training for their employees.

In-house R&D departments. Several of the larger Peruvian mining suppliers have created strong R&D centers, usually these are the well know firms in the sector such as Exsa, Resemin and Tumi. These are the companies that concentrate patents in Peru. Exsa invests around US$2.2 million annually in their R&D department that employ nine highly qualified workers located in the Lurin plant; it holds at least 3 patents. Famesa Explosivos spends 0.75% of its revenue on R&D; yet the company holds the highest number of patents awarded in Peru (CARMAR, 2018). Resemin design their equipment with their in-house team. Similar than Tumi that have created their sophisticated underground mining equipment with their workers in their Peruvian workshop.

Some of the services providers are also investing heavily in their internal R&D departments. Proesmin possesses a strong internal R&D department and has invested more than US$5M in its development. NDT have their own R&D department; in the last two years they have spent more than US$2 million in innovation. Green Mining has put a heavy emphasis in their internal R&D capabilities and have patented much of its work but outside of Peru. Overall, services firms noted that they have concentrated their protection efforts in constantly innovating in their services rather than in patenting them. So, the number of patents does not show a strong correlation with the level of innovation of local mining suppliers.

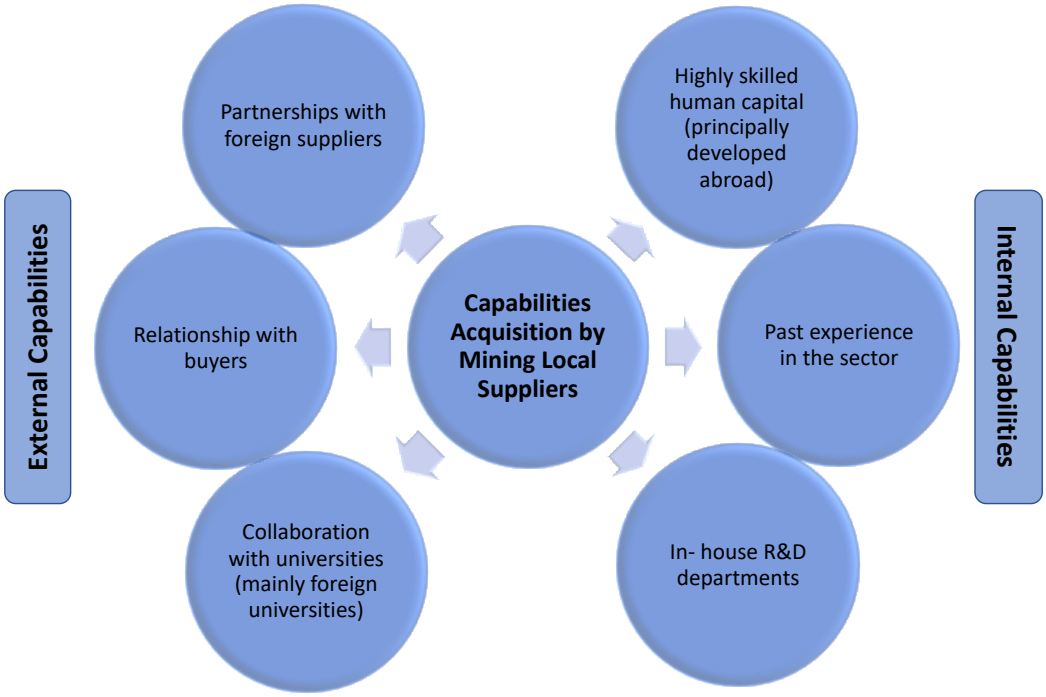
**External Capability Development Strategies**

Universities are important sources of knowledge for innovation in processes and products, as the knowledge and ideas emanating from universities and research institutions increase both the quality and quantity of innovations (Arundel & Geuna, 2004; Demircioglu, Audretsch, & Slaper, 2019) Thus, innovating firms have sought out collaborative partnerships with universities, however, these are typically with foreign universities rather than Peruvian ones. Local mining suppliers generally report that local universities do not offer strategic and applied research that can practically contribute to firm growth. Nonetheless, there are a few exceptions. Three innovative firms – NDT and Qaira have close links to universities, including Universidad Catolica and UTEC. It is more common for these firms to partner with foreign universities, particularly those in Australia (e.g. University of Queensland) and the United States (e.g. MIT, University of Houston). Partnering with universities is one model firms use to access national and international funding for innovation; Qaira, for example, won a seed capital innovation award from MIT to help develop the company.

Relationships with foreign suppliers are considered critical by firms in terms of gaining market access – in Peru and abroad - as well as developing additional capabilities. These partnerships help improve local supplier credibility vis-à-vis buyers, in addition to opening up opportunities for inter-firm learning and incremental innovation in adaptation of foreign technology for the local market. MinConsulting, for example, became an authorized software provider for two key foreign suppliers, which had previously only been available from foreign locations. In addition, international exchange between foreigners and Peruvian staff helped to increase the service quality in Peru and improve their position in the local market. Working with these foreign firms has also helped to improve organizational and services provision to higher global standards which improves firm potential to expand abroad. For example, through its alliance with leading global supplier ABB, MIMCO received specific development advice to improve their quality and processes allowing them to access the Peruvian mining industry.

Relationships with buyers are generally based on limited interactions under which the buyer provides the suppliers with specifications and standards, and the suppliers develop solutions to meet those specifications. This is particularly true for products suppliers. Due to ongoing provision, services firms tend to have a higher degree of interaction in the development of their solutions; Minconsulting, for example, noted that they have weekly meetings with their buyers. Nonetheless, products suppliers also emphasize that their experience working in the mine on a regular basis is a major contributor to their base knowledge and mine needs for new solutions (e.g. Proesmin, Resimin, Tumi, Exsa). New products and/or service testing or piloting is more limited, although both miners and suppliers concur that there is some (limited) space for providing testing innovations where there is a trusted relationship (e.g. Exsa) or there is non-intrusive testing (e.g. Qaira). Overall, there are very few joint development initiatives for innovative products in which any significant transfer of knowledge between miners and their suppliers takes place. There was only one Supplier Development Program, operated by Antamina until recently, which focused on supporting the capability development of local suppliers, but rather than providing technical know-how, this has mostly focused on indicating areas in which new solutions would be welcome and providing testing facilities (Field Research, 2019).

Figure 6. Summary Table of Key Capability Development Mechanisms




Source: Authors.

### 3.6. National Innovation System in Peru

The relatively weak innovative activities by firms in the sector is, in part, the result of an underdeveloped national innovation system. National innovation policy in Peru is still relatively incipient and the country continues to perform relatively poorly in most global innovation indicators (see Table A.4. in the appendix). CONCYTEC, the leading institution responsible for science, technology and innovation systems was only established in the country

in 2006 (Concytec, 2019). While stakeholders agree that significant progress has been made over the past five years to establish a more coherent innovation ecosystem (Field Research, 2019), important gaps remain that need to be addressed to boost its efficacy. As a result, national spending on R&D remains low. Between 2015 and 2017, the country experienced a rise of just 0.004% in R&D expenditure as a share of GDP. Peru also performs poorly compared to both its regional peers, as well as the global average. In 2017, Peru spent 0.12%/GDP compared to 0.36% in Chile, 0.76% in Latin America and 2.2% (global) (World Bank, 2019).

Key shortcomings include the lack of human capital and research institutions adequately prepared to undertake, manage and incentivize innovation, as well as limited institutionalization and coordination of those existing actors to maximize upon their contributions (Field Research, 2019; BBVA Research, 2019; Concytec, 2017). Although, recent efforts have been made to establish new innovation research centers, with the establishment of Centros de Innovación y Tecnología (CITEs). These, however, have been criticized for a lack of market-oriented focus, poor infrastructure and weak administration (Lampadia, 2017). Moreover, with less than a decade of innovation policy experience at the national level, there are still too few policymakers in a position to adequately design and manage incentive projects (Seclén, 2017). Policies to support and coordinate innovation activities are crucial, as country-level macro and institutional characteristics are important determinants of firm-level innovation in developing countries (Paus, Robinson, & Tregenna, 2022).

Importantly, as the innovation ecosystem has slowly emerged in public, private and academic areas, these have operated in silos, with little coordination across actors undermining potential for synergies and applied research. Amongst research centers, only 26% have linkages with the private sector and only 37% have any connection to local, regional and/or the national government (Belapatiño & Perea, 2018). Peru is ranked 98$^{th}$ of 129 economies (2018) for private-sector-university collaboration in the Global Innovation Index (Cornell University, INSEAD, and WIPO, 2018). Even within the public sector, there is a lack of coordination and public awareness in initiatives as a number of different Ministries launch their own innovation programs. For example, by 2018, only 30% of private sector firms engaged in innovative activities were even aware of the availability of fiscal incentives which were launched in 2015 (Gestión, 2019). Many of these initiatives are yet to be institutionalized and are still subject to the decisions of the particular government in power.

### 3.6.1. Peruvian Mining Innovation System[12]

Within this context, the innovation ecosystem supporting the mining sector in Peru is relatively new and fragmented, emerging in parallel to broader national efforts to shift the country towards higher-value added activities. Indeed, the sector is significantly underrepresented in the emerging national innovation initiatives compared to its economic importance to Peru. With no clear policy champion, the industry lacks an effective national strategy. Public policy has focused primarily on regulating the sector, particularly with respect to environmental and social concerns[13], rather than setting a long-term strategy for upgrading and innovation in the

[12] Information in this section was drawn from a combination of primary and secondary research. Interview results were triangulated for veracity.

[13] Since 2007, the Agency for Environmental Assessment and Enforcement and the Ministry of Labor joined the Ministry of Energy and Mines in the oversight of the mining sector activities, which turned in excessive

future. While numerous efforts are emerging, this remains piecemeal, with different institutions undertaking individual siloed and often duplicate efforts. These include a working group at the Ministry of Economics and Finance (MEF) charged with increasing productivity (Gestión, 2018), a similar initiative at Ministry of Production (PRODUCE), developing a Technological Roadmap for the mining sector, and MINEM's Mining Vision 2030, amongst others. These initiatives group a range of different stakeholders, but do not necessarily include key strategic actors for the industry. The result of this lack of coherence has been very little contribution of the state to innovation to the mining sector in general and Peruvian mining suppliers in particular.

The government has launched some transversal policies and programs which could encourage innovation in mining suppliers (see Table A.5 for a detailed list of policies and programs) but these have had a low impact on the industry. The most relevant programs for the development of innovative mining suppliers include (1) Innovate Peru, (2) the 2015 R&D Fiscal Credit and (3) Accelerated Patent Development Programs. However, very few Peruvian mining suppliers have taken advantage of these initiatives to date. Only 51% of innovative firms in Peru serving natural resources industries even know about the public programs (INEI, 2017) and the ones that are familiar with these instruments are reluctant to apply due to high levels of bureaucracy. The only program highlighted by interviewees as having played a useful role in their development was Innovate Peru; high-tech start-ups such as Qaira have benefited from this program. The R&D credit has had very little impact to date with low awareness (Gestión, 2018). Only 49 projects were approved across the entire economy – not just the mining sector in the three years of operation. By comparison, in Chile where a similar R&D credit was introduced in 2012, in 2018, the mining sector alone received the same in R&D credits as the entire economy in Peru (US$10M) (Gestión, 2018).

There are emerging research centers focused on mining, although these initiatives are limited and still relative recent. Most of these are driven by private universities; of the 47 public-private research institutes established under the CITE program by 2018, only one is focused on mining, with initiatives generally coalescing around environmental issues related to mine closure and was established together with the private sector (Instituto Tecnológico de la Producción, 2019; Universidad del Pacífico, 2019). Leading private universities, including Universidad Católica de Peru, Universidad del Pacífico, Universidad Nacional de San Agustín, as well as UTEC have research efforts under way to support the industry, however, funding for these initiatives is limited as is their direct application to the industry. Public universities in key mining localities receive financing for innovation via the mining canon; [14] in 2018, these universities received US$48M which can be destined to scientific research in any topic. The private sector is reluctant to work with local universities to drive innovation, citing that university research agenda is too heavily focused on theoretical issues with limited applicability to the current state of the industry. The majority of firms interviewed which engage with universities for research do so with foreign ones, not local institutions.

bureaucracy and high degrees of redundancy (Vivoda, 2008). As a result, there is an overregulation of the mining industry, as the number of regulations increased more than 10-fold, from 24 to 242.

[14] This is based on the government income from mining. In 2018, the majority of these funds (70%) must be destined to research, development and innovation.

### 3.7. Findings and discussion

**Challenges and opportunities of Peruvian Suppliers**

In this section we will present the main findings obtained from the GVC framework used to study the trends that affect the Peruvian copper mining industry and their current and potential suppliers. As it was stated at the beginning of Section 3, only there is a small number of Peruvian suppliers inserted into copper mining GVCs. The GVC analysis suggests that procurement patterns locally reflect those of the global industry, as the Peruvian copper mining industry is dominated by large MNCs. Purchasing by miners is led by the principals of quality, safety and reliability, while compliance with environmental standards has become increasingly relevant. Generally, supplier preference is based on the risk/cost assessment. Risk is determined by the critical nature of product and how difficult it is to secure. High risk/high cost inputs are procured using long-term (3-5 years) purchasing strategies to lock in costs and secure supply. These inputs are only contracted from reliable, experienced and generally global suppliers. Supply of low risk/low-cost inputs is characterized by high competition. In these cases, miners seek to reduce their transactional costs while limiting contracts to just 1-2 years; proven low-cost products are favoured. In either case, suppliers must be approved and registered on internal procurement platforms to bid on new contracts (Field Research, 2019). Procurement decision-making is generally managed by specialized teams based in corporate offices in Lima or abroad. Miners indicate that the high willingness of local suppliers to customize solutions to meet their needs improves their attractiveness to the industry. In addition to these generalized practices, it is common for miners in Peru to have specific local procurement programs for their immediate areas of impact around the mines to maintain their social licence to operate. These programs include labor contracting and maintenance amongst others.

Procurement of new, innovative products is done generally on a demand-driven basis. Unsolicited solutions are not reviewed. Once a mine has adopted a particular technology or process, new innovations are not encouraged (Field Research, 2019). The cost of disrupting operations to introduce a new process are often prohibitive and operating mines typically only seek new solutions for non-mission-critical activities. Any short-term mission critical events are handled by trusted, large foreign suppliers. On the other hand, miners are open to innovation where it solves a problem they have not yet resolved, offering the greatest opportunity for new suppliers. However, by leaving the contractors and suppliers with the responsibility to update technologically, their role in the process of innovation is only to inform the potential suppliers of their needs rather than to provide them with adequate tools to achieve the solutions required (Molina, Olivari, & Piertrobelli, 2016). In addition to this, miners are typically reluctant to publicly disclose where they have challenges in their operations leading to information asymmetries (Field Research, 2019).

Table 2 summarizes the strengths and weaknesses of these local firms in supplying the copper GVC. These firms have a comparative advantage based on their strong local knowledge, proximity to clients and their willingness to be flexible to specific client needs, as larger foreign suppliers can be reluctant to provide high degrees of customization as their business models are based on scale. Areas of weakness derive from their lack of scale, organizational skills, poor standards compliance and low investment in innovation. Key institutional problems undermine further growth, including access to qualified human capital, and a lack of coordinated industry support mechanisms.

Table 2. SWOT Analysis of Peruvian Mining Suppliers

| **Strengths** | **Weaknesses** |
|---|---|
| • Strong local knowledge (geological, cultural, institutional)<br>• Flexibility<br>• Proximity to clients | • Scale<br>• Weak business management skills<br>• Difficulty meeting global industry standards<br>• Lack of reputation and/or sector contacts<br>• Lower investments in innovation<br>• Shortage of qualified personnel<br>• Poor coordination and collaboration<br>• No supportive industrial policy for local supplier development |
| **Opportunities** | **Threats** |
| • Established and growing local copper mining market with rising global demand for copper<br>• Expansion to international markets<br>• Customization for local market | • Foreign competition<br>• Regulation (environmental, social)<br>• Increase in centralized global sourcing<br>• Social conflict<br>• Uncertain global trade environment |

Sources: Authors.

## Capability development and innovation in Peruvian Suppliers

The GVC framework suggests that, in order to obtain the benefits from participating in the international copper industry, Peruvian suppliers should insert in the copper GVC through the development of backward linkages. In order to provide higher value inputs to mining companies, in Section 3.5 we observe that Peruvian suppliers use different approaches to develop capabilities.

However, the analysis suggests there is virtually no capability development as a result of interaction amongst domestic suppliers. Suppliers typically operate in silos and have no industry representation beyond one focused exclusively on metal-mechanics firms[15] and a brand-new Department for Suppliers at Sociedad Nacional de Minería, Petróleo y Energía (SNMPE), although this organization primarily represents miners' interests rather than the industry as a whole. Most firms consider participation in the range of other professional organizations or associations to have no incidence on their business development. The lack of an efficient and coordinated national innovation system in Peru has limited the capability development of the local suppliers. In the next section, the system is analyzed.

As it was mentioned in Section 3.6, research efforts focused on the Peruvian mining are undermined by lack of sufficient funding and their limited application. The analysis derived from the data collected from the interviews suggests that, underlying these issues there is a shortage of human capital to staff research initiatives for innovation in the copper mining sector, either within university programs, independent research centers or in firms themselves. University programs have typically produced engineers with basic sets of skills, rather than those oriented specifically towards the mining industry. There have been efforts to address this shortage, however, these remain limited and still focused on meeting operational rather than innovative needs of the industry.

The lack of qualified human capital combines with poor access to finance to undermine research amongst private sector actors, amplified by the uncertainty of whether local suppliers will have market access for their innovations. Appropriate human capital for in-house

[15] Asociacion de Empresas Privadas Metalmecanicas del Peru was established in 2013 and currently has 25 members (AEPME, 2019).

innovation is a widespread challenge. Interviewees frequently cited that it is difficult to find personnel with the skills they required, forcing them to train staff in-house or send them abroad. There is a strong perception amongst policymakers that the mining industry has the financial resources to undertake innovation and research activities alone. However, this exposes a lack of understanding of the respective roles of the value chain actors. Large, well-financed mining lead firms around the world typically do not carry out innovation activities; these are rather concentrated amongst mining suppliers. The lack of financial resources amongst Peruvian mining suppliers, especially the small and medium-sized firms, has likely contributed to the weak uptake of the R&D fiscal credit offered by the government.[16]

Finally, there are weak mechanisms in place to encourage the private sector to engage with other stakeholders in the industry. A central underlying issue for mining suppliers is the lack of a representative association that can communicate their interests to other actors. Overall, there are few explicit linkages in which local providers can understand the current challenges faced by the mining companies. This information asymmetry has made it difficult for suppliers to develop appropriate innovations. Leading miner Antamina launched a Suppliers Development program in 2012 to help close this gap.[17] This program was largely modelled on that of BHP's World Class Supplier program in Chile. This consisted of putting the challenge to local suppliers to identify and find innovative solutions and approaches to resolve High Value Challenges, i.e. existing operational problems, inefficiencies or anomalies faced by mining operations. This program, however, remains an individual firm activity. It has, nonetheless, inspired the development of the private platform, Link Miners, which works with mining companies to identify challenges and publishes these for potential suppliers to bid on. Established in 2017, to date the company has 50 challenges published and 450 registered mining suppliers (Field Research, 2019).

Table 3. Summary of Key Challenges for Innovation

| Technical | Commercial | Institutional |
|---|---|---|
| • Shortage of human capital<br>• Poor quality human capital<br>• Universities too theoretical, not focused on applied research<br>• No research centers focused on mining industry | • Information asymmetry regarding opportunities for innovation<br>• Poor coordination and collaboration across value chain actors<br>• Weak access to innovation finance<br>• Lack of experienced innovation managers<br>• Cyclical nature of the industry<br>• Risk innovation | • No strategic direction from government<br>• High levels of bureaucracy in using instruments<br>• Lack of policy makers with experience in innovation instruments<br>• Relatively weak IPP<br>• No coordination amongst industry stakeholders |

Sources: Authors

Poor coordination issues are pervasive across the innovation ecosystem for mining. Universities are usually not aligned with the private sector, nor is the government coordinating with the companies and universities. There have been efforts to overcome this – such as the

[16] In order to receive the R&D fiscal credit, companies need to be turning a profit and be paying sufficient amounts in taxes.

[17] A new project, Mining Innovation Hub, was launched at the end of 2019 by Buenaventura, Nexa Resources and Goldfields and SNMPE to support innovative activities. The goal is to accelerate solutions that can enhance the productive efficiency of mining in Peru (Hub Innovacion Minera del Peru, 2019).

PRODUCE Technology Roadmap, but to date, there is little evidence of their success. As a result, the mining innovation ecosytem remains fragmented and numerous actors are working in silos and developing their own interventions to boost innovation. Ultimately, this means that Peruvian value creation from innovation in the copper mining sector continues to be very limited.

In the next section we will discuss a set of policy recommendations focused on fostering increased participation and innovation by Peruvian suppliers.

## 4. Policy Recommendations

In order to develop strong and innovative local mining suppliers, the country needs to focus first, in creating strong institutions to support the development of the sector; second, it needs to assist and facilitate the entry of the local providers to the mining GVC; and third, it is imperative to incentive innovation and upgrading of the local providers. Below, we present a series of recommendations in these three areas.

### Institutionalization

First, it is important to establish a strong and prioritized strategy for the future of Peru's participation in the mining industry. Public policy has been dominated by environmental and social concerns and little focus has yet been placed on how to upgrade within the copper mining GVC, or how this sector can be effectively utilized as an engine for growth within the economy. Developing this vision will require the government to identify and empower the appropriate national ministry to champion the sector's development and to ensure that ministry has staff qualified to manage innovation initiatives. Currently, there are multiple, redundant initiatives underway in the country, with a varying array of actors participating - from initiatives at MEF, PRODUCE, MIMEN to the CAF supported Arequipa Mining Cluster - leading to inefficient and/or incoherent outcomes and a strong sense of uncertainty amongst investors. A single multi-stakeholder council led by the policy champion, and consisting of the major actors from the public, private, educational and civil society sectors should serve as an overarching institution to establish the goals for the future growth of the industry. This council needs to be institutionalized in such a way that it can withstand political cycles, ensure a long-term approach to the sector strategy and achieve explicit targets.

At the same time, the formation of an industry association to represent mining suppliers should be supported. These suppliers are currently not adequately represented within the policy framework in the country, making it difficult for the group to collectively highlight major barriers to their participation and innovation in the industry. A collective body would facilitate miners' efforts to engage with local suppliers, create a platform for potential collaboration to help suppliers achieve scale, as well as helping to channel efforts at internationalization. PromPeru, for example, could work with the industry association to promote their capabilities in regional and global markets.

### Participation – Entry

Policies need to be implemented both to improve the organizational and technical capabilities of local suppliers and to reduce information asymmetry between miners and local suppliers. While procurement patterns of miners in Peru make entry and participation in the industry for local firms difficult, opportunities do exist for technically capable firms. First, firms would benefit from trainings on the organizational and technical requirements of mining companies,

such as global certifications on quality, health and safety, procurement processes and export procedures as well as more generalized business management support through small business development centers.

A second set of initiatives are required to reduce information asymmetry and ensure full and fair opportunities for local firms to participate in the industry. Peru has advanced local content policy for its extractive sector, by requiring firms to commit to prioritizing local content under the Sustainable Development Legislation.[18] This approach can provide considerable information to the government regarding the local procurement opportunities. The current requirements, however, are vague, lack enforceability, and the institutional complexity in Peru undermines the analysis and transmission of this information to relevant stakeholders. In practice, initiatives need to be undertaken to mandate mining companies to increase the transparency of their procurement needs; to improve the availability of information of local supplier capabilities; and to create opportunities to directly link these two. Examples include public online procurement platforms and/or supplier match-making days amongst others. Suppliers databases can be organized by ethnic groups, gender, geographic locations amongst others to help miners to meet relevant public obligations and internal corporate social responsibility commitments. By applying pre-qualification tools, these supplier portals can also help identify key technical gaps for supplier development programs, such as relevant certifications.

**Innovation and Upgrading**

Promoting innovative local suppliers in the industry requires significantly more support. First, as miners only do not buy turn-key innovation from local small suppliers (supply-driven), opportunities for miners to disclose key challenges to potential suppliers need to be created. Suppliers can then use this as a base to develop innovative solutions. Link Miners is seeking to address this gap; this model could form the basis for a national level program as has happened in Chile.

Developing innovation capabilities requires initiatives in areas of human capital availability, research and development infrastructure and in commercialization of innovation. First, there is a need to address the shortage of qualified human capital in key areas of mining expertise. While initial efforts are underway, such as through UTEC and TECSUP, additional resources can be generated through the availability of scholarships to study abroad in relevant fields. Graduate degree programs at universities such as the Colorado School of Mines and the University of Queensland develop relevant STEM capabilities as well as offering opportunities to work in applied research centers.

Second, the copper mining specific R&D infrastructure in Peru needs a significant boost. Local suppliers highlight that local universities are not yet adequately prepared to undertake applied research for the industry, with the majority of research being too theoretically focused. In the mid-long term, training of R&D personnel at foreign universities can help to shift the culture towards one of greater application.[19] In the short-to-mid term, this can be addressed with a dual approach - by the creation of a new public-private R&D center in one of the key mining regions

[18] It was put in place in 2003 for the first time.

[19] In addition, "research facilitators" can be introduced to help local SMEs in particular connect to the right research centers. This role was introduced by the National Innovation and Science Agenda in Australia to help build linkages between universities and the private sector (OECD, 2017).

such as Arequipa[20] to be staffed by a combination of experienced foreign and younger local researchers; and, by incentivizing firms to engage in R&D activities with foreign universities. Mining3 is an industry-focused research organization in Australia, with the mission to develop solutions to provide both incremental and major increases in productivity and overcome key global mining challenges. The organization partners with members from industry (8-year terms), universities and suppliers and service providers to develop these solutions. The research program is directly linked to mining challenges identified by the miner members and a technology transfer plan ensures these solutions are implemented in the sector (Mining3, 2019).

Another major R&D infrastructure concern is the lack of appropriate testing facilities to prove new technologies and services at scale. Miners generally are reluctant to open mines for testing, but simultaneously will not consider procuring untested technologies. As copper mining is dominated by large mines in Peru, there are limited opportunities for firms to trial solutions first in smaller operations. The government could play a role in establishing a test facility for these innovations, as has Chile under the Alta Ley project. The Mining Technology Testing Center (M2TC) is co-financed by CORFO, four leading Chilean universities and Minnovex, the industry association for mining suppliers. The Center allows suppliers to test technologies at the same scale as the mining sector, access expert advice for scaling up the solutions and applying global mining standards. Successful technologies receive certifications which are recognized by the industry (Centro Nacional de Pilotaje de Tecnologías para la Minería, 2019) Within 12 months of operation, 50 prototypes were being tested.

Third, local suppliers would benefit from capability development specifically with respect to the commercialization of innovation. This has several facets including options for R&D financing, protecting intellectual property (IP) and managing innovation projects. R&D financing includes, but is not limited to, R&D fiscal incentives and the mining canon. While there needs to be increased awareness of these incentives and perhaps a restructuring of the way in which canon financing is distributed, a focus should be placed on educating private and public actors about the range of other opportunities from accelerators such as UP Emprende to angel and venture funds, as well as raising the profile of mining suppliers amongst these risk capital actors (Expande Minería, 2019). Likewise, there is a need for training regarding protection and ownership of intellectual property in the mining sector. Courses on patent filings have been introduced by different actors, however, miners in the region are not well known for respecting these and firms may not be well-positioned to defend against patent infringement. One of the areas where local providers play an important role is in the services sector, patent development in this case is not as relevant. For these services, constant incremental innovation and location specificity can be sufficient to maintain an edge in IP. Finally, as innovation and R&D is relatively recent in Peru, there is a shortage of qualified innovation managers with experience enabling R&D within the industry. While many firms may be too small to hire specific roles, training courses should be developed targeting mid-level managers within the sector.

[20] The South of Peru concentrates 70% of copper production and 50% of all future mining projects.

Table 4. Select Policy Recommendations

| Institutionalization | Participation: GVC Entry | Innovation & Upgrading |
|---|---|---|
| • Develop a long-term national strategy for the copper mining sector<br>• Identify national policy champion<br>• Support the development of an industry association for suppliers<br>• Establish a multi-stakeholder council to support long-term plans for the sector; include export promotion agency, PromPeru to better coordinate internationalization efforts for innovative firms<br>• Strengthen policymaker knowledge in designing, developing and managing innovation policy | • Increase efforts to support value-added mining services suppliers<br>• Develop instruments to strengthen suppliers capabilities:<br>  • Business & organizational skills<br>  • Compliance with global standards<br>  • Registration procedures & bidding on mining project<br>• Facilitate harmonization of mine-access requirements to reduce duplication of effort<br>• Support firms to obtain certification<br>• Reduce information asymmetry between buyers & local suppliers:<br>  • Mandate transparency requirements regarding procurement opportunities<br>  • Support development of online portal to link suppliers & buyers<br>  • Suppliers matchmaking Forums | • Establish/strengthen mechanisms to support demand-driven innovation (e.g. portals, events, studies, etc.)<br>• Improve availability of human capital in the key areas using scholarships abroad.<br>• Support a short-term strategy of local suppliers to work with foreign universities on R&D until the local universities establish know-how<br>• Create a R&D center exclusively focused on applied research for copper mining.<br>• Support establishment of a testing facility.<br>• Increase awareness of R&D credit and reduce bureaucratic requirements for application<br>• Strengthen capabilities related to commercialization of innovation with raining programs on financing innovation, protecting intellectual property, managing innovation programs |

Source: Authors.

## 5. Concluding remarks

In this paper, we used the GVC framework to analyze how the governance structures of the lead miners worldwide shape the acquisition patterns of mining companies in Peru, in spite of the privileged position of the country in the upstream stages of the copper value chains. Our findings suggests that these global trends have an impact on the domestic industry, as local suppliers struggle to insert in higher-value stages of the copper mining GVCs. Is in this context that opportunities for domestic suppliers arise mainly in new mine developments. However, an underdeveloped local industry, in combination with an environment that discourages innovation, hinders the ability of suppliers to provide high-value inputs to miners.

Policies are required to better position the country to strengthen its backward linkages to the chain. Institutionally, the country needs to develop a strong, long-term national strategy, supported by a policy champion. Current policy from the government is overly focused on social and environmental regulation, with no focus on upgrading or innovating in the industry. Efforts need to be made to strengthen access to the chain by increasing opportunities for information sharing and supporting the development of industry specific organizational skills for mining suppliers.

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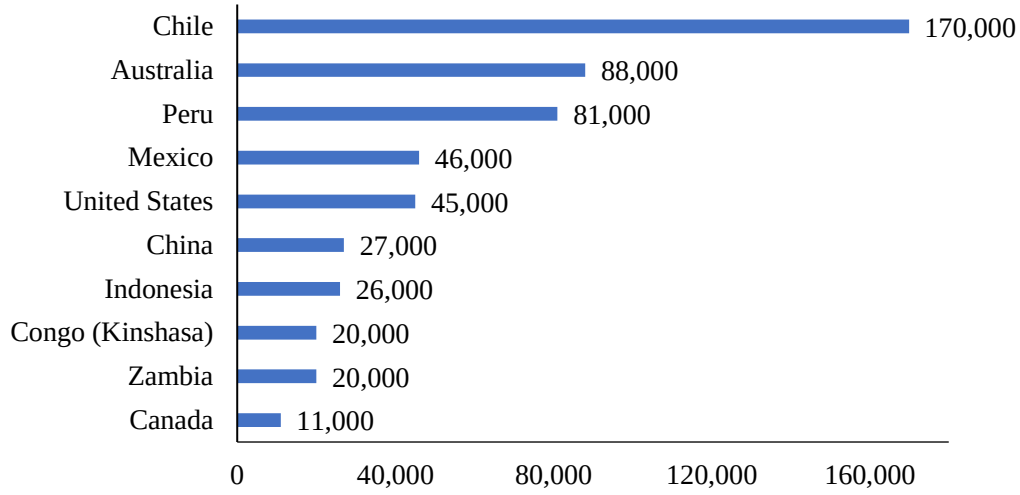
# 7. Appendix

## 7.1. Databases utilized

- London Metals Exchange: Evolution of the price of copper cathode.
- United Nations Statistics Division Comtrade Database: International trade statistics used to identify country positions in the copper global value chain. HS codes analysed: HS 2002 - 260300, Copper Ore & Concentrate; HS-2002, 7402, Unrefined copper, copper anodes for electrolysis; HS-2002, 7403, Refined copper.
- Copper Alliance World Copper Fact Book 2018: Indicators on the production capacity by country, leading mines, leading smelters, leading refineries.
- United States Geological Survey 2018. Indicators global copper reserves, extraction and refining.
- National Supply Use Tables to identify total annual operational procurement and categorize goods and services supplied to the industry from:
    - Australia (2016)
    - United States (2012)
    - Chile (2013, 2016)
    - Peru (2017)
- Anuario Minero Peru for detailed statistics on the Peruvian mining industry (Years covered, 2010-2018): Indicators included production, exports, investment by value chain stage.
- SUNAT – Customs Data (2012, 2017). Imports & exports for all copper exporting companies. Values, Volumes, Destination/Origin, HS2-6D.
- UNESCO Institute for Statistics. Science, Technology and Innovation Indicators. Indicator: R&D Spending.
- WIPO Global Innovation Index. Indicators: Patent Applications, University and Research Collaboration.
- World Bank Open Data. Indicator: Scientific and Technology Publications
- Property Rights Alliance Intellectual Property Rights Index.
- World Economic Forum Global Competitiveness Index.

## 7.2. Tables and Figures

Figure A.1. Copper Reserves per Country, 2018 (MT, million)




Source: USGS (2018)

Table A.1 Leading Global Miners

| | Copper Production (MT) | Copper Revenue (EBITDA) | Origin | Key Mines in Latin America | Key Mines (Rest of World) | VC segments |
|---|---|---|---|---|---|---|
| CODELCO | 1,806 | 4.7 | Chile | Chuquicumata (100%, operator)<br>El Teniente (100%, operator)<br>Radomiro Tomic (100%, operator)<br>El Abra (49%)<br>Las Bronces (20%) | | Exploration, Extraction Smelting, Refining SX-EW |
| BHP | 1,753 | 6.5 | Australia | Escondida (57.5%, operator)<br>Antamina (33.75%, joint-control)<br>Cerro Colorado (100%, operator)<br>Spence (100%, operator) | Olympic Dam (100%, operator) | Exploration, Extraction SX-EW |
| Freeport McMoran (FXM) | 1,733 | 6.5[a] | United States | Cerro Verde (53.6%)<br>El Abra (51%) | Grasburg (81.5%, operator)<br>Morenci (78%) | Exploration, Extraction Smelting, Refining SX-EW |
| Glencore | 1,454 | 4.7 | Switzerland | Antamina (33.75%, joint-control)<br>Collahuasi (44%)<br>Antapaccay (100%, operator) | Ernest Henry (70%, operator)<br>Mount Isa Mines (100%, operator)<br>CSA Mine (100%, Operator)<br>Katanga (86.3%, operator) | Exploration Extraction Smelting Refining SX-EW Trading |
| Grupo Mexico | 1,200 | 2.3[b] | Mexico | Buenavista del Mexico (100%)<br>Toquepala (100%)<br>Cuajone (100%)<br>Caridad | Mission, Ray & Silver Bell<br>Mineria Los Frailes | Exploration Extraction Smelting Refining SX-EW |
| AMSA | 725 | 2.2 | Chile | Antucoya (70%)<br>Centinela (70%)<br>Los Pelambres (60%)<br>Zaldivar (50%) | | Exploration Extraction Smelting SX-EW |
| AngloAmerican | 668 | 1.9 | United Kingdom | Los Bronces (50.1%, operator)<br>Collahuasi (44%, joint-op)<br>El Soldado (51%, operator) | | Exploration, Extraction Smelting |
| Rio Tinto | 634 | 2.8 | Australia | Escondida (30%, joint-control) | Oyu Tongi (33.5%, joint-control)<br>Kennecott (100%, operator) | Exploration, Extraction Smelting, Refining |
| First Quantum | 606 | 1.7 | Canada | Cobre Panama (90%, operator)<br>Las Cruces (100%, 74KT) | Sentinel (100%)<br>Kansanshi (80%)<br>Cayeli (100%) | Exploration Extraction Smelting |
| Norlisk Nickel | 436 | 6.2* | Russia | | Polar division and Kola MMC<br>GRK Bystrinskoye<br>Harjavalta Nkomati | Exploration Extraction Smelting Refining |
| Vale | 395 | 1.1 | Brazil | Sossego<br>Salobo<br>Sudbury | | Extraction |
| Teck Resources | 294 | 2.8 | Canada | Antamina (22.5%)<br>Andacollo (90%)<br>Quebrada Blanca (90%) | Highland Valley (100%) | Exploration |

Source: Annual Reports, Company Websites.
Notes: [a] All mining revenues. [b] Calculated based on 65% share of copper in output.

Table A.2. Expenditure of Peruvian Mining Sector, 2017

| **SUT 2017** | **US$ (Million)** | **Share of Total** | **Share of Products** |
|---|---|---|---|
| Total Procurement | 8,991 | 100% | |
| **Total Goods** | **4,504** | **50%** | **100%** |
| Utilities | 913 | 10% | 20% |
| Chemicals & Explosives | 934 | 10% | 21% |
| Capital Equipment & Parts | 464 | 5% | 10% |
| Fuels & Lubricants | 1,257 | 14% | 28% |
| Consumables | 182 | 2% | 4% |
| Metallic Products, Structural | 326 | 4% | 7% |
| Other | 424 | 5% | 9% |
| Transportation Equipment | 3 | 0% | 0% |
| **Total Services** | **4,487** | **50%** | **Share of Services** |
| Architectural and Engineering Services | 217 | 2% | 5% |
| Professional & Technical Services | 1,178 | 13% | 26% |
| Transportation & Logistics | 1,620 | 18% | 36% |
| Utilities Services | 57 | 1% | 1% |
| Repair and Maintenance Services | 138 | 2% | 3% |
| Labor Contracting Services | 862 | 10% | 19% |
| Equipment Leasing, without Operator | 267 | 3% | 6% |
| Other | 149 | 2% | 3% |

Source: Authors, based on 2017 Peruvian Supply Use Matrix INEI (2017).

Table A.3. Select Peruvian Mining Suppliers

| Company | Products/services | Activities/Products/Services & Changes over time | Mining GVC Stage |
|---|---|---|---|
| Exsa | Manufacturing of explosives/ explosive services | Exsa has more than 60 years. It changed its business model from just manufacturing explosives to provide extract solutions to mines. It also serves the Chilean market. | Extraction |
| Famesa | Manufacturing of explosives | The company was founded 64 years ago. It is engaged to the manufacturing and commercialization of explosives, blasting accessories and agents for mining. Export to all continents. | Extraction |
| GyM | Integral mining services | GyM is a large and diversified engineering company with a big presence in the Latin American market. | Exploration & Mine Development (EPC/EPCM) |
| Link Miners | Marketing services to mining suppliers | Link Miners is a company that connects mining suppliers with mining companies through a web platform in which the mines present their current needs and suppliers offer solutions. | All Stages |
| Mepsa | Mining parts manufacturer | Mepsa was created in 1964. They provide consumables for mining equipment such as steel grinding balls. The majority of its exports goes to Chile. | Extraction Communition/Benefication/ Concentration |
| Mimco | Manufacture and installation of metallic structures | Mimco is a Peruvian company created 14 years ago. It serves several markets and in the latest years has penetrated the mining sector offering the sales and installation of electric rooms. | Exploration & Mine Development |
| Minconsulting | Mining engineering services | The company was founded in 2014 focusing on feasibility studies. They also sales in partnership with a foreign company mining software. | Exploration & Mine Development |
| NDT Innovations | Non-destructive testing services of equipment and assets | NDT opened in 1996 and start exporting its services in 2004. The company offers non-invasive testing to detect defects in equipment before the damage. | Extraction Communition/Benefication/ Concentration |
| Proesmin | Mining services related to environmental issues | Proesmin is one of the three group of Peruvian services companies that offers services during all stages of the value chain. | Exploration & Mine Development |
| Qaira | Drone services to mines | Qaira was born as a start up from an idea developed by a Universidad Catolica del Peru student. The company offers monitoring of mines with drones. | Extraction |
| Resemin | Manufacture of drilling jumbos for underground mining | Since 1979, Resemin has been working in the mining sector. The company exports its products to all continents. | Extraction |
| SRK Consulting | Mining engineering services | SRK Consulting if formed with the merge (2011) of a Peruvian company | All Stages |

| | | | |
|---|---|---|---|
| | | 70% (SBS Ingenieros, created in 1985), with an international company 30% (SRK Global). | |
| Stracon[21] | Mining and construction services | Stracon was part of Graña y Montero until 2018. It provides mining services to several countries in the Americas, including Canada and Mexico. | Exploration & Mine Development Extraction |
| Tecsup | Mining engineering services | Tecsup is a college in Peru that offers tech degrees. At the same time, they possess a consulting and laboratory arm offering services to mining. It also serves the Chilean market. | Exploration & Mine Development Extraction Communition/Benefication/ Concentration |
| Tumi | Manufacture of raise boring equipment | This firm was founded in 1982. They developed the SBM 400 SR, a machine that reduced digging time and costs significantly. It now exports its machines to 22 countries. | Extraction |

Source: Authors.
Note: All of these mining providers (except Stracon and GyM) were interviewed by the research team.

[21] Stracon was acquired by Ashore Group.

Table A.4. Research, Development & Innovation System Indicators

| Indicator | | Peru | Chile | Global Average/ Total | Countries with Adjacent Rank | Source |
|---|---|---|---|---|---|---|
| **R&D Spending (% of GDP)** | | 0.12 (2017) | 0.36 (2016) | Average: 2.2% (2016) | Cambodia, Venezuela, St. Vincent & Grenadines, Tajikistan | UNESCO |
| **Patent Applications, Residents** [i] | | 100 (2017) | 425 (2017) | Total: 2,161,000 (2017) | Armenia, Latvia, Lebanon, Syria, Venezuela | World Bank, World Intellectual Property Organization, WIPO Patent Report: Statistics on Worldwide Patent Activity |
| **Scientific & Technology Journal Citations**<br><br>**Scientific & Technical Articles** | | 1,008 (2016)<br><br>114/129 (2018) | 6,746 (2016)<br><br>39/129 (2018) | Total LAC: 96,586 (2016) | Ghana, Kenya, Sri Lanka, Cuba | World Bank, National Science Foundation, Science and Engineering Indicators. WIPO |
| **Researchers in R&D (Headcount/million inhabitants)** | | 47.4 | 793 (2016) | Average: 1,500 (2015) | Burkina Faso, Cabo Verde, Chad, Ethiopia | UNESCO |
| **Researchers in R&D % by sector of employment (Headcount/million inhabitants)** | **Business Enterprise** | 2.4 | 25 | NA | NA | UNESCO |
| | **Government** | 7 | 12 | | | |
| | **Higher Education** | 71.1 | 58 | | | |
| | **Private non-profit** | 4.5 | 5 | | | |
| | **Unspecified** | 15 | - | | | |
| **University/Industry Research Collaboration** | | 98/129 | 55/129 | | Benin, Kuwait, Tunisia | WIPO |
| **Global Innovation Index** | | 69/129 (2019) | 51/129 (2019) | | Tunisia, Saudi Arabia, Brunei, Colombia | WIPO |
| **IPRI Score/Rank** | | 5.2<br>69/125 (2018) | 6.9<br>29/125 (2018) | | Greece, Sri Lanka, Philippines, Tanzania | Intellectual Property Rights Index (2018) |
| **Global Competitiveness Index:**<br>**Skills Pillar**<br>**Innovation Capacity Pillar** | | <br>83<br>89 (2018) | <br>42<br>53 (2018) | | Skills: Kyrgyzstan, Panama, Mexico, South Africa<br>Innovation Capacity: Ecuador, Kazakhstan, Guinea, Albania | World Economic Forum (WEF) |

Sources: (World Bank, 2019; UNESCO, 2019; Property Rights Aliance, 2019; Cornell University, INSEAD, and WIPO, 2018)

Table A.5. Government and Private Sector Policies and Programs

| Program/Policy | Description | Responsible Institution | Mechanism | Effectiveness |
|---|---|---|---|---|
| **Entrepreneurship** (Support for creation of new firms/start-ups) | | | | |
| **Start-Up Peru: Dynamic Entrepreneurs** | Co-financing up to an amount of approximately US$41k (S./140,000) for new firms with innovative technological solutions in the commercialization phase. | Innovate Peru (Ministry of Production) | To be eligible, firms must have sales above US$36K (S./120K). Firms receive support with respect to software improvement, intellectual property registration, marketing strategies and product upgrading. | NA |
| **Start-Up Peru: Innovative Entrepreneurs** | Co-financing up to an amount of approximately US$15,000 (S./50 000) for teams of 2 to 4 people with innovative products/services/business models. | Innovate Peru (Ministry of Production) | Financing includes market studies and focus groups to validate business model feasibility, prototype development and enhancement, networking events, among others. | NA |
| **Innovation** (Development of new innovative products and services) | | | | |
| **Innovate Peru** | Created through the Supreme Decree N°003-2014-PRODUCE, the program focuses on increasing innovation and facilitating the adoption of new technologies for enterprises. | PRODUCE | The program manages four different funds that are assigned by nation-wide open competitions. The funds are aimed at Competitiveness Innovation (FINCyT 2), R&D for Competitiveness (FIDECOM), Science, Technology, and Innovation (FOMITEC), and Micro and Small Enterprise projects (MIPYME). | As of 2018, the program had co-financed more than 3,000 R&D and entrepreneurship projects. |
| **National Science, Technology, and Innovation Plan for Competitiveness and Human Development (Law N°28303)** | A 15-year (2006-2021) cooperation agreement between regional governments, governmental institutions, private schools and firms. Its main goal is to facilitate the development of innovative products and processes. | CONCYTEC | The plan focuses on different strategies that include the promotion of highly innovative processes, securing foreign financing, the diffusion of innovative practices, direct assistance towards firms in matters regarding innovation, and facilitating the cooperation between private agents, among others. | NA |
| **R&D Fiscal Credit** | Law 30309, the Promotion of Scientific Investigation, Technological Development and Innovation, is a fiscal incentive to promote investment in R&D by the private sector. The law entered into effect in 2016 and will remain in effect until 2022. In 2019, this law was modified to improve its use by SMEs. | CONCYTEC | 100% tax deduction of RD&I expenses for all companies. In addition, companies that are approved through CONCYTEC can apply for up to 75% additional reduction. This additional credit has an annual limit of US$1.5M. | In the first three years of the program, 49 projects received this credit, for a total of US$30M (S/108M). Surveys indicate that only 30% of companies were aware of this benefit by 2019. |
| **Local Participation** (Regulations and mechanisms to encourage hiring local firms) | | | | |
| **Commitment to Sustainable Development (Decree 042-2003-EM)** | In 2003, Local Content was introduced in Peruvian legislation for the first time in Decree 042-2003-EM, known as the Commitment to Sustainable Development. This decree includes a list of commitments that all mining firms must adopt when they undertake mining exploration. | MINEM | Mining firms and their contractors commit to preferentially hiring local people as well as providing training. Equally, they must preferentially purchase local and regional goods and services and support entrepreneurs to promote diversification. This decree establishes that firms are required to submit an Annual Consolidated Declaration (DAC for its name in Spanish) on these commitments to MINEM. Local content requirements are part of mining firms' Environment Impact Assessment plans. In addition, the local content clauses of Decree 042-2003-EM were also included in the privatization agreements between mining firms and the government. | NA |
| **Export Promotion** (Oriented to helping local suppliers export to regional/global clients) | | | | |
| **Exporter Route** | PROMPERU offers a specialized assessment for micro and small exporters firms in order to introduce them to the global market and connect them with potential clients. | PROMPERU - Ministry of External Commerce and Tourism | The assessment consists of several steps that include virtual training programs, nation-wide seminars, international conventions, among others. | NA |
| **Private Sector Initiatives** | | | | |
| **Antamina** | In 2012, Antamina, the largest producer of copper and zinc in Peru, started the program, Developing Suppliers of Excellence for the Mining Industry of Peru. There were two main objectives, namely to improve the productivity of the mining firm and to develop the capacity of suppliers to provide | Antamina | Local suppliers were tasked with identifying and developing innovative solutions and approaches to resolve High Value Challenges the company was facing, i.e. existing operational problems, inefficiencies or anomalies faced by mining operations. The firm offered capable suppliers the opportunity to co-design these solutions, lead to the development of | The program is no longer in operation. |

| | | | | |
|---|---|---|---|---|
| | increasingly complex services for the industry and, potentially, for other industries as well. | | cooperative relationships. Following a process of strategy selection, the Logistics and Operations Departments then offered the opportunity to chosen suppliers to test their solutions before awarding contracts. | |

Source: Authors.

Table A.6. Comparison between EPC and EPCM Contracts

| | EPC | EPCM |
|---|---|---|
| **Accountability** | Contractor fully accountable | Owner has multiple points of accountability |
| **Risk** | Contractor holds risk | Owner holds risk |
| **Time** | Fixed date for completion | No fixed completion schedule |
| **Price** | Fixed price contract | Schedule of Rates / Cost Plus |
| **Procurement** | Contractor responsible for procurement | Procurement as agent for the owner only |
| **Quality/Performance Guarantee** | Contractor guarantees performance of completed facility | Contractor does not provide performance guarantees |
| **Owner's Involvement** | Contractor in control | Owner in control |
| **Defective works/services** | Contractor to rectify any defects | Assists owner to manage rectification of defects |

Source: (Sarcich & Moore, 2014)

Table A.7. Distribution of Refined Copper Production Worldwide 2017, by Country

| Country | Share of Refined Copper Production (%) |
|---|---|
| China | 37.8 |
| Chile | 10.4 |
| Japan | 6.3 |
| United States | 4.6 |
| Russia | 3.9 |
| India | 3.5 |
| D.R. Congo | 3 |
| Germany | 3 |
| South Korea | 2.9 |
| Poland | 2.2 |
| Mexico | 2.1 |
| Zambia | 2 |
| Spain | 1.8 |
| Belgium | 1.7 |
| Australia | 1.7 |
| Kazakhstan | 1.4 |
| Peru | 1.4 |
| Canada | 1.4 |
| Other countries | 9 |

Source: (ICSG, 2018; Natural Resources Canada, 2019).