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The mining global value chain

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THE MINING GLOBAL VALUE CHAIN

Jane Korinek, OECD

The mining sector accounts for a substantial share of exports and GDP in some countries, but rarely creates many direct jobs. This paper examines the mining sector using a value chain perspective, looking at both direct and indirect inputs and outputs. It finds that inputs from other sectors, in particular services, represent an opportunity for some minerals-rich countries. This paper aims to shed light on what those opportunities might be, and on some of the policies that influence whether or not such sectors emerge and develop.

Key words: Global value chains, GVCs, mining, extractive industries, embodied services, input-output methodology

JEL Codes: F1, F13, F60, F63, O33, Q32, Q37, Q38

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Executive summary

The mining sector accounts for a substantial share of exports and GDP in some countries but a significantly smaller share of employment. That said, while the mining sector does not create many jobs in the sector itself (direct jobs), it uses inputs from other sectors which may be more labour intensive and varied in terms of skill levels required. These linkages mean that mining may be an important source of indirect employment in other related sectors, which may represent an opportunity for some minerals-rich countries.

This paper aims to shed light on what those related sectors might be, and on some of the policies that influence whether or not such sectors emerge and develop. It examines the mining sector in a value chain perspective, looking at both direct and indirect inputs and outputs, drawing on new detailed, harmonised data on the mining global value chain available for the first time in the 2018 update of the OECD Trade in Value Added (TiVA) database.

Main findings

- Services are the main input sector into mining activities, outside of the mining sector itself, representing 23% of the value added of mining exports. Although this is lower than for some manufacturing sectors, it represents a potentially large area of economic activity in some minerals-rich countries. Inputs from manufacturing represent a far smaller share: 7% of the value added in mining. As with other natural resource sectors, much of the value added of mining exports comes from the sector itself (59%).
- Embodied services in mining exports represent a global industry of USD 41 billion in the 65 countries in the TiVA dataset, and have doubled in the ten years under review, pointing to a greater "servicification" of the mining sector. As in other sectors of the economy, this can be explained by a greater use of services as well as a tendency to outsource services rather than provide them in vertically integrated conglomerates. In some cases, services replace goods as inputs into the sector, as when firms lease machinery and equipment rather than purchasing it.
- Services are generally less traded than goods and this is confirmed for services inputs into the mining sector: 18% of the value added in mining exports is domestically sourced services and 5% is imported services inputs, compared with 4% (domestic) and 3% (foreign) manufacturing in value added terms.
- Mining industries in higher-income countries use more services as inputs into their production process than those in lower-income countries. This could reflect more developed services sectors in higher-income countries able to offer more targeted services, including those linked to new technologies. It may also reflect higher demand for specialised services to comply with regulatory requirements, given greater enforcement capacity. Finally, it may be the case that in lower-middle income countries in particular, local services firms do not exist in all areas and mining firms must therefore provide some services in-house, in which case they are not captured in this analysis.
- The main providers of services to mining firms are often not located in minerals-rich countries, indicating that mining countries have not generally developed their services sectors to a level to compete in foreign mining markets. The largest provider of traded services to the mining sector by far is the United States, followed by the People's Republic of China (hereafter "China"), Germany, the United Kingdom, Japan, France, and the Netherlands. Notably absent is the

existence of a mining services hub in Latin America, home to three of the top four global minerals exporters in value added terms.

- Services used in the production of mining exports have a significant positive effect on the level of domestic value added in mining exports: a 10% increase in the value added of embodied services in mining is associated with an average 2.8-3.4% increase in the domestic value added (DVA) of mining exports, all else equal. This impact is seen in countries at all levels of development.
- Innovation is of great importance in countries' success in capturing gains from their mineral resources. For every additional mining-related patent registered, a country can expect a 0.1% increase in mining DVA. As an example, this implies that if Chilean mining-related patents were at the level of those of Australia over the ten-year period under review, the domestic value added that it extracts from its mining sector would be 9.6% higher than it is today.
- This study provides some evidence to support the idea that countries in early stages of global value chain (GVC) integration rely more on foreign intermediate inputs to produce their exports, while at later stages these become less significant. The positive impact of imported inputs on the domestic value added of the mining sector is stronger in lower-middle income countries than in higher-income countries. These results confirm similar findings in other studies for the manufacturing sector that as economies newly integrate into GVCs, they rely to a greater extent on foreign inputs to produce and add value to their exports. As they develop, and become more integrated into GVCs, the importance of the positive impact of foreign inputs diminishes. Even in high-income, highly integrated countries, however, the impact of foreign inputs remains positive and significant.

Main policy implications

- This analysis points to the positive impact of services inputs into the mining sector and the positive effect of imported inputs in particular. Countries interested in leveraging their mineral resources for economy-wide growth should not shy away from foreign inputs. Openness to trade, and lowering barriers to services trade, will allow mining firms in minerals-rich countries to increase productivity through lower input costs and to benefit from advances and new technologies.
- Many services providers to the mining sector are small- and medium-sized enterprises. These firms are particularly ill equipped to navigate difficult business environments. Countries wishing to support their mining services sectors should ensure that firms in these sectors do not face overly burdensome regulation.
- Strong innovation systems seem to be strongly correlated with robust performance in the export of services for mining. All seven of the top services exporters (the United States, China, Germany, the United Kingdom, Japan, France, and the Netherlands), accounting for over half of the trade in services for mining in value added terms, are well within the top 20 countries in terms of innovation performance.
- Finally, the policy framework in place in the countries in which they operate strongly affects the ability of firms to access GVCs and to take advantage of the opportunities they offer. The policy framework, however, is only as good as the information used to develop it. Some powerful tools exist to inform policymaking for the mining value chain: the OECD's Trade in Value Added database, Services Trade Restrictiveness Index, Product-market Regulation indicators, as well as the global innovation index and sub-indices. Not all countries have collected data to a sufficient level of detail and quality, however, to fully inform policymaking in these areas.

1. Introduction

Global value chains, where different parts of production processes are carried out in different countries, have become a lens through which to view trade flows and the opportunities and risks created by greater global integration. Some value chains – the iPhone, semi-conductors, motor vehicles, to name a few – have been analysed in detail numerous times. The mining sector, however, has never been examined in a comprehensive fashion, despite its overriding importance for some countries. This paper aims to contribute to filling that gap.

For some countries, the mining sector represents over half of value of exports and accounts for a substantial portion of GDP. This is the case in some OECD countries such as Australia and Chile, and even more so outside the OECD area. However, the extractive industries rarely create many jobs. In the worst case, perceptions of the industry are that it benefits a few firms that extract precious natural resources for export and contribute very little to local and national economies. In the case that extractive firms are multi-nationals with headquarters abroad, negative perceptions are even stronger.

Contrary to the economic activity in most sectors, it is geology rather than the business environment that determines where mining takes place. This implies added constraints for the mining industry and – potentially – opportunities for minerals-rich countries. Although mining does not create many direct jobs, the mining sector uses inputs from other sectors which may be more labour intensive and varied in terms of skill levels required. This paper aims to shed light on what those might be and on some of the policies that influence whether or not such sectors emerge and develop. This analysis benefits from the existence for the first time of detailed, harmonised data on the mining global value chain in the 2018 version of the OECD Trade in Value Added (TiVA) data.

The next section sums much of what is known about global value chains that is relevant to this analysis, followed by an analysis of the mining value chain. Services are found to be a major input into the mining sector and much consideration is given to what those might be and which policies might influence them. The paper concludes with some implications for policies in minerals-rich countries to leverage their natural resources for wider economic growth.

2. Evolutions in trade: Global value chains

Lower trade costs, greater facility in communications and information availability have allowed more specialization by firms and the potential to source goods and services globally. Fragmentation and internationalisation of production chains are not new but have grown substantially in recent decades. Such fragmentation allows firms to specialise in specific activities and has thereby allowed some firms to enter global markets since they can produce one part of a final good, or provide a specific service, rather than needing to integrate an entire complex production process. Unbundling of tasks and business functions may have increased opportunities for developing countries in particular to participate in global value chains (Baldwin, 2012; Escaith, 2014; OECD, 2013) as firms in developed countries outsource to more cost-competitive regions. In this way, production takes place in geographical areas and in firms, in closer alignment with their comparative advantage.

Participation in global value chains (GVCs) provides producers with access to new markets and potentially higher returns, and can affect both the volume and value of goods and services they produce (Greenville et al., 2019). GVC participation creates jobs and generates higher returns to capital (Wright, 2014). Analysis suggests that "upwardly mobile countries have considerably more involvement in GVCs than do languishing countries" due in large part to faster productivity growth

(World Bank et al., 2017). Further, evidence suggests that both the buying and selling activities in value chains tend to bring about economic benefits (Kowalski et al., 2015; Kummritz, 2014).

A country's position in a given value chain will largely depend on its comparative advantage and therefore the mix of skills and resource endowments that it brings to international production (Lopez Gonzalez, 2016). For some, this might involve specialising in the labour intensive segments while others may specialise in the high-tech elements. The rich research on global value chains suggests a number of structural characteristics of countries are the main determinants of GVC participation, most importantly (Kowalski et al., 2015):

- Market size: the larger the domestic market, the lower the backward integration of countries and the higher the forward integration. Backward integration is measured by the share of foreign value added embedded in a country's exports; forward integration is measured by the share of a country's exported value added that is further exported by the importing country. The intuition is that countries with a larger market can draw on a wider array of domestically available intermediate goods and services.
- Level of development: The higher the per capita income, the greater the engagement in global value chains. More developed countries tend to source more abroad and sell a higher share of their gross exports as intermediate products.
- Industrial structure: The higher the share of the manufacturing sector in GDP, the higher the backward engagement, and the lower the forward engagement.
- Location: GVC activity is organised around large manufacturing hubs. The greater a country's distance from one of the large hubs in North America, Europe or South-east Asia, the lower the backward engagement, suggesting that there is a premium to locating close to large "headquarter" economies for engagement in GVCs.

In general, and in developing countries in particular, mainly large firms tend to be involved in global production networks. In Latin America, for example, small firms rarely trade outside the region (World Bank, 2017).

Countries with better institutions such as stronger property rights and rule of law participate more in GVCs, other things being equal (World Bank, 2017). High trade costs also strongly affect countries' potential to participate in GVCs, whether their cause is border measures, inefficient procedures, bureaucratic red tape, or poor infrastructure (OECD, 2013). Foreign direct investment, which tends to be sensitive to policy barriers and red tape, is a key vehicle of GVC participation. International rules, standards and regulations make GVC-related transactions easier. However, strengthening institutions and reducing trade costs may not be sufficient for policy makers aiming to increase GVC engagement. "Some sobering research shows that in addition to one's own institutions, the quality of neighbouring countries' institutions matters as well" (World Bank, 2017). As regards complex global value chains, countries with neighbours with malfunctioning institutions export less, even after controlling for the country's own institutions (Ibid).

Recent research on GVCs also suggests that structural and policy drivers of GVC participation can vary significantly by sector and with the level of development. This suggests that there is "merit in nuancing the analysis of GVC participation on the basis of economic sectors and the level of economic development" (Kowalski et al., 2015, p. 7).

One of the key factors determining convergence of some developing countries' incomes with those of high-income countries is their ability to embrace GVCs (Hausmann, 2014). By importing some intermediate goods and services, firms gain access to new technologies and business processes, and may further increase their productivity by "learning by doing" (Hausmann, 2014) or "learning by importing" (Jouanjean et al., 2017). "Learning by importing" signifies that the use of higher quality

and more sophisticated imports of intermediates and technologies through GVCs increases the quality of final products and efficiency of firms' processes and increases access to know-how, which can potentially spill over to the rest of the economy. In this way, imported technologies can have a positive impact on industries' total factor productivity both through embodied intermediate inputs and through allowing firms to improve their own technologies (Miroudot et al., 2009).

Gains from imported intermediate goods seem to depend in part on the country from which they are sourced. Increased benefits seem to occur if intermediate inputs are imported from developed countries (Bas and Strauss-Kahn, 2014). Imported intermediates from developed countries are seen to provide a greater boost to productivity, highlighting the technological transfer element in the use of foreign intermediates (Lopez Gonzalez, 2016). Similarly, a positive relationship has been found between imports and GDP, although with gains distributed unevenly across sectors (Kummritz, 2014).

The importance of imported intermediate goods and services in enhancing productivity and therefore the propensity to export suggests that imports and exports are complementary. In other words, "export competitiveness is inextricably linked to having access to competitively priced intermediate imports" (Kowalski et al., 2015). This suggests that public policies should seek to maximise the domestic value addition of exports, rather than the share of domestic content, thereby accounting for both the potential for value- and volume-enhancing impacts of GVC integration.

GVCs can provide opportunities to move into higher value activities. Beyond the productivity increases from greater specialization in tasks and greater economies of scale, GVCs provide opportunities to increase value added over time through processes generally called "upgrading". Upgrading is a term with various interpretations both at the firm and sector level. In a general sense, upgrading represents a process of improving productivity through organisational change or improved production techniques that may be driven by the use of foreign intermediates that come from GVC participation, or through GVC-related creation of economies of scale or scope (Greenville et al., 2019).

There are several approaches to upgrading in a value chain (Humphrey and Schmitz, 2002; OECD, 2013):

- *Process upgrading* occurs when firms can process tasks with greater efficiency and lower defect rates than their rivals or process more complex orders.
- *Product upgrading* occurs when firms can supply higher value-added products than their rivals through superior technological sophistication and quality. It also involves the capability to introduce novel products faster than rivals.
- *Functional upgrading* occurs when firms can provide competitive products associated with higher value-added in new segments of a GVC.
- *Chain upgrading* occurs when firms are able to participate in or switch the locus of their activities to new GVCs producing higher value-added products or services. These capabilities include managerial talent, which helps identify potential opportunities and threats and enables firms to reconfigure their resources and organisational structures in a timely manner.

It has commonly been considered that once countries have successfully entered GVCs, they should necessarily aim to move into areas with higher value added products on a unit value basis: metals rather than unprocessed minerals and ores, food production rather than agriculture, etc. Among raw materials producers in particular, there has been a push to move production downstream to sectors with higher unit values in order to capture a greater share of the value added in-country. However, analysis suggests that not only the share of value added matters, but also the volume of trade (Kowalski et al., 2015). Moreover, it may not always be the case that downstream activities generate

greater domestic value added, even if observed unit values are higher. In the food and agriculture sectors, for example, the value added of processed food sectors is of similar magnitude as that for unprocessed agricultural exports (Greenville et al., 2019).

More importantly, the notion of comparative advantage cannot be avoided. Not every natural resource-rich country has a comparative advantage in moving into downstream processing. Geological and environmental factors largely determine where production and extraction of natural resources take place. The factors of production necessary for achieving comparative advantage in processed products are, however, very different. Not all countries with abundant natural resources have a comparative advantage in turning these resources into processed materials. These considerations highlight the importance of applying a GVC lens to public policy questions of upgrading and increasing value addition.

Services in GVCs

In value added terms, services represent half of the value of world trade (Miroudot et al., 2017). While two-thirds of economic activity is made up of services, trade in services accounts for only 20-25% of world trade in terms of balance of payments gross exports and imports. Using a value added approach, accounting for the value of goods and services that have been used as inputs into traded products, however, services account for close to half of the value of trade.

Conceptually, services *embodied* in goods can be distinguished from services *embedded* in goods (Low, 2013). Services *embodied* in goods are intermediate inputs in manufacturing, agriculture or mining value chains. Services *embedded* in goods are sold together with goods as a bundle. The difference is that embodied services support the producer in the manufacturing process while the producer delivers embedded services to the customer.

The servicification of economic activity refers to the fact that increasingly, producers of goods rely on substantial inputs of services in their production processes, and potentially as outputs bundled with goods. Services provide links between different stages of value chains, and are often important inputs into production processes. Services are used early on in value chains in the form of research, design and engineering activities. They are also present far downstream in the areas of marketing and distribution. Services also support production in a variety of ways, from accounting, legal and financial services to logistics, transportation and telecommunications.

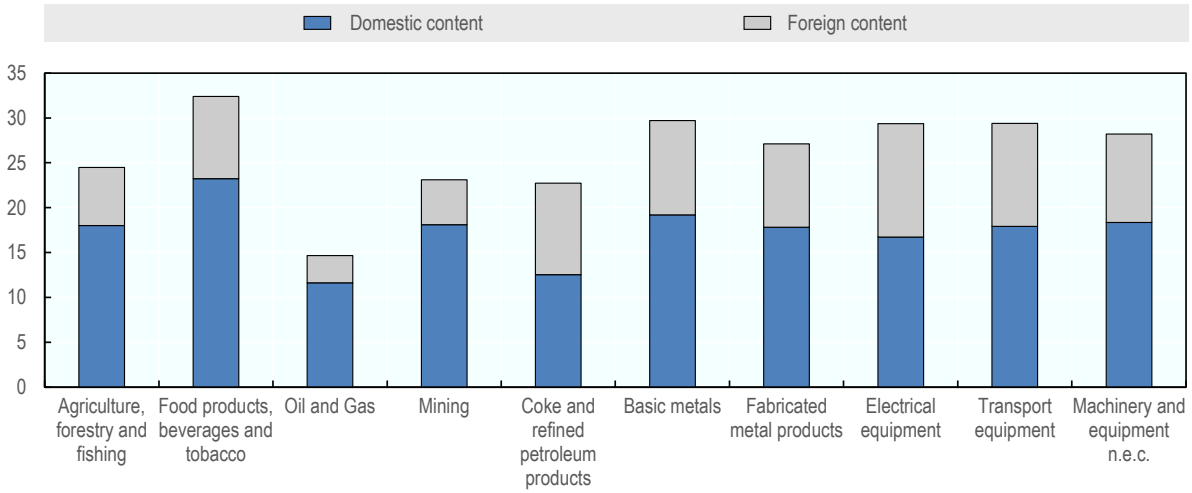
Increasingly, services that were previously provided within firms are being outsourced and, in some cases, offshored to lower cost locations. Although this phenomenon is similar to that observed for goods, the increasing sophistication of services, from software in cars to remote sensors for example, has meant that existing measures of services components of goods have grown both in the absolute and due to the way these inputs are captured due to the increase in the splintering of such activities.

The vast majority of services trade in value added terms is in fact services embodied in exports of goods. The share of embodied services in exports of goods differs by sector. Complex value chains that support sophisticated final goods require more services inputs than, for example, raw materials value chains. Embodied services make up about 30% of the value added of exports of electrical and transport equipment, products fabricated from metals and processed food (Figure 1). However, even in raw materials sectors such as mining, services account for 23% of the value added of exports. The sector with the lowest share of services value added of exports is oil and gas (15%).

In addition, a substantial share of the services embodied in exports of goods are produced domestically. For most manufacturing sectors, the domestic value added of embodied services is between 17% and 19%. For the mining sector, it is 18% of the value added of exports. Extractive energy sectors have a lower share of domestically produced services in value added terms: for oil and gas, the corresponding share is 12% and for coke and refined petroleum, 13%.

In general, services are less traded than goods. Although services generate more than two-thirds of global GDP,[1] they account for less than a quarter of gross exports (World Development Indicators, 2017). This suggests that services sectors that support exports potentially represent large industries. In the case of natural resource rich countries where exports of their natural resources represent a substantial share of total exports, for example, services inputs into the sector may represent a substantial economic activity.

Figure 1. Value added of services in exports of selected sectors



Source: OECD Trade in Value Added (TiVA), 2018 release.

3. Mining in global value chains

The Trade in Value Added (TiVA) dataset traces value addition into and out of the mining sector throughout the entire value chain. Analysis of this type is comprehensive and includes all stages of the mining value chain, not only the direct input and output sectors.[2] Upstream linkages to sectors that feed into the mining sector as inputs are referred to as backward linkages. Downstream sectors that integrate exports from the mining sector into their production processes are referred to as forward linkages.

This analysis benefits from the existence for the first time of detailed, harmonised data on the mining global value chain in the 2018 version of the TiVA data. It exploits the newly disaggregated value added data of the mining and quarrying sector and analyses exports of mining and metal ores, excluding the energy sectors of crude petroleum, natural gas, and coal.[3]

[1] http://www.oecd.org/tad/policynotes/oecd-services-trade-restrictiveness-index-policy-note.pdf.

[2] http://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm.

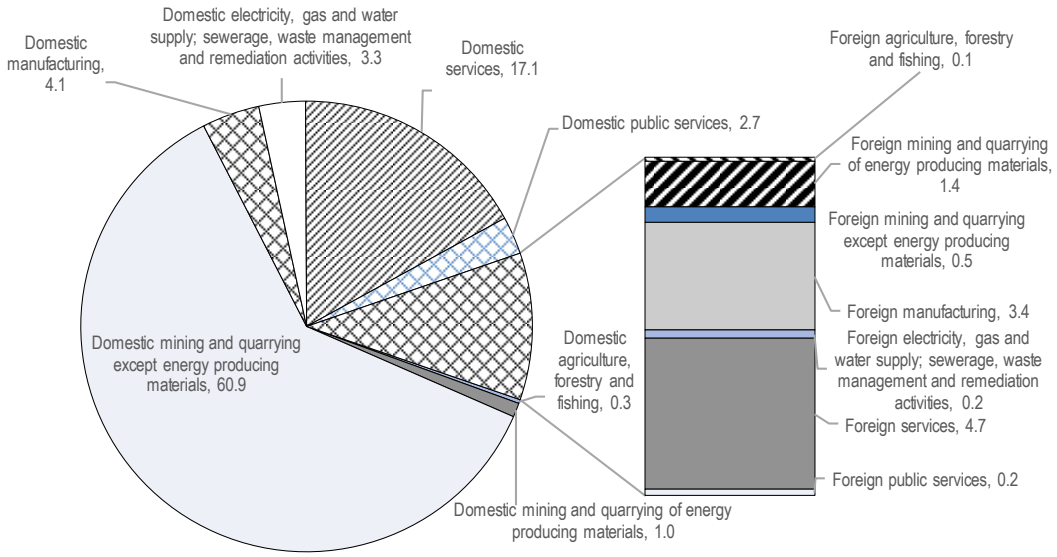
[3] The December 2018 revision breaks down the mining and quarrying sector into the following five subsectors:

ISIC4 classification	Description
D05	Mining of coal and lignite
D06	Extraction of crude petroleum and natural gas
D07	Mining of metal ores
D08	Other mining and quarrying
D09	Mining services (available for a subset of countries)

As with other natural resource sectors, much of the value added of mining exports comes from the sector itself (59% in 2015). This is due to the inherent value of the minerals extracted, plus the value addition of labour and capital expenditures in the sector. The sector to which mining displays the strongest backward linkages is services, representing 18% (domestic) and 5% (foreign) value added of the mining sector (Figure 2). Inputs from manufacturing represent a far smaller share of the value added in mining: 4% (domestic manufacturing inputs) and 3% (foreign manufacturing). Energy and water represent collectively 7% of the value added in mining.

Figure 2. Backward linkages, mining sector

Inputs by sector into mining, value added terms, 2015



Source: OECD Trade in Value Added (TiVA), 2018 release.

Changes in input sectors into mining since 2005 point to the "servicification" of the mining sector. The inputs of services in the mining sector increased by 2 percentage points over the decade examined. As in other sectors of the economy, this can be explained by a greater use of services as well as a tendency to outsource services rather than provide them in vertically integrated conglomerates. In some cases, services replace inputs of goods in the sector, as when firms lease machinery and equipment rather than purchasing it.

Compared with most other sectors of the economy, mining is unusual in that it is its own main input sector by far. This contrasts with most manufacturing sectors, for example, and even other natural resource sectors such as agriculture. The only sector that has even fewer backward linkages is oil and gas, where 77% of the value added of exports from the sector are in fact domestic inputs from the sector itself. The potential for backward linkages with other sectors for oil and gas producers is therefore lower than for minerals producers. The share of domestically produced services in the oil and gas sector, for example, is 12% as compared with 18% for mining.

Examining upstream sectors into mining in value added terms indicates therefore the importance of embodied services in mining exports, and most of them are provided domestically. Inputs provided domestically are those that are provided by firms in the country where the mining firm operates. These can be both locally owned and operated firms as well as firms affiliated with foreign-headquartered firms but operating in the country where the services are procured. Since services are substantial inputs into the mining sector, and they are generally provided domestically, demand for

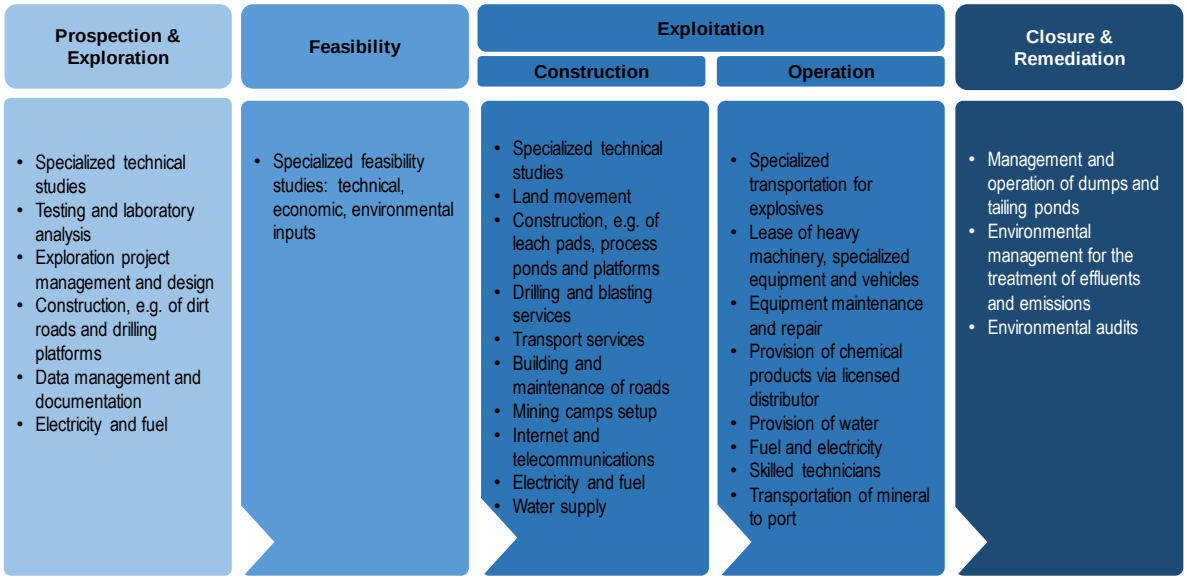
services in minerals-rich countries represent a strong link with the wider economy and may represent one pathway through which natural resource rich countries develop.

As with most natural resource sectors, mining is located upstream within its value chain. Exports of the sector are used in many further stages of intermediate and final goods production. Conversely to the mining sector, however, which is necessarily located in minerals-rich regions, downstream sectors are easily located anywhere. The proximity to raw materials is only one element of many that determine the comparative advantage of processing and manufacturing sectors. The sectors to which mining is an input are outlined in Annex Figure 1.

Services in mining global value chains

The mining industry uses a variety of services throughout the lifecycle of mines. The mining lifecycle is composed of four main stages: prospection & exploration, feasibility, exploitation, and closure and remediation. Due to the specific legal, technical and economic needs of the mining process, each stage requires specialised mining services. These include geological services like surveying and sample analysis; engineering services that contribute to feasibility studies, mining design and oversight of mining operations; construction services for roads, mine sites and mining camps; drilling services at both exploratory and construction phases; blasting and other uses of explosives; provision of energy and water; environmental services for the management and treatment of effluents and emissions; environmental audits; communications services, including at remote mine sites; leasing of machinery and equipment; maintenance and repair of machinery and equipment; road, rail and sea transport; food, accommodation and uniform services at mining camps; business and other professional services such as accounting, legal services and managerial and human resources services; and financial services to support this capital intensive sector. Increasingly, mining is done remotely: digital mining includes services related to data collection and management; specialised software; technologies such as sensoring, information gathering through drones and machine learning; and innovative business processes. However, it should also be noted that many of the services purchased by mining firms are not specific to the sector. As in all sectors, mining firms purchase telephones and internet services, banking and financial sector services, accounting and many other business services.

Figure 3. Examples of services provision throughout the mining lifecycle



Source: Authors' identification based on stakeholder interviews, METS Survey (2017), MINEM database and Infomine Directory.

Services account for 23% of the value added of exports from the mining sector on average.[4] Embodied services in mining exports represent a global industry of USD 41 billion in the 65 countries in the TiVA dataset, and has doubled in the ten years under review. The majority of these embodied services are produced domestically, accounting for 18% of the value added of mining exports (Figure 1). However, there are substantial differences by region. Australia uses the largest share of services to produce the outputs from its mining sector: 26.5% of the value added of Australia's substantial exports from the mining sector are in fact embodied services (Pacific region, Figure 4, panel 1). This is followed closely by the European and Central Asian countries for which services account for 26% of the value added of minerals exports. Services account for a smaller share of mining exports in value added terms in the Middle East and on the African continent, accounting for 20% of mining exports in South Africa (Sub-Saharan Africa region, Figure 4, panel 1) and 18% in the Middle East and North Africa. In both North and South America, the mining sector uses an average share of services, 19% and 22% of value added respectively, and a large proportion of those are produced domestically.

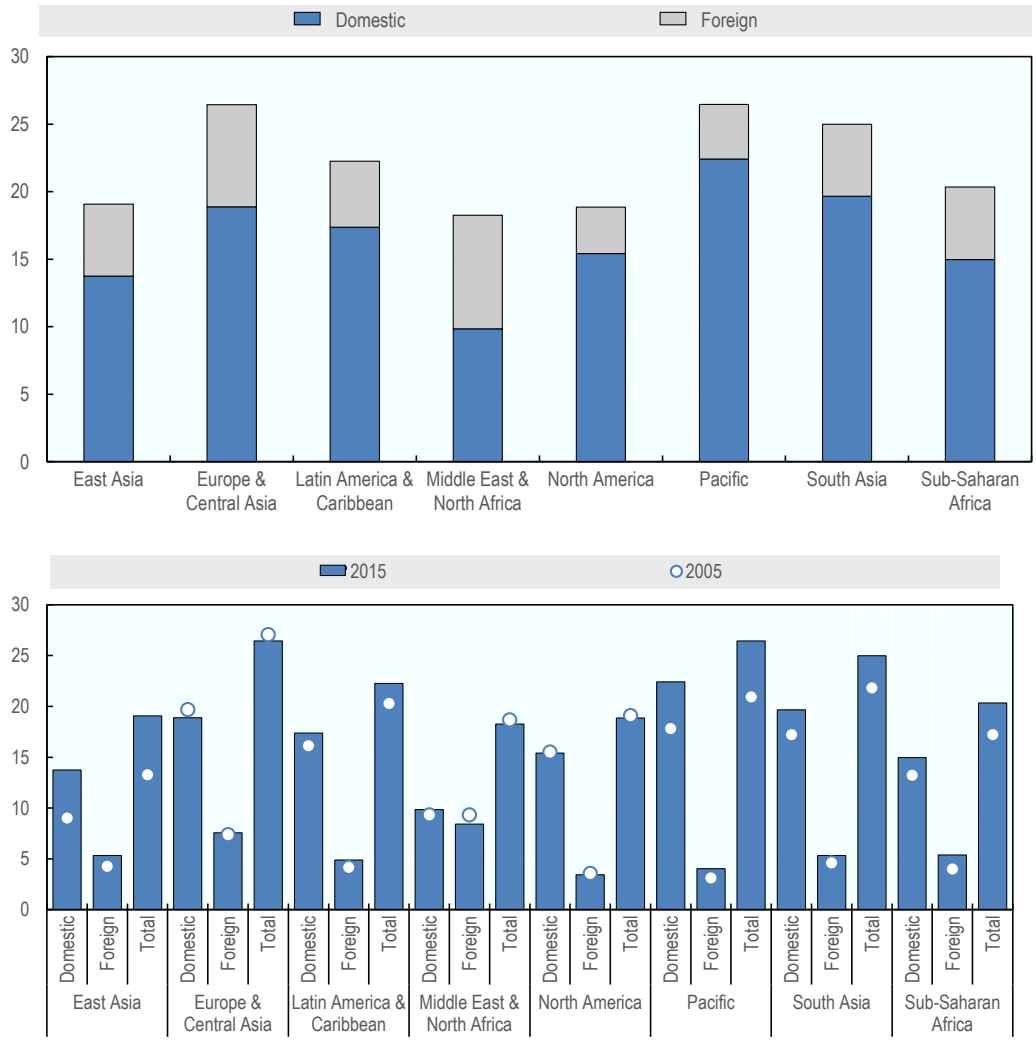
In almost all regions, a large majority of services to the mining sector are produced domestically. The only exception here is the Middle East and North Africa, where domestically produced services to mining are only slightly more prevalent than imported ones (10% and 8% respectively). Even in regions where inter-regional trade is very strong, such as Europe and East Asia, most services are domestically sourced.

Some of these trends have been building over the last decade. Australia has increased its use of services in the mining sector substantially since 2005, and almost all of the growth in services has been sourced domestically. A similar trend can be observed in East Asia and, to a lesser extent South Asia and Sub-Saharan Africa, where the mining industry has increased its provision of services and has awarded most of these new services contracts domestically (Figure 4, panel 2).

It is not altogether surprising that services used in the mining sector are generally sourced domestically. In general, services are less traded than goods. This suggests, however, that the mining sector may provide opportunities for job creation in supporting services in minerals-rich countries. Although the majority of services embodied in mining exports are sourced domestically, some countries import services that are productivity enhancing or that require skills or technologies that are not available in-country. Mining industries in lower-middle income countries, for example, import a higher share of services used in the sector as compared with those in upper-middle income or high-income countries (Figure 5, panel 1). In addition, this share has increased slightly since 2005 (Figure 5, panel 2. In all income groups, however, most services are sourced domestically. In both high income and lower-middle income countries, domestic services to mining have increased significantly, but have not replaced imported services. In fact, in no region or income category have domestically produced services replaced imported services in the aggregate, pointing to the need to import some specialised or more cost-effective services in all regions and among all income categories.

[4] On average of all 65 countries included in the 2018 version of the OECD's Trade in Value Added (TiVA) dataset.

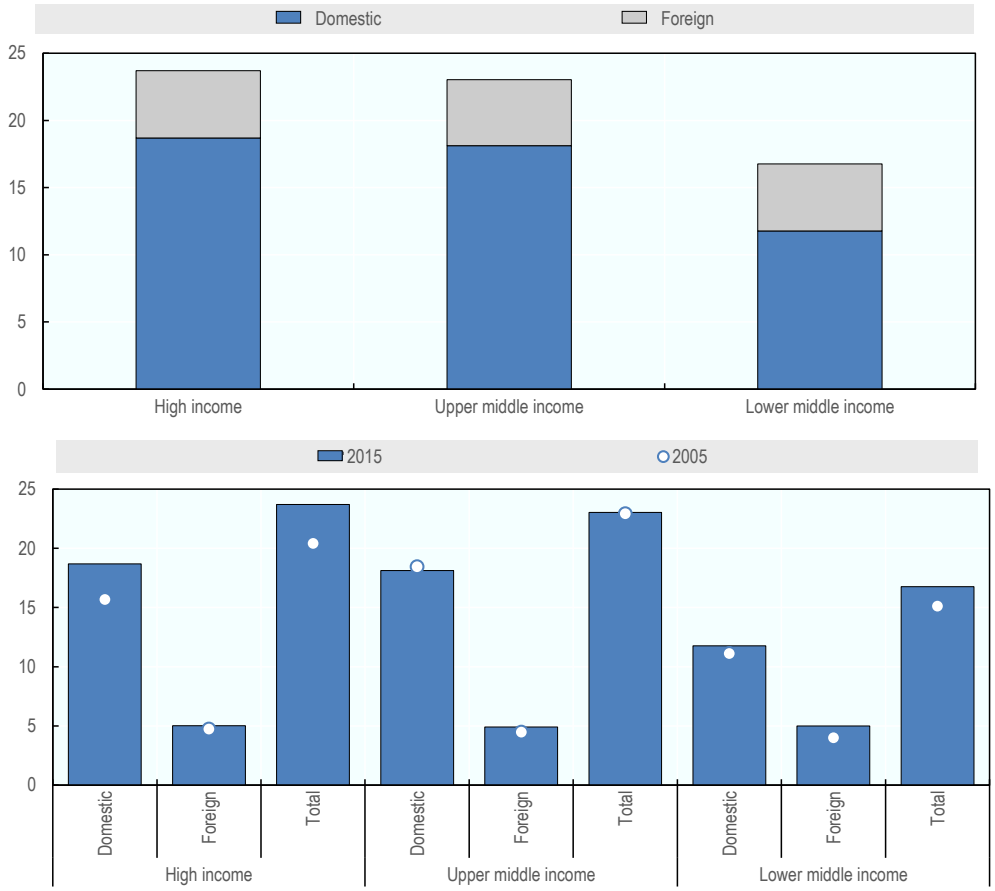
Figure 4. Share of services in mining value added by region



Note: Data in bars refer to 2015. Definition of regions based on the World Bank classification. Country coverage is TiVA countries.
Source: OECD Trade in Value Added (TiVA), 2018 release.

Mining industries in higher-income countries use more services as inputs in their production process, and they use a larger share of domestically sourced services (Figure 5, panel 1). This could be the result of a number of phenomena. In high-income countries, services sectors are probably more highly developed, with a greater offer of certain targeted services such as information and communications, services linked to new technologies and logistics services, among others. In addition, regulation of the mining sector in high-income countries is probably more strongly enforced which entails greater use of environmental services, audits and other more sophisticated, and therefore higher value, services to comply with regulations. Finally, it may be the case that in lower-middle income countries in particular, services firms do not exist in all areas and mining firms must therefore provide some services themselves. In this case, the added value of services procured within firms are not captured in the Trade in Value Added (TiVA) dataset. This point will be further developed later.

Figure 5. Share of services in mining value added by income category



Note: Data in bars refer to 2015. Definition of income categories based on the World Bank classification. Country coverage is TiVA countries.
Source: OECD Trade in Value Added (TiVA), 2018 release.

The provision of services to the mining sector takes place through various channels. Technological changes have rendered cross-border supply (mode 1) of services increasingly viable via electronic communications and mail. Engineering and architecture services are increasingly provided in this way and this trend will continue as digital mining becomes more widespread.[5] Many mining services – engineering and architecture services, construction, contract mining for example – are also often supplied through the temporary movement of natural persons (mode 4). On-site inspection is essential to the installation, project management, and advice involved in these services, requiring the movement of the supplier to the infrastructure projects. The supply of many services including specialised technical services, and leasing and repair of machinery and equipment by means of a commercial presence abroad (mode 3) also seems to be a significant form of supply, be it by subsidiaries, branch offices or strategic partnerships. A more permanent presence in the market enables firms to have greater access to projects in host countries and supply after-sales support.

Not all countries that are large exporters of minerals use a large share of services to produce their minerals exports. Considering the largest mining producers in value added terms, the share of

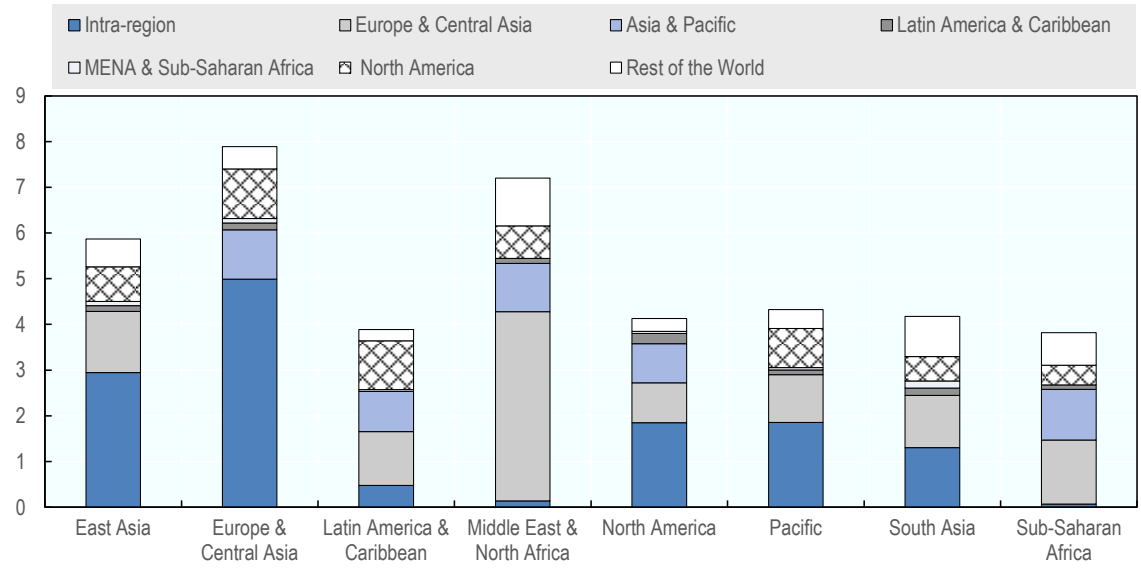
[5] For a discussion on this point, see IISD (2016).

services used in their sectors vary strongly. Australia is the largest minerals producer of all countries in the TiVA dataset in value added terms and services account for 26% of the value added of its mining sector. The second most important mining country is Chile where services account for 21% of the value added of the sector. Other important mining countries in terms of value added are Brazil, where services account for 33% of mining value added; Canada, 18%; followed by Peru, where services account for 15% of mining value added; South Africa, 20%; the United States, 20%; the Russian Federation, 23%; and Indonesia, 13% (Annex Figure 2).

In all countries, with the exception of two, services to the mining sector are sourced domestically in their majority (Annex Figure 2). In Brazil, China and Australia, where services make up a substantial share of the value added of the mining sector, most services are sourced domestically, accounting for 27%, 23% and 22% of the value added of the sector respectively. Moreover, these three countries are among the highest in terms of growth of the use of domestically produced services in mining, even though they started from high levels in the 2005 reference year. The mining industry also in India uses substantial services inputs, in particular compared with its income and regional grouping, equalling 25% of the value added of the sector, with a substantial share, 20% of the total, coming from within the country (Annex Figure 2).

There is much variability in the sourcing of imported services. Imported services, although lower in all regions than domestically produced ones in terms of value added, differ in magnitude and in region of origin. Two regions, Europe and East Asia, show significant regional trade in services for mining (Figure 6). For all other regions, intra-regional trade in services accounts for less than 2% of the value added of the mining sector. In sub-Saharan Africa, MENA and Latin America, the share is less than 1% of the value added of the sector. In Latin America in particular, home to three of the top four global minerals exporters in value added terms, the existence of a regional mining services cluster is surprisingly absent. In Latin America, MENA and sub-Saharan Africa, the largest share of imported services for the mining sector comes from Europe.

Figure 6. Sources of imported services for mining by region



Source: OECD Trade in Value Added (TiVA), 2018 release.

Of the major mining countries and regions therefore, some – Australia, Brazil and China – are strong users of services and have developed their domestic sectors strongly in the last decade. Others – e.g. North American countries – make moderate use of mining services and source a large share of them domestically. Still other countries – Indonesia, Argentina, Peru, Malaysia – use outsourced and offshored services more sparingly in their minerals production processes. Hubs of mining services exist in Europe and East Asia but seem fairly absent in other regions. European suppliers seem most successful in exporting their services to other regions (expressed as the imported share of services for mining from Europe in value added terms).

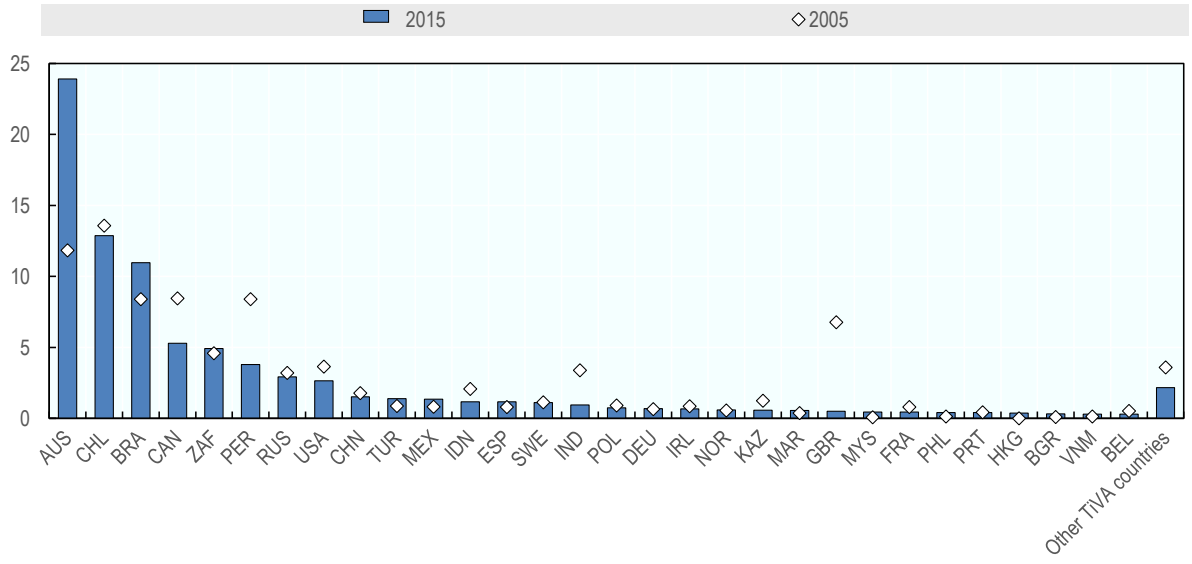
The major markets for services suppliers to mining firms are unsurprisingly countries with large mining industries – Australia, Chile, Brazil, Canada, South Africa and Peru, which are the six largest countries both in terms of the value added of exports of the mining sector and the imports of services by the mining sector in value added terms (Figure 7). Clearly, these are large markets for any services suppliers looking to increase their exports to the mining sector. Imports of services by these six countries make up 62% of the imported services by the mining sector of all TiVA countries in value added terms. Thirty per cent of the global imports of services by the mining sector go to Latin America which is the largest regional market.

Some other minerals-rich countries import relatively fewer services compared with the size of their mining sectors. These include the United States, China, Kazakhstan, India, Germany as well as Turkey. There are a number of reasons for this: either these countries use fewer services in their mining sectors, or those services are provided within mining firms (as is the case in India and Kazakhstan), or the services to the mining sector are provided to a large extent by domestic firms (as is the case in the United States and China).

Some countries have strongly increased their intake of services for mining, in particular Australia and Brazil. Australia more than doubled its share of services imports into the mining sector as a share of global imports between 2005 and 2015. Mining sectors in other countries, however, reduced their imports of services, in particular the United Kingdom, Peru, Canada, and India.

Figure 7. Main importers of services into the mining sector in value added terms

Share of global imports of services into mining sectors of TiVA countries



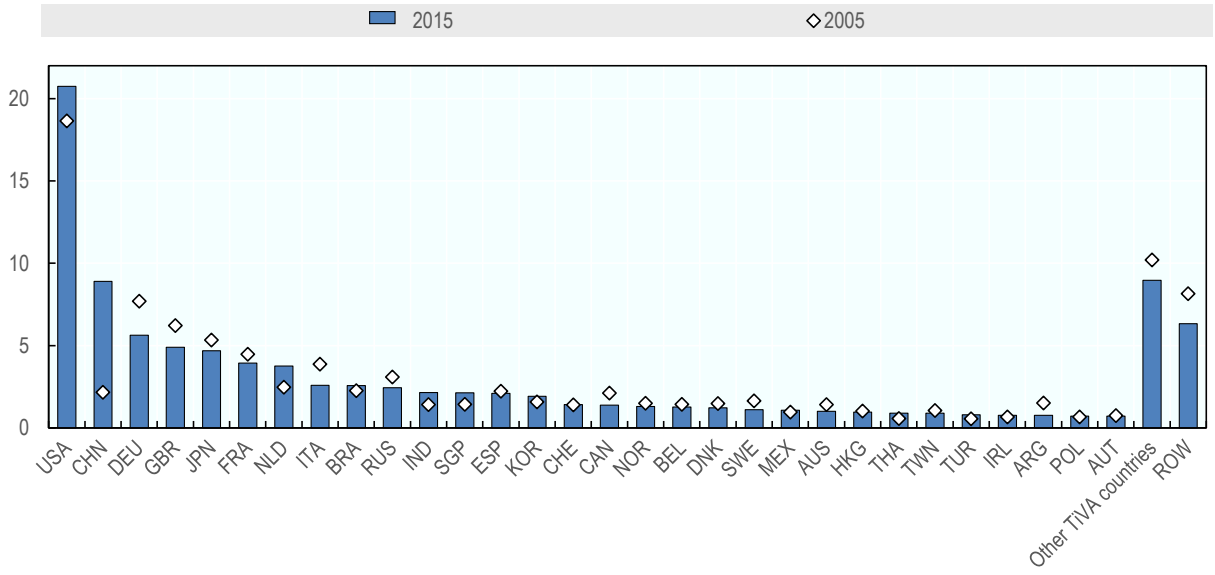
Source: OECD Trade in Value Added (TiVA), 2018 release.

The main providers of services to mining firms, however, are a very different set of countries, indicating that not all minerals-rich countries have developed their mining services to a level to compete in foreign markets. The largest provider of traded services to the mining sector by far is the United States, followed by China, Germany, the United Kingdom, Japan, France and the Netherlands (Figure 8). In many countries, the share of global trade in services for mining has not changed substantially in the last decade in value added terms with the exception of China. China now captures a much larger proportion of the global mining services market than in 2005 (9%, up from 2%), having captured market share from some European countries as well as Japan.

Services providers to the mining sector are not always located in countries where mining exploration and production take place. Some of the countries that provide global mining services are also home to top providers of mining equipment. These include the United States (headquarters of top mining equipment producers Caterpillar, Joy Global and Terex) and Japan (Komatsu and Hitachi). The strong provision of mining services from these countries could in part be explained by services that are sold bundled with mining equipment, or the leasing of mining equipment. Mining equipment is generally highly sophisticated and specialised and repairs and maintenance often represent substantial outlays and are undertaken within producer warranties. However, some other major mining equipment providers such as Sweden (headquarters to top mining equipment producers Sandvik and Atlas Copco) and Finland (headquarters to Metso) do not figure among the top providers of global mining services.

Figure 8. Top global mining services providers

Share of TiVA countries' total imports of mining services in value added terms



Note: ROW corresponds to countries not covered individually in TiVA.
Source: OECD Trade in Value Added (TiVA), 2018 release.

At the very least, it seems minerals-rich countries could develop further their exports of services for mining. None of the top mining countries in value added terms are among the top mining services exporters. Even Australia, where exports of services for mining have grown in recent years, does not figure among top mining services exporters in terms of value added.[6] Despite the strength of the mining sector in Latin America, home to three of the top four global exporters of minerals in value added terms, none of the top global providers of services for mining are in Latin America and only Brazil (9th largest provider of services to the sector) as well as Argentina (28th) figured in the top 30 providers in 2015. There may be a number of reasons why strong mining countries such as Chile and Peru are not among the top mining services providers. In some countries, mining services suppliers are small firms and small firms do not generally trade much. Some mining services are also quite specific and specialised to different mining conditions (remoteness, elevation, open pit vs. underground mining) as well as to different minerals extracted. There may therefore be a reduced market for some specialised mining services. Moreover, for some services (legal, financial, insurance, transport) some countries have erected strong barriers to imports. This point will be developed in the next section on policies affecting the provision of mining services.

The main services embodied in exports of the mining sector are: wholesale and retail trade and repairs (5% of the value added of mining exports), professional, scientific and technical services (4%), transportation and storage (4%), financial and insurance services (3%), construction (2%), ICT services (1%) and real estate (1%). Notably, accommodation and food service activities are relatively low in terms of value added to the sector (0.2% of the value added of mining exports).

The largest subsector within services to the mining sector in many regions is wholesale and retail trade and repairs. Repairs to mining equipment and vehicles are a particularly valuable service to the mining sector that is highly capital intensive and uses sophisticated machinery and equipment. Construction services are generally procured in large quantities when new mines are opening so the share of those services used by the mining sector is in part a function of the scale of new operations underway. Construction services make up a larger share of services used by the mining sector in Australia and Europe and Central Asia (Figure 9). Transport and storage represent a somewhat larger share of mining value added in Europe and Central Asia and in South Asia (India), compared with some other regions. The services procured by the mining sector in Europe and Central Asia may be higher for reasons of remoteness (northern Europe and Central Asia) and due to trade in high value items (e.g., diamond trading in Belgium). In India, rail transport is subject to specific regulations that raise transport costs within the region.[7] Maritime transport is also highly restricted in India.[8] Professional, scientific and technical services are used more in Europe and Central Asia, in Australia and in Latin America, in proportion to the services procured overall by the mining sector in value

[6] These figures account only for mining services exported to TiVA countries. Australia's exports of mining services to Papua New Guinea, for example, are not included here as PNG is not in the TiVA dataset. This applies also to exports of mining services to smaller Latin American minerals producers such as Bolivia and Ecuador and to sub-Saharan African countries other than South Africa.

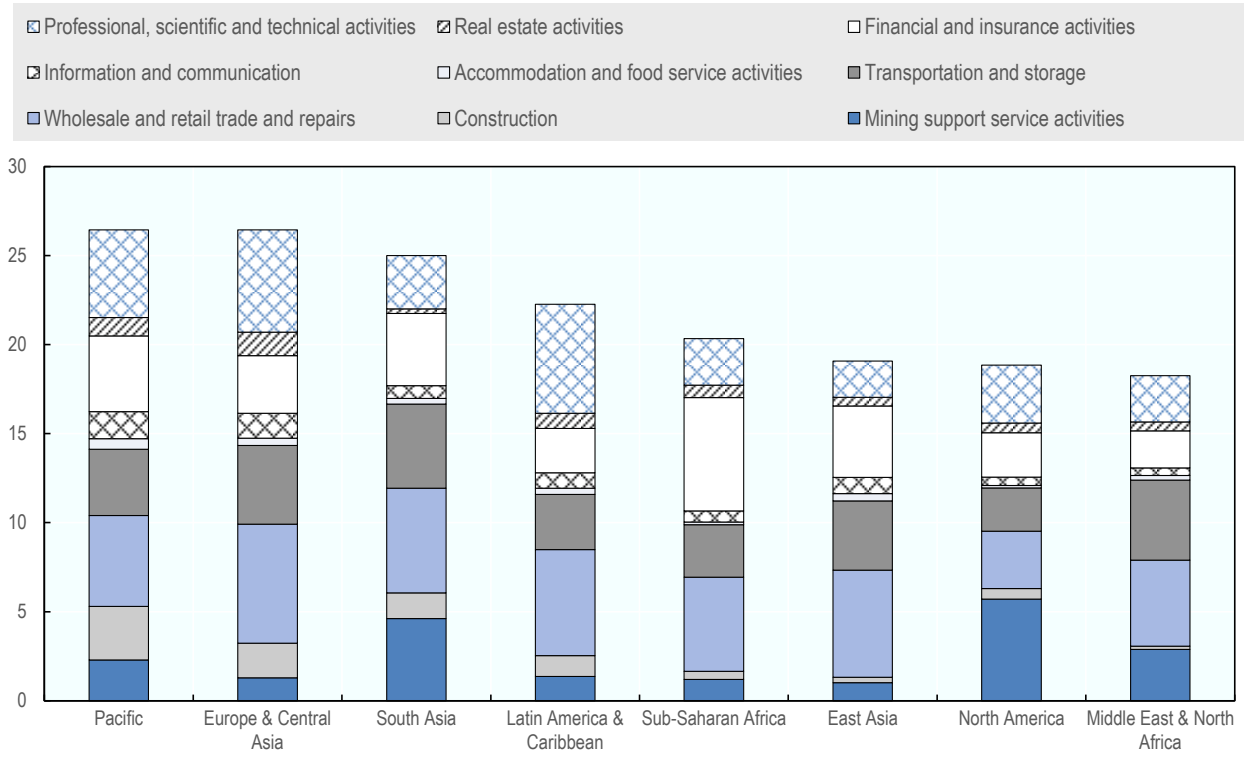
[7] India, for example, imposes an additional 20% congestion tax on rail freight exports to Bangladesh and Pakistan (OECD Inventory of export restrictions on industrial raw materials, https://qdd.oecd.org/subject.aspx?Subject=ExportRestrictions_IndustrialRawMaterials).

[8] https://www.compareyourcountry.org/service-trade-restrictions?cr=oecd&lg=en&page=0&charts=c1489764899717+c1489763242568+c1489763243858+c1489763957370&template=7.

added terms.[9] Financial services are a strong proportion of services procured in South Africa, East Asia, and to a lesser extent in Australia and South Asia. This may reflect in part the highly leveraged nature of some mines, which is particularly the case in East Asia.

Figure 9. Types of services procured by the mining sector by region

Share of services in value added of mining exports in 2015



Source: OECD Trade in Value Added (TiVA), 2018 release.

The main global suppliers of services to the mining sector have specialised to some extent in the provision of different types of services. Repair of mining equipment and vehicles is a particularly important service to the sector. Some major suppliers, in particular in Japan, China, the United States, and to a lesser extent Germany, France and the Netherlands, have specialised in the provision of these services. Some repairs of machinery and equipment occur within the producer warranties of equipment and specialised vehicles. This may be the case for some of the repairs services provided by Japan (headquarters of major mining vehicle producer Komatsu and equipment producer Hitachi), the United States (equipment producers Caterpillar, Joy Global and Terex) and, increasingly, China. In some cases, producer warranties are not valid if repairs are undertaken by providers other than those certified by the producing firms, many of which may be located in the country where the producing firm is headquartered. The repairs that are undertaken within these type of contracts may increase the share of imported repair services.

[9] Professional, scientific and technical services include specialised activities that require a high degree of training and specialised knowledge. These include legal and accounting activities, activities of head offices, management consultancy activities, architectural and engineering activities, technical testing and analysis, scientific research and development and advertising and market research.

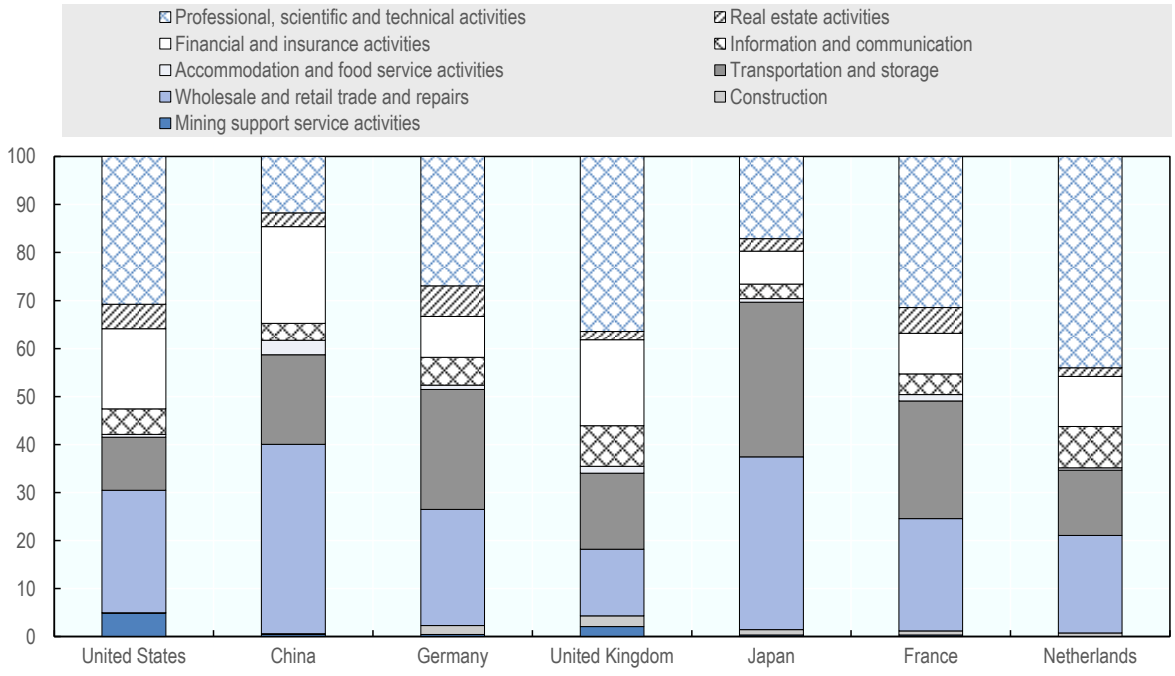
Professional, scientific and technical services are more likely to be imported than other types of services. Among major services suppliers to the mining industry, many OECD countries, and in particular the Netherlands, the United Kingdom, the United States, France and Germany have specialised in supplying professional, scientific and technical services (Figure 10).

China, the United Kingdom and the United States provide financial services in higher proportion compared with other major services exporters. Provision of financial services to the mining sector seems to follow patterns of financial services provision to other sectors: financial services in the United Kingdom and the United States are traditionally strong whereas China's provision of global financial services has risen sharply in the past decade.

This suggests that demand for imported services by the mining sector reflects quite closely overall demand for services by the sector. Demand for imported services is mostly in similar areas as those that are procured domestically. Imported services therefore seem to complement, rather than replace, demand for domestic services. In one area, however –professional, scientific and technical services – demand for imported services is substantially higher. This may be due to specialization that is not available in all mining jurisdictions, or superior technologies or business processes that are not readily available. This segment of mining services imports may provide an opportunity for 'learning by importing', i.e. increasing productivity in the mining sector by imported intermediate inputs of higher quality. On the other hand, one area, in particular the repair of sophisticated mining equipment and vehicles, may represent "locked in" consumption due to the necessity to undertake repairs with certified firms in the context of producer warranties.

Figure 10. Composition of services exported to the global mining industry by main providers

Share of value added by type of service in total services provided to the global mining sector, 2015



Source: OECD Trade in Value Added (TiVA), 2018 release.

Impacts of services on the domestic value added of mining exports

The extent to which minerals-rich countries maximise the gains from extraction of their mineral resources depends on the factors that affect the domestic value added of the mining sector. The analysis that follows aims to assess the role that services inputs play in explaining levels of domestic value added of mining exports. Furthermore, it estimates the impact of the value added of foreign inputs on the domestic value added of mining sector exports and the analysis verifies whether there are differences based on levels of economic development. This tests whether foreign inputs are complements or substitutes for domestic inputs in mining and whether there is evidence to support the notion of "learning by importing".

The importance of innovation for the mining sector has been documented (see, for example, IISD/CCSI, 2016). The analysis that follows aims to ascertain the importance of home-grown innovation in the ability to extract value from a country's mineral resources. This is a partial view of innovation in the mining sector, since new technologies are often sold internationally and multi-national firms in particular source their technologies from the many countries in which they operate. However, examining the impact of domestic innovation on the value added of the mining sector is relevant from a policy perspective since it ascertains whether policies that support innovation outcomes may impact the value extracted from the sector.

The value added data used for the econometric analysis is obtained from the TiVA database and covers the years 2006-15 for 45 mining exporters.[10] As in the analysis above, it exploits the newly disaggregated value added data of the mining and quarrying sector and analyses exports of mining and metal ores, excluding the energy sectors of crude petroleum, natural gas, and coal. The TiVA data, based on inter-country input-output matrices, allow estimation of different inputs (domestic or foreign) on the domestic value added of the mining sector (defined here as ISIC4 sectors 07 mining of metal ores and 08 other mining and quarrying). In this analysis, the dependent variable is the domestic value added of mining exports, expressed in log form, and not, notably, the sum of domestic value added of inputs into the mining sector.

Moreover, the analysis makes use of a new dataset from the World Intellectual Property Organization (WIPO) regarding mining-related patent applications which is a measure of the capacity to innovate.[11] Since patent systems differ substantially by country, only "major" innovations are included, i.e. patents that were applied in more than one country. Other variables include GDP per capita, which controls for broad structural factors and the contribution of mining to the economy (mining contribution index[12]) which captures the country's reliance on the mining sector. Table 2 presents a description of the explanatory variables used in the econometric analysis.

These empirical models use country level data and all estimates are carried out using the within panel estimator with year fixed effects.[13] This estimator controls for correlation between time-invariant, unobserved, country-specific effects and the right-hand side explanatory variables by using time-demeaned data. To control for possible endogeneity brought about by simultaneity between the dependent variable and the independent variables of interest, a temporal lag is included for the

[10] The dataset used in the estimation is an unbalanced panel of 45 countries for the years 2006-15. Since the independent variables of interest are lagged, the observations on 2005 are dropped.

[11] See Daly et al. (2019) for a description of the methodology used to assemble the dataset.

[12] International Council on Mining and Metals, https://www.icmm.com/en-gb/society-and-the-economy/role-of-mining-in-national-economies/mining-contribution-index.

[13] The within estimator uses time-demeaned variables and is equivalent to including country fixed effects.

independent variables. This assumes that past services inputs or foreign valued added have no contemporaneous effect on current levels of domestic value added.

The econometric analysis shows that services used in the production of mining exports have a significant positive effect on the level of mining domestic value added in exports: a 10% increase in services used in the production of mining exports is associated with an average 2.8% increase in mining domestic value added, all else equal (Table 1, model 1). The effect is positive and significant, suggesting that services inputs have a strong impact on countries' ability to extract value from their minerals. Examining this impact in countries at different levels of economic development (Table 1, model 2), the effect of services inputs on mining DVA is confirmed in countries at all levels of development. Not only are services inputs significant at every level of development, this alternative scenario suggests the effect is even stronger: in this alternative model, a 10% increase in services used in the production of mining exports is associated with an average 3.4% increase in mining domestic value added, all else equal.[14]

Across all specifications, wealthier countries, measured by GDP per capita, have a higher mining DVA, that is, countries with a 10% higher GDP per capita are associated with between 4.1–6% higher mining DVA. This suggests that richer economies, that are generally correlated with higher capital inputs, higher skill levels and stronger institutions implementing the rule of law, extract more wealth from their natural resources than do less developed countries, all else equal.

Countries whose economies are more reliant on mining also extract more value added from their resources. Countries can expect 2.7-2.8% higher mining DVA for every additional 1-point in the value of their mining contribution index. This suggests that there is a premium in terms of value added in mining exports to specialization in the sector.

Innovation, captured here by the number of registered patents 10 years previously, has a positive effect on mining DVA. For every additional mining-related patent registered, a country can expect a 0.1% increase in mining DVA. As an example, this implies that if Chilean mining-related patents were at the level of those of Australia on average over the ten year period under review, the domestic value added that it extracts from its mining sector would be 9.6% higher than it is today. The corresponding figure for Peru is 10.1%. If Australian mining-related innovation were at the level of the United States, using WIPO's mining-related patent data with a 10-year lag, their DVA of the mining sector would be 15% higher. These figures indicate the importance of innovation for value added in the mining sector.

Impacts of imported inputs on the domestic value added of mining exports

A better understanding of the importance of imported inputs for economic growth is one of the contributions of endogenous growth theory, which demonstrates how improvements in technology foster long-term growth and maintains that imported inputs are a channel for technology diffusion (Romer, 1990; Aghion and Howitt, 1998). If new technologies developed from a wider knowledge base are embodied in imported intermediate inputs or imported capital goods used in production processes, importers can increase productivity by incorporating such state-of-the-art inputs (Grossman and Helpman, 1991). It is suggested that firms will import intermediate inputs if they are of higher quality than those available domestically, and if they embody technology and knowledge leading to higher firm productivity, new product creation, improved quality of final products and, ultimately, output growth.

[14] No lower income countries are included in the TiVA sample of minerals-rich countries therefore this income category does not figure in the analysis.

There is some evidence that countries use GVC integration to build capabilities and upgrade in the first instance, and over time produce their own intermediate goods and services to respond to the demand of producers of exported goods (Baldwin, 2012; Lopez-Gonzalez and Holmes, 2011). As a consequence, as countries integrate in GVCs, the first period is characterised by an increase in imports of intermediates allowing specialisation, resulting in an increase in the share of FVA but nonetheless in an increase in the total value (but not the share) of DVA in exports. Only during the second period of GVC integration does the *share* of DVA increase. This involves increasing the scale of production, as well as the quantity of jobs created, which – together with spillovers throughout the economy – support processes of economic transformation. During the transformation, the share of DVA may fall. However, the importance for policymakers is that there is an increase in the level of domestic value added, rather than its share, which indicates growth in economic activity due to GVC integration (Kowalski et al., 2015).

There is some evidence in manufacturing sectors that imported intermediate inputs can positively impact output due to superior technology and business processes and more specialised knowledge that they bring (Jouanjean et al., 2017). Since these findings suggest that use of higher quality and more sophisticated imports of intermediates and technologies through GVCs increases the quality and efficiency of firms (product and process upgrading), and increases access to know-how, it has been called "learning by importing". According to this hypothesis, increasing the share of foreign value added can be the source of increased productivity and upgrading (Jouanjean et al., 2017).

Baldwin (2012) suggests that the relationship between foreign inputs and domestic value added of export sectors needs further empirical testing in particular as it is unclear whether such a trajectory is valid for non-manufacturing sectors. The present analysis aims to test this hypothesis for the mining sector. To understand the connection between foreign inputs and domestic value added, models 3-6 in Table 1 assess the importance of foreign value added in mining exports, as well as the role of foreign services in explaining the domestic value added of mining exports. Lags of the independent variables of interest are used in order to circumvent possible bias introduced by simultaneity.

In the mining sector, imported intermediate goods and services, measured in value added terms, are associated with higher levels of domestic value added in mining exports. For a 10% increase in the value added of foreign inputs, mining DVA is expected to increase by 2.8%, all else equal (Table 1, model 3). This is true for high-income countries and upper-middle income countries and the impact is even greater for lower-middle income countries. Breaking down the effect by level of development (model 4), we find that in lower-middle income countries (the baseline category), a 10% increase in the use of foreign inputs in value added terms is associated with 4.1% higher mining DVA, whereas for high-income countries the effect is lower, at 2.1%. Upper-middle income countries are not statistically significantly different from lower-middle income countries. These results provide some evidence to support the idea that countries in early stages of GVC integration rely more on foreign intermediate inputs to increase the value of their exported products, while at later stages their impact becomes less significant. These results confirm similar findings in other studies in the manufacturing sector that find that as economies newly integrate GVCs, they rely to a greater extent on foreign inputs to produce and add value to their exports. As they develop, and they become more integrated in GVCs, the positive impact of foreign inputs diminishes. Even in high-income, highly integrated countries, however, the impact of foreign inputs remains positive and significant.

The "learning by importing" hypothesis, which suggests that deeper integration in GVCs brings less reliance on foreign inputs, was also tested with respect to foreign services inputs into mining (Table 1, models 5 and 6). An increase in imported services inputs into the mining sector is positively associated with an increase in the domestic value added of mining exports: on average, a 10% increase in foreign services inputs raises the level of mining DVA by approximately 2.8%. Imported

services inputs could be producing this effect for a number of reasons: they could be more cost effective than domestically produced services thereby reducing production costs for the sector; or they could bring new technologies and processes that increase the productivity of existing natural resources, for example, enabling access to remote deposits or extracting more ore from mined material.

Table 1. Impacts of services and foreign inputs on the domestic value added of mining exports

Dependent variable : Mining domestic value added in exports (log of value)	(1)	(2)	(3)	(4)	(5)	(6)
Lagged total services (log)	0.281***	0.338***				
	(0.052)	(0.132)				
Interacted with:						
High income		-0.135				
		(0.122)				
Upper mid income		0.108				
		(0.191)				
GDP per capita (log)	0.509***	0.409**	0.589***	0.531**	0.598***	0.550**
	(0.187)	(0.199)	(0.197)	(0.201)	(0.192)	(0.199)
Mining contribution index	0.028**	0.027***	0.028**	0.028**	0.027**	0.027**
	(0.013)	(0.011)	(0.013)	(0.012)	(0.013)	(0.012)
Lagged no. patents (10 yr)	0.001**	0.001***	0.001***	0.001***	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lagged FVA in mining (log)			0.279***	0.412***		
			(0.055)	(0.102)		
Interacted with:						
High income				-0.203**		
				(0.100)		
Upper mid income				-0.025		
				(0.130)		
Lagged foreign services (log)					0.284***	0.458***
					(0.056)	(0.117)
Interacted with:						
High income						-0.246***
						(0.109)
Upper mid income						-0.081
						(0.266)
Constant	0.281	1.249	-0.377	0.213	-0.236	0.266
	(1.890)	(2.005)	(1.948)	(2.014)	(1.895)	(1.981)
R-squared	0.435	0.454	0.434	0.444	0.497	0.445
N	350	350	350	350	350	350

Note: Robust standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01. All regressions are estimated at the country level and estimated using the within panel estimator. Year effects included in all specifications.
Source: Own calculations using OECD Trade in Value Added (TiVA), 2018 release, and World Intellectual Property Organization (WIPO) data for mining-related patents.

We find a similar non-linear effect of foreign services inputs into mining DVA for countries at differing economic development levels as in the models described above for total foreign inputs. The positive effect of foreign services inputs is highest for lower-middle income countries. In lower-middle income countries, a 10% increase in foreign services is associated with a 4.6% increase in mining DVA. For high-income countries, the overall effect falls to 2.1%. The effect for upper middle-income countries is statistically the same as for lower middle-income countries.

This analysis suggests that countries interested in leveraging their mineral resources for economy-wide growth should not shy away from importing intermediate inputs. Foreign inputs are shown to be associated with higher levels of domestic value added in the mining sector, both for total inputs and specifically as regards services. This underscores the importance of facilitating trade in intermediates, both goods and services, for increasing domestic output.

Table 2. Variables used in econometric analysis and descriptive statistics

Variable	Description	Source
Mining Domestic value added in exports	Total mining Domestic value added to produce exports	OECD TiVA
GDP per capita	Gross domestic product per capita	World Bank. World Development Indicators
Mining contribution index	Measures significance of an economy's mining sector contribution to the economy	International Council on Mining and Minerals (ICMM)
Number of patents	Number of mining related patents registered by nationals in more than one country	World Intellectual Property Organization (WIPO)
Total services value added in mining exports	Total services value added in mining exports	OECD TiVA
Foreign services value added in mining exports	Foreign services value added in mining exports	OECD TiVA
Foreign value added in mining exports	Total foreign mining value added in exports	OECD TiVA
Income indicators: High income, upper middle income, lower middle income	Indicators to capture levels of development	OECD

Variable	Obs	Mean	Std. Dev.	Min	Max
Mining domestic value added in exports (log)	350	7.226054	1.773099	3.262608	10.99449
Foreign services value added in mining exports	350	4.087952	1.678976	-0.428384	7.856179
Foreign value added in mining exports (log)	350	5.057214	1.630578	0.6205563	8.75202
GDP per capita (log)	350	9.941729	0.9578561	6.674594	11.54306
Mineral contribution index	350	10.0992	14.01983	0.87	65.01
Number of patents (10-year lag)	350	102.5857	260.1743	1	1717

Services provided by foreign firms, by domestic firms and within mining firms

The services embodied in mining exports examined thus far relate to outsourced (domestic) services and offshored (foreign) services that contribute to the value added of the sector. These do not include services provided within vertically-integrated mining firms. Many mining and manufacturing firms develop their own support services in, e.g. engineering, information technology and research and development. In some cases, services are traded between headquarters and affiliates of mining firms. Inasmuch as these have changed over time, or between countries, use of in-house services by mining firms will affect the analysis using TiVA data. In order to better understand possible evolutions in services procured by the mining sector, a firm-level analysis was undertaken. Only a firm-level analysis can account for not only off-shored and outsourced, but also in-house services. The country coverage, however, of the available firm-level data is only partial. In addition, the sectoral breakdown is such that it includes both mining and oil and gas sectors.

Firm-level data shows that the share of services procured within extractive firms in all countries examined is substantial. In India, almost all services are provided within extractive firms themselves, in value added terms (Figure 11). The value added of in-house services in India accounts for the majority of the value added of exports in the sector. This may be due to the relatively high labour cost of Indian services providers in the sector compared with non-service providers. Services are also

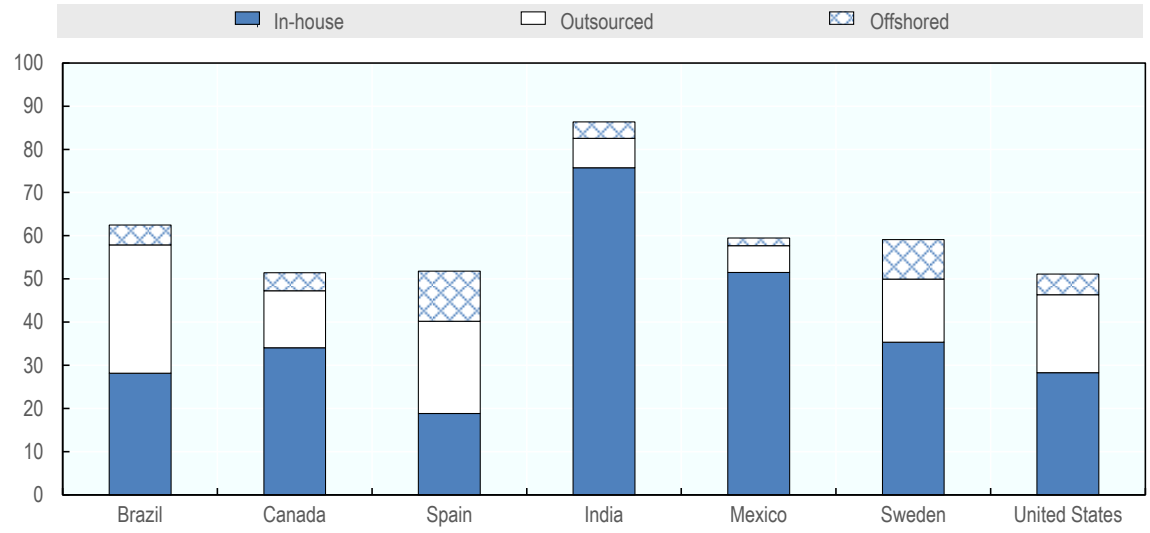
provided in large proportion in-house in Mexico and, to a lesser extent in Sweden and Canada. In Brazil, outsourced domestic services provide the most substantial share of value added of exports from the extractive sector.

Examining changes in the share of services provided within extractive firms over time (Annex Figure 3) also gives a diverse picture of evolutions in the different countries. In some countries, extractive firms reacted quickly to the global downturn in 2008-09 by substituting in-house services with outsourced services. This was particularly the case in Brazil, Sweden, Spain and to a lesser extent Canada. Extractive firms in the United States reacted to the downturn by procuring slightly more services in-house as compared to domestically outsourced services. The share of services procured in-house by extractive firms in Mexico and India were unaffected by the global downturn. For the most part, the share of foreign services, although small in most countries, was unaffected by global economic shocks, indicating that many services imported by the extractive sector are not easily substitutable in-country.

These firm-level data are fairly difficult to interpret for a number of reasons, not least of which is that they cover both mining and oil and gas sectors. Is the large share of in-house services provided to the sector in Mexico due to the fact that Pemex is a large, publicly operated conglomerate that provides its services in-house? Is the large share in India due to many highly skilled engineers and other professional service providers that are hired by mining firms and whose expertise is highly valued as compared with non-services providers? Answers to these questions require further research but these firm-level data indicate that the picture gleaned from country-level data is a good but partial indicator of the total services procured by the sector.

Figure 11. In-house, outsourced and offshored services in the extractive sector

Share of value added of extractive exports, 2011



Source: OECD Trade in Value Added (TiVA) combined with national Labour Force Surveys. See Miroudot and Cadestin (2017).

4. Policies affecting the provision of mining services

Barriers to trade in services

Many policies affect trade in services, the breakdown between domestically- and foreign-sourced inputs, and whether minerals-rich countries use foreign services to increase productivity, bring expertise that is not available in-country, or to complement or augment existing services capabilities. Not least of these is how open countries are to services imports. OECD research suggests that services trade barriers have a strong anti-export bias impeding services exports as much as services imports.[15] Trade costs rise both due to policies that explicitly target foreign suppliers, and from domestic regulation that falls short of best practice in the areas of competition policy and rule-making.

Countries restrict the foreign provision of services in different ways. Foreign equity limitations are most common in infrastructure sectors, whereas behind-the-border regulations related to licensing constitute considerable barriers to trade in professional services. Access to the public procurement market is particularly important for example for construction firms. National treatment in relation to taxes and subsidies is important in all sectors, most importantly in the transport sector. Restrictions on the movement of natural persons significantly hinder trade, particularly in skilled labour-intensive sectors such as digital and professional services.

The OECD Services Trade Restrictiveness Index (STRI) catalogues barriers to services trade and identifies potential scope for regulatory reform. The STRI monitors barriers to services trade in a number of areas of particular importance to the mining sector, most importantly engineering, construction, digital and maritime transport services. Examining the restrictiveness to foreign services provision in these areas in minerals rich countries gives an indication of areas where mining sector productivity could be increased due to more competitive and lower cost services inputs. It also offers a picture of potential foreign markets for mining services providers, and the difficulties that could be encountered in accessing them.

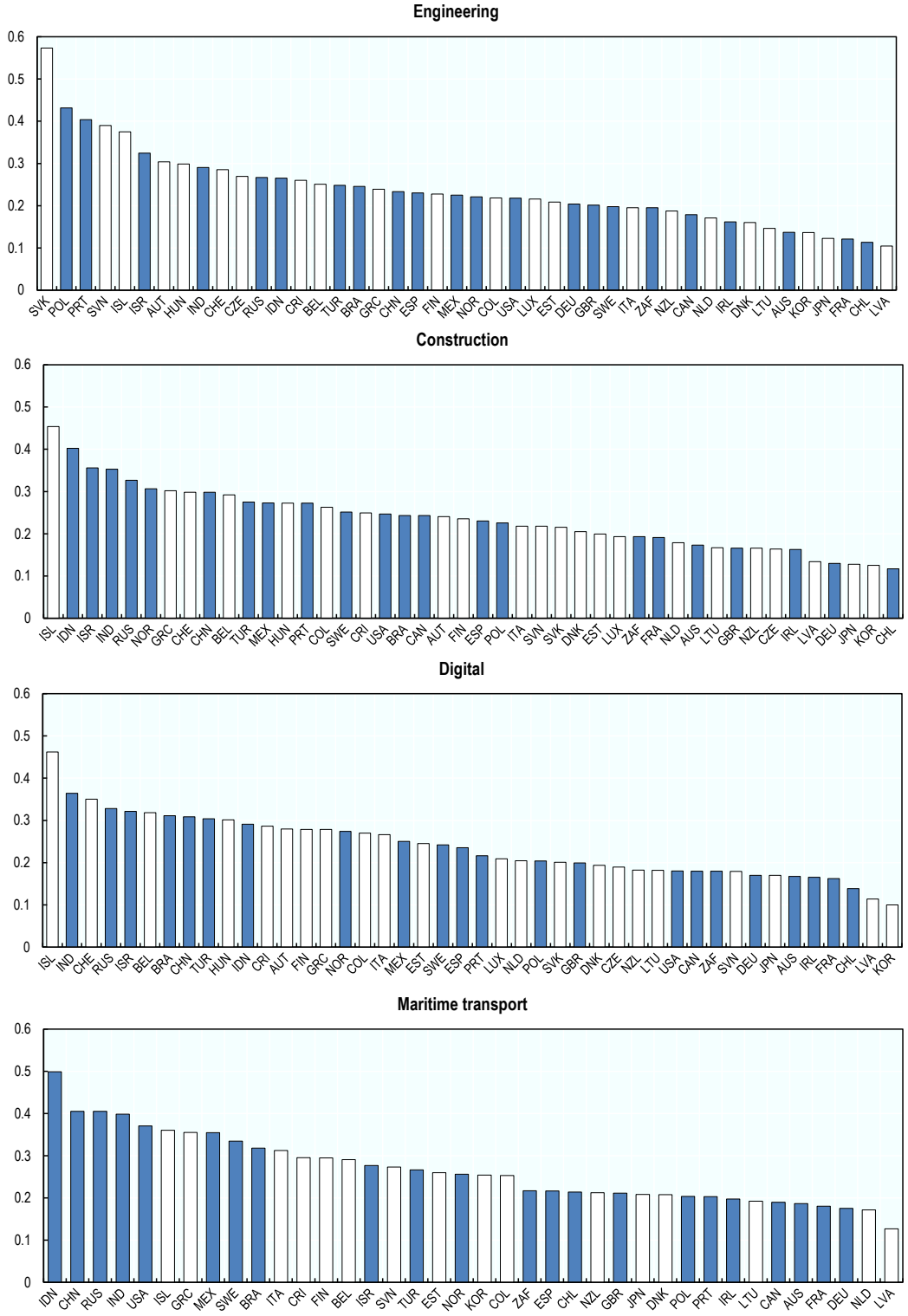
The services most procured by mining firms are not generally the most restricted services. Restrictions on provisions of engineering, construction, cross-cutting digital services and maritime transport services, all important for mining, are lower on average than those on, e.g. air transport, legal services, accounting and auditing services. Since changes in regulatory frameworks impacting services are generally undertaken as part of a wider overhaul of regulation, restrictions on the provision of services do not tend to evolve rapidly.

OECD countries are generally more open to foreign services provision than non-OECD countries in the services most important to mining (Figure 12). Chile is particularly open to foreign providers of engineering, construction and cross-cutting digital services. Australia and Canada, as well as South Africa, are also quite open to foreign services providers. Mining firms in these countries can therefore access know-how and potential comparative advantage of foreign service providers that can lead to productivity gains. The United States is more restrictive than these countries in engineering, construction and cross-cutting digital services and is the most restrictive OECD country in terms of maritime transport.

[15] http://www.oecd.org/tad/policynotes/oecd-services-trade-restrictiveness-index-policy-note.pdf.

Figure 12. Trade restrictiveness in major mining services sectors, 2017

Index ranging from 0 (least restrictive) to 1 (most restrictive)



Note: Shaded bars represent mining exporters. Not all large minerals exporters are included in the STRI: Peru, Kazakhstan, Philippines, Morocco and Malaysia, for example, are not included.
Source: OECD Services Trade Restrictiveness Index (STRI).

Provision of maritime transport services are particularly important to the mining sector as a substantial share of minerals is exported; additionally, since minerals and metals are heavy and voluminous and are not shipped in containers, transport costs represent a substantial share of the value of minerals and metals at destination.[16] However, many minerals-rich countries restrict access to foreign providers of maritime transport services, in particular Indonesia, China, the Russian Federation and India in addition to the United States. Higher costs of transportation by sea can compromise the competitiveness of the mining sector, particularly during times of high transport costs or low metals prices.

Restrictions on foreign services provision are high in some non-OECD countries, which will impact the productivity of their mining sectors; this is true in particular as regards digital mining services, for which the restrictions on the provision of cross-cutting digital services to all sectors is used as a proxy. Digital mining has quickly evolved: drones and sensors increasingly perform much of the remote and dangerous work once undertaken by people, data collection provides detailed information about the exact place and quality of deposits, and remote management of some mining operations is now possible. Given the growing importance of digital mining, restricting imports of the most recent technologies could disadvantage mining firms' productivity. Major mining countries that most strongly restrict imports of digital services are Indonesia, Russian Federation, Brazil and China.

Of course, the aim is not to do away with necessary regulation: the regulatory environment plays an important role in facilitating trade. In professional services such as architecture and engineering services, regulation should guard against market failures caused by information asymmetries. Architects and engineers need a specialised level of technical knowledge, which the consumer of such services typically does not possess, and hence cannot judge the competence of the service provider. Hence, most regulations in those sectors concern qualifications and licensing requirements that aim to curtail informational gaps in the quality assessment of architects and engineers. Other motivations derive from the inability to fully internalise externalities associated with services rendered. For instance, a poorly constructed bridge, building or tunnel can jeopardise the safety of great numbers of people and compromise the value of assets. The underprovision of such services may affect third parties or the society at large.

The costs of overcoming regulatory hurdles and complying with diverging regulations in export markets fall more heavily on small and medium-sized enterprises (SMEs). For micro firms engaging in cross-border exports, an average level of services trade restrictiveness represents an additional 7% in trade costs relative to large firms. Establishing an affiliate abroad involves even higher costs: in this case, an average level of services trade restrictiveness is estimated to be equivalent to an additional 12% tariff for a small firm compared to a large one.[17]

Support to SMEs

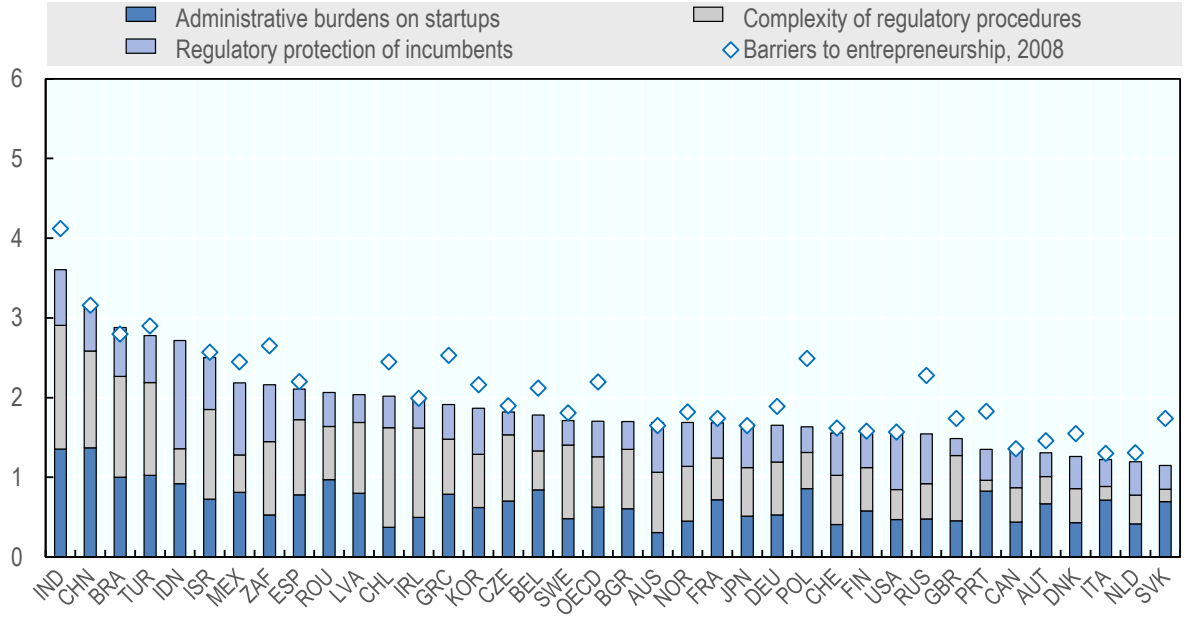
Ensuring access to global markets for micro-, small and medium-sized mining services firms is especially important since SMEs play a key role in all countries. In OECD countries, they account for 99.7% of businesses, 60% of employment and between 50% and 60% of value added. The contribution of SMEs in services sectors is even higher where they typically account for more than 65% of employment and value added (OECD, 2017). Among services suppliers to the mining sector in both Australia and Chile, for example, close to 70% were SMEs (Austmine, 2013 and Austmine, 2018).

[16] Although both minerals prices and transport costs vary greatly over time, maritime transport costs were estimated to account for 24% of the price of traded minerals in 2007 (Korinek and Sourdin, 2009).

[17] http://www.oecd.org/tad/policynotes/oecd-services-trade-restrictiveness-index-policy-note.pdf.

Figure 13. Barriers to entrepreneurship

Scores from 0 (least restrictive) to 6 (most restrictive)



Note: Data refer to 2013 and are compared with 2008. The selection of countries is based on the top 50 mining countries. For Indonesia, Romania, Latvia and Bulgaria, 2008 is not available.
Source: OECD Product Market Regulation Statistics.

Conditions for accessing international markets have generally improved for SMEs in recent years, due to improvements in physical and ICT infrastructure as well as specific policy developments aimed at increasing SME access to information, easing procedures, or offering financial support to small businesses. Explicit barriers to trade and investment have been reduced significantly in the OECD area in recent decades, but other less explicit barriers, such as measures discriminating against foreign suppliers, remain in place in a large number of countries.

Barriers to entrepreneurship are particularly high in some minerals-exporting countries – India, China, Brazil, Turkey, and Indonesia (Figure 13). High barriers to entrepreneurship tend to negatively impact potential job creation and value addition. In some countries – Indonesia and to a lesser extent, Mexico – such barriers are implemented through measures that shield incumbent firms from competition.

Some other countries create barriers to SME expansion due to the complexity of their regulatory procedures. Within the OECD area, Chilean SMEs navigate a more restrictive environment than in most other OECD countries due to the complexity of regulatory procedures. In fact, examining that indicator alone, Chile has the most complex regulatory procedures of all OECD countries (OECD, 2017). Although the complexity of regulations impacts all firms, the burden falls disproportionately on small firms that have less capacity and fewer advisory services to navigate complex business environments.

Regulatory cooperation can reduce trade costs. Differences among countries in regulating the same service create additional costs for exporters that need to adapt to new sets of rules in each new market they enter. Regulatory differences are even more difficult for SMEs to overcome than for larger firms. Regulatory cooperation, harmonization of regulations and mutual recognition agreements are carried out in a variety of contexts, in particular in trade and investment agreements. Firms in

countries that have deep and numerous preferential trade agreements tend to face fewer regulatory barriers to exports of their goods and services.

Innovation policies

Given the importance of innovation in mining in recent years, innovation policies are among the most important policies that impact productivity in the sector. Indeed, empirical analysis shows that innovation, in its various forms, can account for a substantial share of economic growth – often around 50% of total GDP growth – depending on the country, the level of economic development and the phase of the economic cycle.[18] The analysis outlined in the previous section indicated that innovation strongly impacts the potential for minerals-rich countries to extract value from their national resource endowments. Using the number of mining-related patents filed in more than one country ten years previously as a proxy for innovation, this analysis concludes that for every additional patent registered, a country can expect a 0.1% increase in mining DVA ten years later. Innovation is central to advanced and emerging economies alike; in many OECD countries, firms invest as much in the knowledge-based assets that drive innovation (such as software, databases, research and development, firm-specific skills and organisational capital) as they do in physical capital (machinery, equipment or buildings).[19]

There are five policy areas that are necessary pillars to strengthen the environment for sustainable innovation (OECD, 2015):

- effective skills strategies
- a stable, sound, open and competitive business environment
- sustained public investment in an efficient system of knowledge creation and diffusion
- increased access to and participation in the digital economy
- sound governance and implementation.

Indicators exist to measure aspects of each of these areas. Measurements of human capital and research, knowledge and technology outputs, infrastructure, business sophistication, market sophistication, creative outputs and institutions are combined to devise the Global Innovation Index (GII) (Cornell University et al., 2018). Some main mining exporters rank highly – the United States (ranked 6 out of 126 countries included in the GII), Canada (ranked 18) and Australia (20). The Russian Federation (ranked 46), Chile (47), Mexico (56) and South Africa (58) show average or above-average performance in terms of fostering an innovative environment, and Brazil (64), Peru (71) and Indonesia (85) are laggards in this area.

Strong innovation systems seem to be strongly correlated with robust performance in the export of services for mining. All seven of the top services exporters (the United States, China, Germany, the United Kingdom, Japan, France, and the Netherlands, accounting for over half of the trade in services for mining in value added terms) are well within the top 20 countries in terms of innovation performance.

Finally, the policy framework in place in the countries in which they operate strongly affects the ability of firms to access and take advantage of the opportunities afforded by GVCs. The policy framework, however, is only as good as the information that is used to develop it. Some powerful tools to inform policymaking have been referenced in this paper: the OECD Trade in Value Added

[18] http://www.oecd.org/sti/Innovation-Imperative-Policy-Note.pdf.

[19] http://www.oecd.org/sti/Innovation-Matters.pdf.

database, Services Trade Restrictiveness Index, Product-market Regulation indicators and the global innovation index and sub-indices. Not all countries have collected data to a sufficient level of detail and quality, however, to adequately inform good policymaking. For example, the quality of TiVA data is only as high as the underlying input-output tables and national accounts data that are used to calculate them. For some TiVA countries, the level of detail of background data could be improved. Another example is the coverage and inclusion in the STRI. All major mining countries are included in the STRI with the exception of Peru. The STRI is a powerful tool that can inform policymakers that may want to reflect on how to leverage value added in services to increase productivity in the mining sector.

5. Summary, conclusions and implications for policy

This paper examines the global mining value chain in a comprehensive fashion for the first time. This method of analysis accounts for economic activity that is directly or indirectly linked to exports from the mining sector. The importance of different inputs into the mining value chain can be evaluated in terms of the value they add to final exports. The economic activities linked to the extraction of mineral resources have implications for job creation, productivity and upgrading in minerals-rich countries. This analysis has focused on upstream sectors to mining, i.e., inputs into the sector, rather than downstream sectors that use the outputs from the mining sector, in order to reflect demand from the mining industry.

Many minerals-rich countries aim to leverage their mineral resources to create jobs and contribute to economic growth but many have not succeeded. A review of linkages to the mining sector shows that mining services make up the largest share of inputs into the mining industry in value added terms after the mining sector itself. In 2015, 23% of the value of mining exports were in fact embodied services, i.e. services inputs used to produce minerals and metals exports. Moreover, services are the only input sector that grew in share of value added over the ten-year period under review.

Embodied services in mining exports represent a global industry of USD 41 billion in the 65 countries included in the TiVA dataset. Some countries represent large mining services markets: for example, Australia's share of embodied services in exports of mining is now 27% in value added terms. Australia is also the world's largest importer of services to the mining sector, accounting for 23% of global imports, and its share has almost doubled in 10 years. Services also account for a large share of the value added in Brazil's mining industry – 33% of the value added of Brazil's mining exports is embodied services. Latin America accounts for 30% of imports of global mining services.

Services inputs into the production of mining exports increase the value extracted from mineral resources: the econometric analysis shows that a 10% increase in services used in the production of mining exports is associated with a 2.8-3.4% increase in mining domestic value added on average, all else equal. Moreover, the positive impact of services on the value added from mining exports is confirmed in countries at all levels of development.

In almost all countries, a large majority of services used by the mining industry is provided domestically. Moreover, imported services inputs into the mining sector do not displace domestically produced services over the 10-year period under review, but are rather complementary to them. As mining firms increase their use of services, they may import them or procure them locally in greater amounts but foreign services do not replace domestically-sourced ones in any region. This may indicate that imported services are different than those that are sourced locally, or that they fill qualitative or quantitative gaps in the domestic provision of services.

Innovation strongly impacts the ability of countries to extract value from their minerals. The econometric analysis indicates that innovation shows positive and significant impacts on the domestic value added of the mining sector. Using the number of mining-related patents filed in more than one country ten years previously as a proxy for innovation, this analysis concludes that for every additional patent registered, a country can expect a 0.1% increase in mining DVA ten years later. This implies, for example, that if Chilean mining-related patents were at the level of those of Australia on average over the ten year period, the domestic value added that it extracts from its mining sector would be 9.6% higher than it is today. This finding underlines the importance of new technologies such as digital mining and the increasing complexity of mining and mining equipment, and confirms the importance of innovation policies for countries wishing to benefit from their natural extractive resources. This aspect will be developed further in the companion paper that examines the mining and mining services GVCs in three minerals-rich countries, Australia, Chile and Peru.

Countries wishing to support their mining services sectors should ensure that firms in these sectors do not face overly burdensome regulation. Small and medium sized enterprises, in particular, are less well equipped to navigate difficult business environments. Since a substantial share of mining services firms are SMEs, regulatory barriers to entry, complex regulatory procedures and overly protective regulation for incumbent firms will strongly impact the potential for minerals rich countries to develop a mining services sector and thereby leverage their mineral resources for job creation throughout the value chain. This aspect will be developed further in the companion paper that examines the mining and mining services GVCs in three countries, Australia, Chile and Peru.

Countries interested in leveraging their mineral resources for economy-wide growth should not shy away from foreign inputs. Foreign inputs of goods and services are associated with higher levels of domestic value addition in mining. A 10% increase in the value added of foreign inputs is associated with a 2.8% increase in the domestic value added of mining exports on average, all else equal. Similar results are found for imported mining services inputs.

This finding provides support for the hypothesis, usually tested in manufacturing sectors, that countries in early stages of GVC integration rely more on foreign intermediate inputs to add value to their exports, while at later stages, these become less significant. As they develop, and they become more integrated in GVCs, the positive impact of foreign inputs diminishes. This analysis confirms that the positive association between foreign inputs and domestic value added in the mining sector is stronger in lower-middle income countries as compared with high income countries – in fact, it is twice as strong. Even in high-income, highly integrated countries, however, the impact of foreign inputs remains positive and significant.

There are a number of policies that countries can implement to more fully benefit from the value addition of foreign goods and services inputs. One aspect relates to their relative openness to trade. This analysis points to the positive impact of services inputs into the mining sector and the positive effect of imported inputs in particular. Notwithstanding, minerals-rich countries differ in their openness to trade in goods and services. Regarding restrictiveness to trade in services, Australia, Canada and Chile, all large and sophisticated mining countries, are quite open to trade in the main services inputs for mining: engineering services, construction, digital services and transport. South Africa is fairly open to foreign services providers. Other mining countries such as Brazil are less open. The United States shows a more mixed picture as it is open to foreign services providers in some sectors such as digital, and more closed in others such as maritime transport and construction.

With regard to trade in inputs of goods into the mining sector, high tariffs and non-tariff measures increase the cost of foreign inputs into the mining sector, with associated impacts on productivity in the sector. One indicator of a country's openness to trade is its MFN (most favoured nation) applied tariff rates and use of restrictive non-tariff measures. Another is the breadth and depth of preferential trade agreements (PTAs) undertaken. Few PTAs, or PTAs that lack depth, may impede the flow of

intermediate inputs into the mining sector, as well as exports of such inputs to other minerals-rich countries. Barriers to trade in inputs will generate a rise in costs for the mining sector.

Services providers to the mining industry are generally not located in the largest mining countries. Services providers are located in the United States, which provides over 20% of global mining services, followed by China (9%), Germany, the United Kingdom, Japan, France and the Netherlands. Only the United States is in the top 10 mining countries, and none of the mining services providing countries are among the top 10 importers of mining services which indicates little intra-industry trade in mining services. Notably absent is a "mining services hub" in Latin America whereas Latin America accounts for 30% of the imports of embodied mining services and is home to three of the top four mining countries in terms of the value added of minerals exports. One reason for this may be the lack of fully implemented trade and investment agreements among Latin American minerals rich countries to facilitate trade in services. Deep trade agreements increase GVC-related trade among participating countries. Many preferential trade agreements deepen regulatory co-operation as well as creating new market opportunities. Greater convergence of regulatory requirements, mutual recognition of standards and qualifications and lower barriers to entry for services providers could facilitate greater regional trade in services for the mining sector.

References

Aghion, P. and P. Howitt (1998), "Endogenous Growth Theory", MIT Press. Cambridge, MA, USA.

Austmine (2018), "Chile Mining, Equipment, Technology and Services (METS) Sector Development Project", MTF 04 2016A, Final report – July 2017 (updated April 2018).

Austmine (2013), "Australia's new Engine for Growth: Mining, Equipment, Technology and Services", July.

Baldwin, R. (2012), "Trade and Industrialisation after Globalisation's Second Unbundling: How Building and Joining a Supply Chain are Different and Why it Matters", in *Globalization in an Age of Crisis: Multilateral Economic Cooperation in the Twenty-First Century*, R. Feenstra and A. Taylor (eds.), University of Chicago Press.

Bas, M. and V. Strauss-Kahn (2014), "Does importing more inputs raise exports? Firm-level evidence from France", *Review of World Economics*, Vol. 150(2), pp. 241-275.

Cornell University, INSEAD and WIPO (2018), *The Global Innovation Index 2018: Energizing the World with Innovation*, Ithaca, Fontainebleau, and Geneva.

Daly, A., G. Valacchi and J. Raffo (2019), "Mining patent data: Measuring innovation in the mining industry with patents", *World Intellectual Property Organization (WIPO) Economic Research Working Paper* No. 56.

Escaith, H. (2014), "Exploring the policy dimensions of trade in value-added", *MPRA Paper*, No. 59891, University Library of Munich, Germany.

Greenville, J., K. Kawasaki and M. Jouanjean (2019), "Value Adding Pathways in Agriculture and Food Trade: The Role of GVCs and Services", *OECD Food, Agriculture and Fisheries Papers*, No. 123, OECD Publishing, Paris, https://doi.org/10.1787/bb8bb93d-en.

Grossman, G. and E. Helpman (1991), "Innovation and Growth in the World Economy", MIT Press, Cambridge, MA, USA.

Hausmann, R. (2014), "In Search of Convergence", Project Syndicate, 20 August 2014, http://www.relooney.com/NS4053/00_NS4053_221.pdf.

Humphrey, J. and H. Schmitz (2002), "How does insertion in global value chains affect upgrading in industrial clusters?", *Regional Studies*, 36:9, 1017-1027, https://doi.org/10.1080/0034340022000022198.

International Institute for Sustainable Development (IIDS) and Columbia Center on Sustainable Investment (CCSI), *Mining a Mirage? Reassessing the Shared-value Paradigm in Light of the Technological Advances in the Mining Sector*, September 2016.

Jouanjean, M., J. Gourdon and J. Korinek (2017), "GVC Participation and Economic Transformation: Lessons from Three Sectors", *OECD Trade Policy Papers*, No. 207, OECD Publishing, Paris, http://dx.doi.org/10.1787/617d7a19-en.

Korinek, J. and P. Sourdin (2009), "Clarifying Maritime Transport Costs and Their Impact on Trade", August 2009, http://www.etsg.org/ETSG2009/papers/korinek.pdf.

Kowalski, P., J. Lopez Gonzalez, A. Ragoussis and C. Ugarte (2015), "Participation of Developing Countries in Global Value Chains: Implications for Trade and Trade-related Policies", *OECD Trade Policy Papers*, No. 179, OECD Publishing, Paris, http://dx.doi.org/10.1787/5js33lfw0xxn-en.

Kummritz, V. (2015), "Global Value Chains: Benefiting the Domestic Economy?", Graduate Institute of International and Development Studies, International Economics Dept., *Working Paper* No. IHEIDWP02-2015.

Laget, E., A. Osnago, N. Rocha and M. Ruta (2018), "Deep Trade Agreements and Global Value Chains" (English), *Policy Research Working Paper no. WPS 8491*, World Bank Group, Washington, DC, http://documents.worldbank.org/curated/en/356541529933295649/Deep-trade-agreements-and-global-value-chains.

Lejárraga, I. (2014), "Deep Provisions in Regional Trade Agreements: How Multilateral-friendly?: An Overview of OECD Findings", *OECD Trade Policy Papers*, No. 168, OECD Publishing, Paris, https://doi.org/10.1787/5jxvgfn4bjf0-en.

Lopez Gonzalez, J. (2016), "Using Foreign Factors to Enhance Domestic Export Performance: A Focus on Southeast Asia", *OECD Trade Policy Papers*, No. 191, OECD Publishing, Paris, http://dx.doi.org/10.1787/5jlpq82v1jxw-en.

Lopez Gonzalez, J. and P. Holmes (2011), "The Nature and Evolution of Vertical Specialisation: What is the Role of Preferential Trade Agreements?", Swiss national centre of competence in research, *Working Paper* no. 2011/41, May 2011.

Low, P. (2013), "The Role of Services in Global Value Chains", Fung Global Institute Working Paper 2013-1, June 2013, http://www.asiaglobalinstitute.hku.hk/en/wp-content/uploads/2015/04/456-The-Role-of-Services-in-Global-Value-Chains.pdf.

Miroudot, S. and C. Cadestin (2017), "Services in Global Value Chains: From Inputs to Value-Creating Activities", *OECD Trade Policy Papers*, No. 197, OECD Publishing, Paris, https://doi.org/10.1787/465f0d8b-en.

Miroudot, S. and A. Ragoussis (2009), "Vertical Trade, Trade Costs and FDI", *OECD Trade Policy Paper*s, No. 89, OECD Publishing, Paris, https://doi.org/10.1787/222111384154.

OECD (2017), *Small, Medium, Strong. Trends in SME Performance and Business Conditions*, OECD Publishing, Paris, https://doi.org/10.1787/9789264275683-en.

OECD (2015), *The Innovation Imperative: Contributing to Productivity, Growth and Well-Being*, OECD Publishing, Paris, https://doi.org/10.1787/9789264239814-en.

OECD (2013), "Interconnected economies: Benefiting from global value chains synthesis report", https://www.oecd.org/sti/ind/interconnected-economies-GVCs-synthesis.pdf.

Romer, P. (1990), "Endogenous Technological Change", *Journal of Political Economy* 98(5), pp. 71-102.

World Bank (2017), "Measuring and Analyzing the Impact of GVCs on Economic Development", *Global Value Chain Development Report*, World Bank Group, Washington, DC., http://documents.worldbank.org/curated/en/440081499424129960/pdf/117290-WP-P157880-PUBLIC.pdf.

Wright, G. (2014), "Revisiting the Employment Impact of Offshoring", *European Economic Review*, vol. 66, pp. 63-83.

Annex A.

Annex Table 1. TiVA countries by region and income group

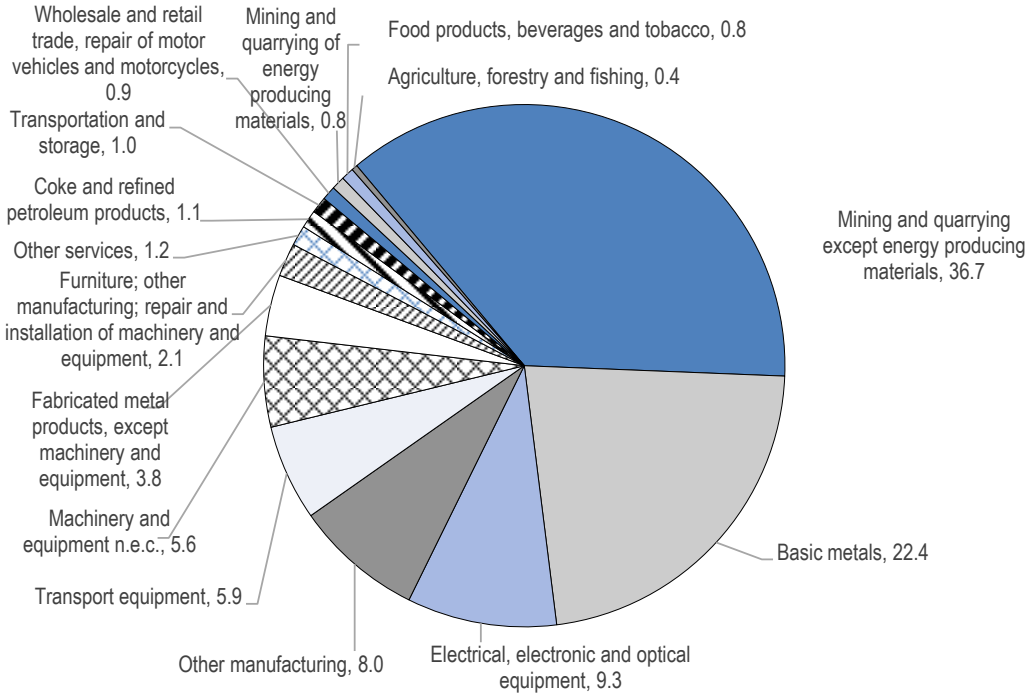
		Region	Income group
Argentina	ARG	Latin America & Caribbean	High income
Australia	AUS	Pacific	High income
Austria	AUT	Europe & Central Asia	High income
Belgium	BEL	Europe & Central Asia	High income
Brazil	BRA	Latin America & Caribbean	Upper middle income
Brunei Darussalam	BRN	East Asia	High income
Bulgaria	BGR	Europe & Central Asia	Upper middle income
Cambodia	KHM	East Asia	Lower middle income
Canada	CAN	North America	High income
Chile	CHL	Latin America & Caribbean	High income
China	CHN	East Asia	Upper middle income
Chinese Taipei	TWN	East Asia	High income
Colombia	COL	Latin America & Caribbean	Upper middle income
Costa Rica	CRI	Latin America & Caribbean	Upper middle income
Croatia	HRV	Europe & Central Asia	High income
Cyprus[1,2]	CYP	Europe & Central Asia	High income
Czech Republic	CZE	Europe & Central Asia	High income
Denmark	DNK	Europe & Central Asia	High income
Estonia	EST	Europe & Central Asia	High income
Finland	FIN	Europe & Central Asia	High income
France	FRA	Europe & Central Asia	High income
Germany	DEU	Europe & Central Asia	High income
Greece	GRC	Europe & Central Asia	High income
Hong Kong	HKG	East Asia	High income
Hungary	HUN	Europe & Central Asia	High income
Iceland	ISL	Europe & Central Asia	High income
India	IND	South Asia	Lower middle income
Indonesia	IDN	East Asia	Lower middle income
Ireland	IRL	Europe & Central Asia	High income
Israel	ISR	Middle East & North Africa	High income
Italy	ITA	Europe & Central Asia	High income
Japan	JPN	East Asia	High income
Kazakhstan	KAZ	Europe & Central Asia	Upper middle income
Korea	KOR	East Asia	High income
Latvia	LVA	Europe & Central Asia	High income
Lithuania	LTU	Europe & Central Asia	High income
Luxembourg	LUX	Europe & Central Asia	High income
Malaysia	MYS	East Asia	Upper middle income

		Region	Income group
Malta	MLT	Middle East & North Africa	High income
Mexico	MEX	Latin America & Caribbean	Upper middle income
Morocco	MAR	Middle East & North Africa	Lower middle income
Netherlands	NLD	Europe & Central Asia	High income
New Zealand	NZL	Pacific	High income
Norway	NOR	Europe & Central Asia	High income
Peru	PER	Latin America & Caribbean	Upper middle income
Philippines	PHL	East Asia	Lower middle income
Poland	POL	Europe & Central Asia	High income
Portugal	PRT	Europe & Central Asia	High income
Romania	ROU	Europe & Central Asia	Upper middle income
Russian Federation	RUS	Europe & Central Asia	Upper middle income
Saudi Arabia	SAU	Middle East & North Africa	High income
Singapore	SGP	East Asia	High income
Slovakia	SVK	Europe & Central Asia	High income
Slovenia	SVN	Europe & Central Asia	High income
South Africa	ZAF	Sub-Saharan Africa	Upper middle income
Spain	ESP	Europe & Central Asia	High income
Sweden	SWE	Europe & Central Asia	High income
Switzerland	CHE	Europe & Central Asia	High income
Thailand	THA	East Asia	Upper middle income
Tunisia	TUN	Middle East & North Africa	Lower middle income
Turkey	TUR	Europe & Central Asia	Upper middle income
United Kingdom	GBR	Europe & Central Asia	High income
United States	USA	North America	High income
Viet Nam	VNM	East Asia	Lower middle income

1. *Note by Turkey:*
The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
2. *Note by all the European Union Member States of the OECD and the European Union:*
The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.
Source: Based on World Bank classification.

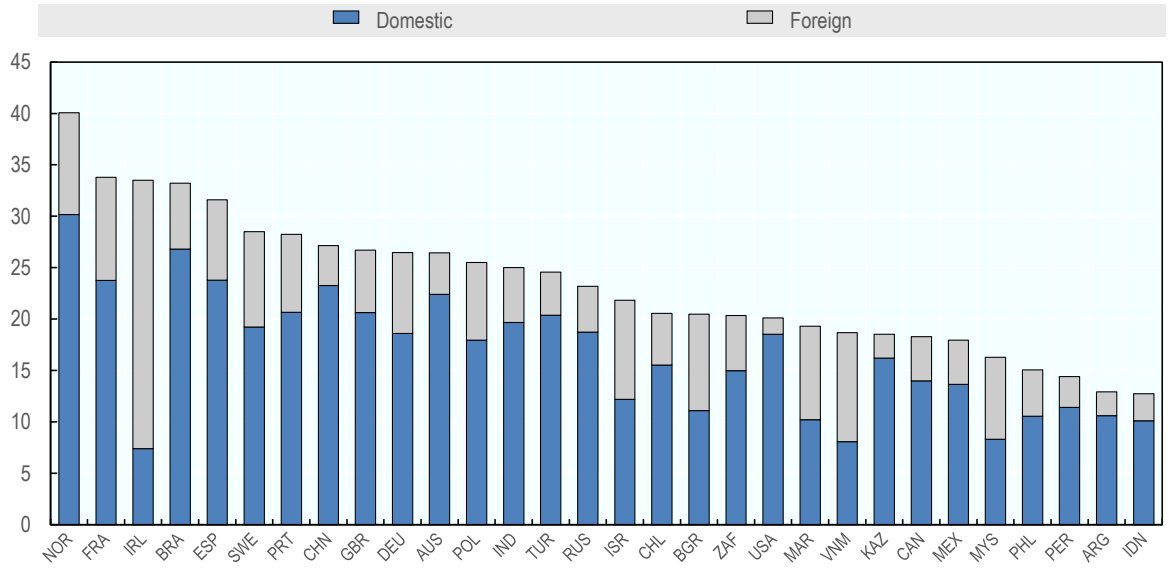
Annex Figure 1. Forward linkages from mining

Sectors that absorb the value added from the mining sector, 2015



Source: OECD Trade in Value Added (TiVA), 2018 release.

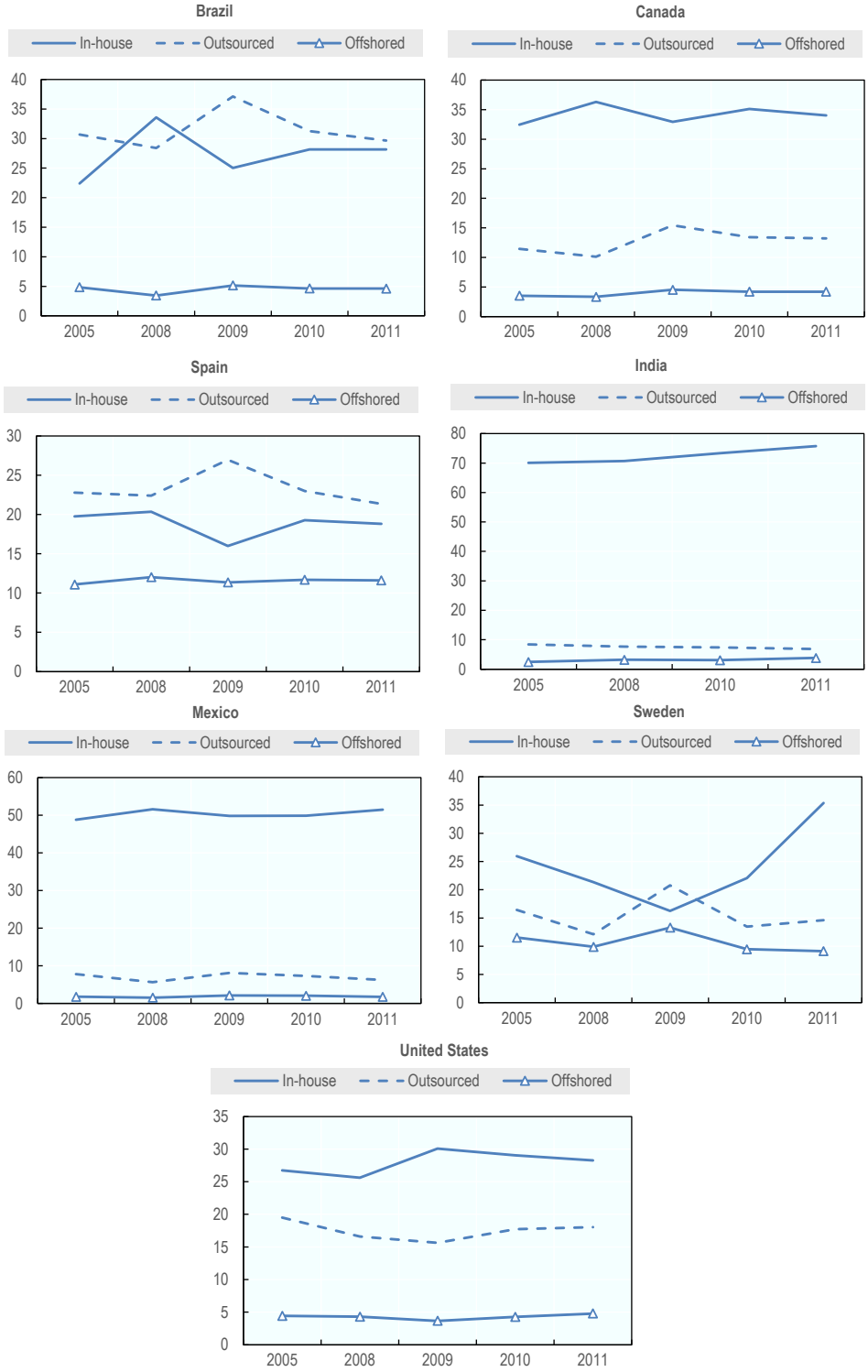
Annex Figure 2. Share of services in value added of mining in selected countries



Note: Selection of countries based on the top 30 mining exporters in terms of value added.
Source: OECD Trade in Value Added (TiVA), 2018 release.

Annex Figure 3. In-house, outsourced and offshored services in the extractive sector

Share of value added of extractive exports, 2005 and 2008 to 2011



Source: OECD Trade in Value Added (TiVA) combined with national Labour Force Surveys. See Miroudot and Cadestin (2017).