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FDI Technology Spillovers in Extractive Industries: Lessons from Practice*

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Abstract

Resource-rich countries are increasingly aiming to benefit from technology and knowledge spillovers in their extractive industries. Based on successful country case studies, this paper provides recommendations on how governments can enhance technological spillovers in the oil & gas and mining sectors. Technology and knowledge transfer by foreign multinationals may spill-over to local firms through several channels and the relevant channels are analyzed separately. It follows from the results that spillovers do not occur by themselves in extractive industries. Host country government policies aimed at linking international resource companies with local firms play an important role in the process of creating knowledge spillovers. However, these policies are only effective when they go hand in hand with policies that enhance the skill level of local workers, improve the capacity of local suppliers, and foster local research initiatives.

JEL Classification: F23; O32; O33; Q32

Keywords: Foreign Direct Investment, Extractive Industries, Multinational Enterprises, Technology Transfer, Spillovers, Innovation Survey

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1 Introduction

In many developing countries extractive industries are the main beneficiaries of Foreign Direct Investment (FDI). The largest component of FDI flowing to the African continent is, for example, directed at natural resource sectors. Resource-rich countries increasingly aim to benefit from technology and knowledge spillovers. In order to prevent the emergence of resource enclaves, countries have imposed regulations on international resource companies, including obligations to hire and train local workers, to buy from local suppliers and to advance local research and development.[1] Due to the profitability of the investment opportunities, international resource companies are accepting such regulation even if such regulation is often banned by the World Trade Organization's Agreement on Trade-Related Investment Measures and by bilateral investment treaties (BITs). This study measures to what degree and under which circumstances such legislation has enhanced technology and knowledge spillovers in natural resource sectors.

International resource firms transfer superior technology to their affiliates in host countries in order to improve the competitive position of their subsidiaries. Furthermore, multinational companies may transfer knowledge and skills to local suppliers in order to enhance the quality of their inputs. Due to the partially non-excludable nature of knowledge, foreign multinationals are not able to fully appropriate the benefits of their knowledge transfer. Furthermore, knowledge is non-rival, so, the use of this knowledge by multinational affiliates does not diminish the ability of local firms to use it. This implies that knowledge and technology transfer by multinational companies may spill-over to domestic firms. There are different channels through which FDI technology spillovers can occur. First, local firms may imitate technology adopted by foreign multinationals. Second, employees trained by multinational corporations may join local firms which may enhance local firm productivity (labor mobility). Third, due to backward and forward linkages, local suppliers and downstream

[1] Mckinsey (2013) shows that more than 90 percent of resource-driven countries worldwide have some form of local content regulation (see e.g. West African local content legislation in the oil & gas sector).

companies may benefit from spillovers. Fourth, the presence of foreign multinationals may enable local firms to enter export markets.[2] According to the empirical literature on FDI spillovers, the main characteristics that determine the existence and size of spillovers are, the technology gap between foreign and local firms, and the capacity of local firms to absorb spillovers. As shown by e.g. Findlay (1978), Wang and Blomström (1992), and Kokko (1994), when, there is no technology gap between foreign and local firms, there is no room for local firm improvement and FDI spillovers will not occur. If the technology gap is, however, too large local firms lack the absorptive capacity to benefit from spillovers (see e.g. Lapan and Bardhan, 1973; Kinoshita, 2001; Crespo and Fontoura, 2007). Absorptive capacity is the ability of firms to identify and use knowledge and technology of other firms, for their own commercial purposes (Cohen and Levinthal 1989 and 1990). The capacity to absorb foreign firm technology depends on the skill level of the local workforce. Furthermore, Research and Development (R&D) by local firms enhances the absorptive capacity of these companies and enables them to benefit from foreign firm technology and knowledge spillovers.

Also, from the case studies addressed in this paper it follows that the existence of spillovers depends on host country government policies aimed at improving local technical skills and on policies that stimulate local research initiatives. Besides host country governments, international resource firms play an important role in developing these local skills, by training their local workforce and through supplier development programs. Furthermore, policies that create linkages between international resource companies and local firms have played an important role in the process of generating knowledge spillovers in extractive industries.

Singer (1950) argues that due to the capital intensive nature of the natural resources sector, spillovers will not occur in resource-rich developing countries. Few local workers are hired and inputs are often acquired from leading international suppliers. On the contrary Hirschmann (1981) argues that in the natural resources sector, linkages and spillovers to the rest of the economy will occur naturally as a result of market forces. Morris et al.

[2] The *competition channel* is not considered. Spillovers through this channel occur when local firms increase their efficiency due to an increase in competition after foreign companies enter the host country.

(2012) separately analyze backward, forward and horizontal linkages in different Sub-Saharan African countries. They show situations in which linkages occur due to market forces and situations in which they do not occur naturally. The main contribution of our study is that we analyze the relevant spillover channels separately (including linkages) and provide policy recommendations for each channel.

The next section analyzes host country government policies which aim to enhance spillovers through the labor mobility channel. Section 3 analyzes requirements on local procurement and their role in generating spillovers through the backward linkage and the export channel. Section 4 studies forward linkages. Section 5 looks at requirements on local R&D and the effects of R&D collaboration on the innovation performance of local firms. The last section concludes and provides policy recommendations.

2 Labor mobility

When multinationals transfer equipment to their subsidiaries in host countries, they need to accompany this with knowledge transfer on how to use this technology effectively (see Teece, 1977). Knowledge spillovers through the labor mobility channel occur when local firms hire workers that were trained by foreign multinationals or when these trained workers start their own businesses. The knowledge these workers gained during their employment at foreign companies enhances the productivity of local firms.[3] Negative spillovers may also occur when foreign firms attract the most highly skilled workers in the local economy and when highly skilled local workers are not willing to work for local companies anymore (see e.g. Sinani and Meyer, 2004).

Knowledge spillovers through labor mobility may have played a crucial role in strengthening South Africa's mining supply industry. Many of the senior skilled employees of mining suppliers in South Africa, developed their knowledge and skills as technicians on mines or working at research institutes. This implies that, while, working for foreign mining compa-

[3] For a theoretical analysis of this *labor mobility* channel see e.g. Fosfuri, Motta, and Ronde (2001).

nies these workers gained knowledge which may have enabled them to fill high-skill positions in local firms. South African suppliers provide capital equipment in areas such as hauling, drilling, and crushing (Walker, 2005). Former workers of multinational companies may also start their own businesses and become suppliers to the industry. Farole and Winkler (2014) show that in Chile 4.1 percent of local employees in foreign mining companies start their own businesses that supply the mining industry. Furthermore, in Ghana a former mining company engineer, working in a mines "gold room", started his own business supplying kiln products and maintenance services to mines. A Ghanian worker with 17 years of experience in mining set up an electrical engineering company providing mainly mining companies with engineering consultancies, and electro-wind services. Besides supplying the mining industry these suppliers provide intermediate inputs and services to other industries as well. This implies that horizontal linkages may also occur as a result of labor turnover.

In extractive industries host country governments have often put in place legislation which imposes on foreign resource firms that they hire and train local workers. Malaysia's foreign production sharing partners need to provide training to local workers in order to replace expatriates. Upon request training needs to be given to Petronas employees (Tordo et al., 2013). In Tanzania Article 19 mandates foreign companies to establish training programs for Tanzanian citizens and to provide grants to support training of Tanzanians selected by the state oil company. However, training of local workers is costly. Teece (1977) defines technology transfer costs as: "the cost of transmitting and absorbing all of the relevant unembodied knowledge". If local workers lack basic technical skills, the cost of transferring this unembodied knowledge will become too high and foreign firms may choose to hire skilled expatriates instead of local workers.

2.1 Determinant factors

In order to compare the level of education of employees at foreign companies with the level of education of employees at local companies, the South African innovation surveys of 2005 and 2008 are employed. The periods covered by these surveys are, respectively, 2002 to 2004 and 2005 to 2007. Hence, both surveys were conducted during the commodities super-cycle. The South African innovation survey is comparable to the European Community Innovation Survey and follows the guidelines of the Organization for Economic Cooperation and Development (OECD) and Eurostat. This enables international comparison of the different indicators. The final sample contains 158 natural-resources companies. There are 78 observations from the 2005 survey and 80 observations from the 2008 survey. The sample contains 40 affiliates of foreign multinationals and 118 local firms. Figure 1 shows that foreign affiliates have a higher percentage of workers with university or technikon degree's or diploma's compared to local firms. The difference in means between foreign and local companies is significant at the 5 percent level. Hence, the employees of foreign natural-resources companies are associated with higher levels of prior education compared to the employees of local companies. In many resource-rich Sub-Saharan African countries there is a lack of technical skills; this phenomenon is largely accounted for by the lack of local technical training facilities. African countries have the highest percentage of social science and humanities graduates in the world, 70 percent compared to 53 percent in Asia. Education in these countries should focus more on Science, Technology, Engineering, and Mathematics (STEM) fields (World Bank, 2014). In this way the cost of technology transfer for international resource firms is lowered and their willingness to hire local workers will increase.

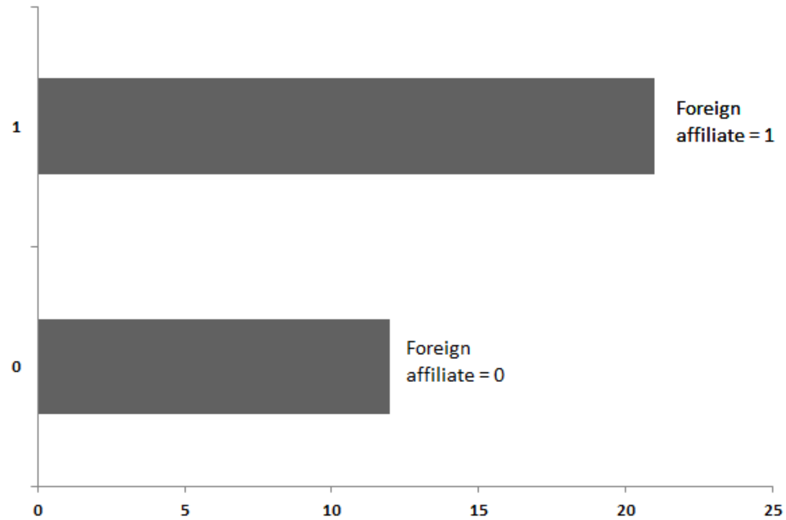

Figure 1: mean percentage employees with university or technikon degree or diploma

In Chile local research centers and universities have played an important role in providing the necessary skills to the mining sector. In 2011 a center was formed together with Australia's world class research center CSIRO. CSIRO-Chile provides training and education in order to develop skills and technology for the mining sector. The center comprises the major foreign mining companies, local state-owned Codelco, local research center CICITEM, University of Antofagasta, and the University of Chile. Norway started upgrading its local human capital in the early stages of oil extraction in order to provide the sector with suitable personnel. The University of Stavanger (UiS) was established in 1969 and has been closely linked to the oil and gas industry from the start. The University provides key educational programs and was the first University in Norway to introduce an undergraduate program in petroleum engineering (Hatakenaka et al., 2006). In order to participate in the oil industry and build up Norwegian competency within the petroleum sector, the Norwegian Government created the Norwegian State Oil Company in 1972. Today, the Government is still the majority shareholder of Statoil. To build a competitive company with independent technological know-how, Statoil created a structure that was modeled closely on Mobil's organization. Mobil was Statoil's partner and the operator of the Statfjord oil field. As part of this imitation strategy and due to the lack of local know-how, Statoil hired

American managers for leadership positions in different branches of the company. As local universities increased their ability to meet the needs of the industry, Statoil benefitted from Norwegian staff such as engineers from the technical college in Trondheim (NTH). Over time, Statoil was able to replace the foreign nationals with Norwegian workforce and in 1986 Statoil took over from Mobil in operating Statfjord, albeit three years later than originally agreed.[4] Also, Brazil's Petrobras recognized the need for upgrading the capacity of local workers. It has invested strongly in targeted skills and technical training since the 1960s and has trained 2,800 qualified engineers (Peyerl, 2013). Malaysia's national oil company Petronas has also made significant investments in order to upgrade local technical skills in the oil and gas sector. Petronas finances several educational institutes. In 1981, it set-up the Institut Teknologi Petroleum (INSTEP) that has provided technical training to almost 10,000 employees (INSTEP, 2014). As a result, in Malaysia, international oil companies mainly depend on local workers. Around 98 percent of ExxonMobil's workforce comprises of local workers and ExxonMobil has trained over one thousand skilled technicians in Malaysia (Wise and Shtylla, 2007). It follows from the above that legislation on hiring and training local workers must go hand in hand with a policy of upgrading the basic skills of the local workforce. As more local workers are hired and trained by multinational companies, knowledge spillovers through the labor mobility channel will become more likely.

3 Local procurement

The phenomena of outsourcing has made it possible for host country firms to take part in the different segments of the supply chain of the natural resources sector.[5] FDI spillovers to local suppliers can occur through the labor mobility channel as we have seen in the previous section but they can also occur through backward linkages. Aragón and Rud (2013) analyzing a large gold mine in Peru find positive spillovers due to an increase in local procurement. Due to

[4]See Ryggvik (2010) for an extensive analysis of the Norwegian oil experience.

[5]The largest share of the economic value distribution of Anglo American were payments to suppliers. Furthermore, 14.7 percent ($1.8 billion) of total supplier expenditure, was spend with local suppliers.

higher demand from multinational affiliates local suppliers may benefit from scale economies and suppliers may upgrade their production management. Linkages with local suppliers may also include the transfer of technology and knowledge to local suppliers. International resource firms have an incentive to transfer knowledge and technology because this improves the quality of supply and reduces input cost. Hence, backward linkages may enhance both the competitive position of multinational affiliates and that of local firms.

Besides knowledge and skills transfer to local suppliers, foreign multinational companies may also make financial investments in local suppliers. An example of such a program is Anglo American's Zimele program in South Africa. Besides providing local suppliers with technical training in order to improve the quality of supply, Anglo American (AA) takes an equity share in these local firms and provides a board member. As a result AA is involved in enhancing the management and financing skills of local suppliers. This knowledge allows local companies to effectively manage their enterprise and attract funding also after AA exits the company. A survey from 2005 showed that 72 percent of the firms AA had invested in, survived 8 years or longer (Wise and Shtylla, 2007). Furthermore, the Nigerian Local Content Act imposes a levy of one percent on all contracts awarded in the upstream sector. This money is invested in training local suppliers and lending money to local firms through the Nigerian Content Development Fund.

The presence of foreign multinationals may also enhance the export capacity of local companies. Foreign multinationals with a presence in different countries will have valuable information about possible export markets for local firms (Aitken et al., 1997). As Krugman (1989) and Clerides et al. (1998) show exporting involves fixed costs related to establishing a distribution network, advertising, and acquiring market information. A multinational partner located in the host country can become a source that provides this information and the multinational can become a channel for local suppliers to enter foreign markets (Greenaway et al., 2004). For example, when a local firm supplies a foreign multinational, it may in the future start supplying this multinational in other countries as well. Farole and

Winkler (2014) found that assistance from foreign investors to local mining suppliers helps local suppliers to become exporters. Types of assistance include support with implementing health, safety, environmental (HSE) and social conditions; training of workers; providing advance payment. They also showed that a third of the mining suppliers in Ghana has started exporting as a result of supplying foreign mining companies. In Chile 42 percent of local suppliers started exporting as a result of supplying foreign mining companies.

Developing a supply industry in extractives through backward linkages may in turn result in the emergence of other sectors through horizontal linkages. An example is South Africa's mining equipment and services industry, which has played an important role in developing other sectors in the economy. Firms supplying directly to the mines are the so-called Tier 1 companies. These include consulting firms providing engineering, procurement, construction and management services (EPCM), and Original Equipment Manufacturers (OEMs). These suppliers have modified and adapted generic technologies and products for use in other industries such as construction, agriculture, and general manufacturing (Walker, 2005). Also, In Nigeria's IT sector, skills were developed in order to provide services to the oil and gas industry, now, these skills are being applied in other industries as well (Oyejide and Adewuyi, 2011).

3.1 Determinant factors

Local content policies aim to induce foreign multinationals to buy their products from local firms. Some countries impose strict legislation on foreign extractive companies that they procure products and services domestically. In many Sub-Saharan African countries such as Angola and Tanzania, legislation on local procurement has led to local suppliers importing products on behalf of foreign resource companies with no or only limited value addition by local suppliers. Local firms may, for example, be representatives of international suppliers. In Zambia 80 percent of local sourcing is from intermediaries of international suppliers. This so called "Window dressing" of local supply through imports with no added value, limits the possibility for the transfer of knowledge and technology from foreign multinationals to local firms (Hansen, 2014). In order to spur spillovers through the backward linkage channel, local value addition matters rather than local ownership in supply, as the latter may lead to the emergence of trading companies rather than manufacturing value addition with higher spillover potential.

Norway is famous for developing its equipment and services supply industry in a relatively short time frame. Today Norway boasts some of the worlds leading oil service companies such as Aker Solutions. In the early years of Norwegian oil extraction the country was, however, dependent on US technology in the oil and gas supply chain. Drilling equipment on oil rigs, was produced in the US and installed by American experts. Norwegian share in supply for the Ekofisk field was 20 percent in 1973. The Norwegian government induced international oil and gas companies to increase local sourcing by allowing them to extend the area of oil extraction if they would depend more on local suppliers. In the short term this resulted in higher operating costs for the international oil & gas companies (Ryggvik, 2010). The portion of Norwegian supply increased gradually and for the Frigg oil field in 1974, local supply was 28 percent. The development of the Gullfaks offshore oil field in 1986 fully depended on Norwegian suppliers and there were no cost overruns as before (Thurber and Istad, 2010 and Engen, 2007). The rapid learning experience can partly be traced back to Norway's experience in other sector such as shipbuilding. Shipbuilding firms such as the Aker Group made a strategic transition into the oil and gas industry. In 1964 the Aker Group established three new companies: a drilling company, a supply service company, and a partnership company for oil platform construction. To provide engineering services in the design and construction phases, Norwegian Petroleum Consultants (NPC) was founded in 1973. Also, Kvaerner another Norwegian supplier had established an equivalent department. Hence, this is in line with what Hausmann and Klinger (2006) argue: "the probability that a country will develop the capability to be good at producing one good is related to its installed capability in the production of other similar, or nearby goods for which the currently existing productive capabilities can be easily adapted".

Besides transforming existing industries to meet the demand of international resource companies, technical support for local firms may also foster the ability of local companies to provide inputs to the extractive industry. In 2003 the Brazilian government together with Petrobras created the PROMINP program. This program enhances local skills in the different links in the supply chain. In 2004 the program initiated an agreement between Petrobras and Sebrae, a micro and small enterprise support organization. The agreement aims at providing local companies with the necessary skills needed for supplying the oil and gas sector. Furthermore, in 2009 a web-site was launched that creates interaction between oil and gas companies and Small and Medium Enterprises (SMEs). On this web-site local suppliers can disclose products and services which they are able to supply to the industry. This platform is not open to local companies that import goods and services. By 2013 more than 13 thousand companies had participated in more than 122 business rounds creating around $2.9 billion in transactions between oil and gas companies and local SMEs (Rodrigues Alonso, 2014). The PROMINP program also stimulates international suppliers to open subsidiaries in Brazil and to form joint ventures with local suppliers. The program has increased local content from 57 percent in 2003 to more than 75 percent in 2009 (Tordo et al., 2013).

4 Forward linkages

A stable supply of low-cost feedstock may give local downstream users of raw materials e.g. refineries and smelters a competitive advantage over downstream industries in other countries. In the oil & gas sector, the Gulf Cooperation Council (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) have been relatively successful at developing downstream industries that refine, sell, and distribute hydrocarbons. The abundance of oil and gas has also enabled these countries to develop capital-intensive industries such as petrochemical, aluminium, and steel production. In mining, Botswana may become an exceptional success story of downstream beneficiation in Africa. It has started cutting, polishing and selling diamonds locally. Downstream companies e.g. the cutting and polishing firms in Botswana are often affiliates of foreign-owned multinational companies. Hence, in this case forward linkages do not result in direct spillovers to local downstream firms. Based on the South African innovation survey, Figure 2 compares the level of foreign ownership in downstream sectors with the level of foreign ownership in upstream sectors. The data set contains 57 downstream companies and 101 suppliers and mining companies. Figure 2 shows that, also in South Africa's natural resources sector, downstream companies are more often associated with foreign ownership compared to other natural-resources companies (the difference in means is significant at the 5 percent level).

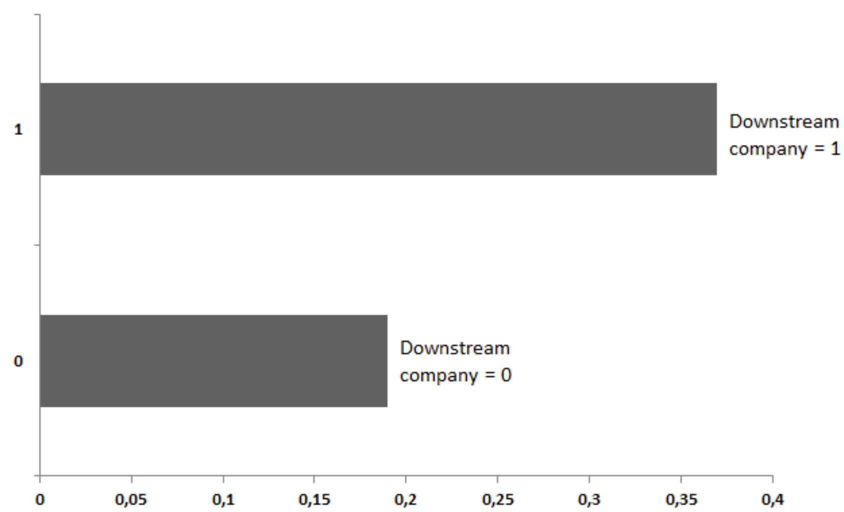

Figure 2: mean foreign ownership in downstream and upstream sectors

However, as a result of developing downstream sectors, so called side-stream linkages with local firms may emerge. These are linkages with firms that provide services to the downstream industry such as banks, courier companies, machinery suppliers, security, laboratory, mining houses, brokers, and consultants.[6] Hence, forward linkages with foreign-owned downstream companies may indirectly lead to FDI spillovers to local firms through side-stream

[6]See the Diamond Technology Park (DTP) in Botswana.

linkages. Furthermore, given that downstream industries and the sectors that service these industries, hire and train local workers, the scope for indirect spillovers through labor mobility may also increase.

4.1 Determinant factors

The GCC countries have been able to develop refining and petrochemical industries due to a stable supply of low-cost feedstock. Botswana is the world's largest producer of diamonds and the foreign-owned cutting and polishing companies expect that the country will produce sufficient diamonds for at least two decades. However, the Mozal aluminium smelter in Mozambique which uses alumina imported from Australia shows that also downstream industries that depend on imported raw materials may become profitable. Mozal's success is related to the fact that there is a relatively large market for aluminium ingbots in the region. Recently, Midal Cables, one of the world's largest manufacturers of aluminium wire rods and cables, constructed an aluminium factory near the Mozal smelter in order to serve regional markets. Hence, lower trade barriers may be one device to make forward linkages more attractive as this creates new markets for downstream industries in nearby countries (see Jaumotte, 2004).

5 Local R&D

The main argument for the necessity of public policy to stimulate private R&D is provided by Arrow (1962) and Nelson (1959). They show that knowledge generated by one firms' R&D effort can be freely used by other firms. Due to these technological spillovers, firms are unable to fully appropriate the benefits from their R&D effort which reduces their incentives to invest in R&D. Hence, the social rate of return to R&D investment is higher than the private rate of return. This implies under-investment in R&D, relative to the social optimum. Hence, host country governments are increasingly trying to stimulate foreign companies to be active in local R&D. In order to internalize knowledge spillovers public policy encourages R&D collaboration between firms. A large theoretical literature which includes studies by Katz (1986), d'Aspremont and Jacquemin (1988), and Kamien et al. (1992) shows that in case of relatively large technological spillovers, R&D collaboration enhances social welfare. Firms cooperate in so called Research Joint Ventures (RJVs) in which they internalize knowledge spillovers by sharing all the knowledge gained through R&D. Furthermore, by collaborating in R&D, duplication of R&D efforts will be prevented.

Norway successfully enhanced local R&D by international resource companies in its oil & gas industry. At the end of the 1970s international petroleum companies in Norway were given points for contracting Norwegian firms and local research institutes for oil and gas related research and they were given points for developing Norwegian research institutions. These points would increase a multinational's chance of getting concessions in new licensing rounds. The Norwegian government also made R&D spending tax deductible and through the Ministry of Science and Technology, the government invests a percentage of revenues in scientific research and technology development for the oil industry. In 1978 the Norwegian government decided that at least 50 percent of research done by international oil companies, on developing oil from the Norwegian continental shelf, should be done domestically. Research centers such as Sintef, Christian Michelsens Research, and Rogaland Research were established and the international oil companies started to collaborate with these research centers and with local Universities such as the Norwegian University of Science and Technology. The main research areas became applied geology, well drilling technology, and principles for enhanced and improved oil recovery (Gulbrandsen and Nerdrum, 2007; NTNU-Trondheim, 2014). Also, the Norwegian Petroleum Directorate (NPD) started a number of R&D initiatives bringing the oil industry together with local research centers.[7] These policy initiatives taken by the Norwegian government resulted in much oil-related research in the host country

[7] NPD is the regulator of the oil and gas industry and the third body of the Norwegian model, besides the policy making ministry, and commercial Statoil. NPD governs the accreditation of local research institutes and the use of research funds.

and were a crucial step in order to upgrade local capabilities in the oil and gas sector.

South Africa has a well developed mining equipment and services supply industry with a number of firms at the global technological frontier. In South Africa, R&D partnerships have also played an important role in developing this supply industry. Beginning in the 1960s the cooperative research institute of the mining industry (COMRO) undertook several R&D initiatives. COMRO wanted to develop technologies that allowed for gold extraction from deposits that were located deeply below surface. Its aim was to have local equipment manufacturers produce these technologies. While, overseeing the development of the new equipment, COMRO outsourced some of its R&D to equipment suppliers, other research organizations, and South African universities (Pogue, 2008). This research led to the development of different hydraulic equipment in which the country is a world leader. Furthermore, the country is, now, a regional hub in Southern Africa for supplying different kinds of mining equipment and services.

BHP Biliton's Cluster Program for the Development of World-Class Suppliers aims for close collaboration between BHP Billiton (BHPB) and local suppliers in order to develop innovative solutions in mining. By 2013 BHPB had operated 43 projects with 36 suppliers participating. These suppliers had a combined sales of $400 million and they have around 5000 employees. BHPB has invested over $50 million in the program, which is less than half of the estimated savings resulting from the innovations ($121 million) (Porter, 2014). One of the successes of the program is a solution developed by Biohydro.cl. This local supplier was given the task to automate the wetting phase in the copper leaching process. BHPB's goal was to minimize the exposure of operators to acid mist and to reduce the variability of the wetting phase process. By the end of 2012 Biohydro.cl had reduced the variability of the wetting phase from seven percent to less than one percent. Furthermore, it reduced water consumption and increased mineral recovery. Micomo, another local supplier that develops communication and information solutions for the mining industry, developed an innovative forecast system. The software it developed, assesses a combination of elements, such as weather, geography and operational activities, to predict potential dust emissions from mining activities. It can predict with 75 per cent accuracy the likely level of dust output up to 48 hours in advance of planned mining activities. The software reduced the need for costly last-minute changes in BHPB's work schedule (BHP Billiton, 2012). Prodinsa a local firm that produces steel cables for electromechanical shovels was able to become an exporter of its shovel cable solution as a result of the World-Class Supplier Program. The snapping of cables in BHPB's Escondida mine resulted in high cost for BHPB – not only due to the repair of the cables, but more importantly due to the interruption in operations. To solve this problem BHPB allowed local suppliers to conduct research in its open pit mine. Prodinsa developed a solution that increased the shelf life of the cables by 40 percent. Prodinsa, now, exports its solution to the Antamina mine in Peru of which BHPB is one of the owners (BHPB, 2012). Hence, the link created between Prodinsa and BHPB and the presence of BHPB in Peru, enabled Prodinsa to gain access to Peru's mining sector.

5.1 Determinant factors

The South African innovation surveys of 2005 and 2008 are employed in order to find whether R&D collaboration actually enhances local firm innovativeness (i.e. introduce product innovations and new methods of production). Table 1 gives some sample statistics. Of the total number of firms in the final sample, 57% (67 firms) introduced some kind of innovation or had ongoing or abandoned innovation activities. This study restricts the attention to the 67 innovation-active local firms because only these local firms provided information on key variables related to R&D investments. Of the total number of local innovation-active firms, 43% (29 firms) had introduced new or significantly improved products or services that were new to the market and 47 (70%) firms introduced new methods of production.

Table 1
Sample statistics (number and percentage of firms)

Firms	158
Local firms	118 (75%)[a]
Innovation-active local firms	67 (57%)[b]
Firms that introduced products new to the market	29 (43%)[c]
Firms that introduced new methods of production	47 (70%)[c]

[a] percentage with respect to total number of firms
[b] percentage with respect to local firms
[c] percentage with respect to innovation-active local firms

This study models the probability that local firms introduce innovations as a result of R&D cooperation with foreign partners, as well as traditional variables which are thought to affect innovativeness. Three types of R&D partnerships are considered (i) partnerships with foreign competitors (*RDcoop_ForComp*); (ii) partnerships with foreign clients or suppliers (*RDcoop_ForClienSupp)*; and (iii) partnerships with foreign universities or public research centers (*RDcoop_ForUniPubres).* In line with the existing literature the variable *Size* is included which is measured by the logarithm of the number of a firm's employees. In order to allow for a nonlinear effect of firm size, the squared logarithm of the number of employees (*Sizesq*) is also included. The variable *ContinuousRD* takes the value of one if a firm invests continuously in R&D and zero otherwise. This variable measures a firm's absorptive capacity. A firm's absorptive capacity is its ability to benefit from R&D investments done by other firms or institutions (see Cohen and Levinthal, 1990). The variable *Skill* is measured by the percentage of workers with a university or technikon degree or diploma and serves as a proxy for the skill level of a firm's employees. Firms competing in the export market are likely exposed to higher levels of competition, so, the binary variable *Export* is included in order to capture the effects of competition intensity. The variable *Cost* controls for financial constraints as obstacles for the innovation process. This variable is measured by the average score of importance of the following obstacles to the innovation process: no suitable financing available internally; no suitable financing available externally; high costs of innovation. If a firm is part of a larger group, it may have access to technological and managerial expertise from the headquarters and as a result such firms may be more innovative. To take this effect into account, the variable *Part_ of_ larger_ group* is included. The data set contains mining companies, suppliers, and downstream firms. Suppliers include firms that provide machinery and equipment and such companies will more likely introduce product innovations, compared to mining companies and downstream firms. Variable *Supplier* takes the value of one if a firm is a supplier and zero otherwise. The last control *Year05* takes the value of one if a firm participated in the 2005 survey and takes the value of zero if a firm participated in the 2008 survey. In Appendix A detailed definitions of the variables is provided.

Table 2 reports the results. R&D collaboration with foreign clients or suppliers has a positive and significant effect on the likelihood that firms introduce product innovations that are new to the market. Furthermore, as expected *suppliers* are more likely to introduce product innovations which are new to the market compared to mining companies and downstream firms. These results are in line with the findings in the previous subsection, where, different case studies show the introduction of product innovations as a result of R&D collaboration between local suppliers and foreign customers. Host country governments have put in place different types of requirements on local R&D by foreign companies. In Malaysia foreign production sharing partners have to invest 0.5 percent of the sum of costs and their share of profits in local research (Tordo et al., 2013). Nigeria's rules on research and development state that the operator should submit a R&D Plan every 6 months to the Nigerian Content Development and Monitoring Board. The operator has to submit an outline of a three to five year plan for research and development. Also, the expected expenditure to implement the plan needs to be submitted. The operator needs to publicly seek proposals for R&D initiatives related to its activities. Similarly, in Ghana's oil industry foreign companies have to provide a plan outlining a 3-5 year program of R&D initiatives to be undertaken in Ghana. Details of expected expenditure on the R&D initiatives should be provided. The contractor has to update the R&D plan annually which will then be reviewed by the Petroleum Commission, the regulator of the Ghanaian oil industry (CCSI, 2014).

Table 2
Results of probit regressions for product innovations and new methods of production

	Product innovations	New production methods
Constant	−1.742	0.934
	(1.328)	(1.287)
RDcoop_ForClienSupp	1.158**	1.317*
	(0.544)	(0.766)
RDcoop_ForComp	−0.914	−2.128**
	(0.769)	(0.998)
RDcoop_ForUniPubres	1.736	0.865
	(1.062)	(0.981)
Size	0.205	−0.00486
	(0.432)	(0.440)
Sizesq	−0.0201	−0.00729
	(0.0328)	(0.0335)
Part_of_domestic_group	0.0893	−0.163
	(0.435)	(0.436)
Export	−0.103	0.0286
	(0.469)	(0.470)
Cost	0.176	−0.291
	(0.210)	(0.208)
Skill	−0.00254	−0.00971
	(0.0117)	(0.0125)
ContinuousRD	0.658	1.240***
	(0.423)	(0.478)
Year05	−0.353	−0.0824
	(0.399)	(0.389)
Supplier	1.493***	−0.104
	(0.486)	(0.448)
Observations	67	67
X^2	28.71	17.80
McFadden R^2	0.3132	0.2179

* Significant at 10 percent
** Significant at 5 percent
*** Significant at 1 percent

This legislation, however, does not necessarily lead to collaboration in R&D between international resource companies and local partners. International resource firms may use their own research facilities without collaborating with local firms and local knowledge institutions. Since, research collaboration is most conducive to FDI spillovers, host country governments should incentivize international resource firms to collaborate in research and development with local partners.

Variable *ContinuousRD* which measures a firm's absorptive capacity, has a highly significant effect on the probability of introducing new methods of production. When, local firms are active in R&D themselves they create the capacity to benefit from technology spillovers emanating from international resource companies. In mining, Chile is one of the countries that has been able to benefit from technology transfer by international mining companies. For instance, at the end of the 1960s, US mining company Kennecott introduced a new smelter technology at its El Teniente mine as part of an experiment to increase production. Following the nationalization of foreign owned mining projects in 1971, Chile's national mining company Codelco became the owner of the El Teniente mine. However, the new smelter technology was only used by Japanese and Canadian firms and Codelco did not have the knowledge and capacity to service the technology. To resolve this problem, Codelco engineers worked closely with Japanese counterparts and eventually mastered the new technology. In 1976 the Chilean engineers even improved the smelting technology by: increasing energy savings, increasing the treatment capacity, reducing equipment requirements, lowering handling material costs, and reducing air pollution. In 1988 Codelco exported the smelter technology to Zambia.[8] In Brazil local capacity has been developed through the research center of Petrobras (CENPES), which collaborates with local and international universities, other research institutes, and international suppliers. CENPES was created in 1963 and its initial focus was on imitating technologies. In later years CENPES developed into a technology generating center and it has been a vehicle for developing in-house technological capacity (Tordo et al., 2013). One percent of gross revenue of each oil and gas field in Brazil has to be invested in oil and gas related R&D. At least half of this investment needs to finance research which is carried out by local research institutes or local universities. The operator may invest the other half of investments in its own research facilities located in Brazil. Given that

[8]See Gana (1992) for a case study of Codelco's experience with the smelter technology.

Petrobras is the main operator, 99 percent of the investments made in this way have come from Petrobras (ANP, 2011). By combining in house technology investment with expertise and knowledge from its foreign partners, Petrobras has developed leading-edge capabilities in deep-water and ultra-deep water exploration and production. More recently Brazil has attracted leading international oil service companies to open research centers in Brazil with a focus on the new technological frontier of pre-salt oil and gas. In this way Brazil aims to gain technology and knowledge in the supply chain of the pre-salt oil and gas sector.

Finally, table 2 also shows that R&D collaboration with foreign competitors negatively effects the probability of introducing new methods of production. Foreign resource firms collaborating with local competitors may less aggressively pursue process innovations as they may want to prevent their competitors from imitating these new methods of production. It is important to take into account that international resource companies may be less willing to be active in local research and development and to transfer innovative technology if their innovations are not sufficiently protected. Without sufficient Intellectual Property Right (IPR) protection, legislative rules on local R&D may not be effective. So, instead of simply imposing legislation that demands that foreign companies be active in local R&D, putting in place proper IPR protection can be a policy tool for host country governments to enhance local research and development by international resource companies.

6 Concluding remarks and policy recommendations

This study analyzes the different FDI spillover channels and provides policy recommendations on how host country governments can foster knowledge and technology spillovers in the oil & gas and mining sectors. In order to benefit from spillovers through the labor mobility channel, most resource-rich countries have imposed legislative rules on hiring and training local workers. This has, however, not been effective without an accompanying policy of developing local technical skills. The skill level of local workers is an important determinant of the cost of technology transfer. In case of high cost of technology transfer, international resource firms will prefer to hire expatriates. As a result governments that focus on developing local technical skills have been much more successful at accomplishing local workforce participation. This in turn has enhanced the scope for knowledge spillovers through labor mobility.

As a result of FDI in the natural resources sector local downstream industries may emerge. In resource-rich developing countries, downstream companies are likely to be foreign-owned and this prevents the development of direct forward linkages with local firms. However, due to so called side-stream linkages, local firms that service downstream companies may still benefit from technology and knowledge spillovers. Furthermore, legislation on local procurement has not led to the desired effect in different developing countries. Instead, in these countries local firms import intermediate inputs, with no or limited local value addition. This has reduced the scope for knowledge spillovers to local suppliers. To spur spillovers through the backward linkage channel, local value addition matters rather than local ownership, as the latter may lead to the emergence of trading companies rather than manufacturing value addition with higher spillover potential. Local value addition in supply is also conducive to R&D collaboration between foreign resource firms and local suppliers. Such joint research initiatives have led to the development of innovative goods and services by local firms. These innovations in turn have enabled local firms to enter export markets. Finally, the results show that the absorptive capacity of local firms, determined by their own investment in research and development, plays a crucial role in enabling local firms to develop of new methods of production.

7 Appendix A. The variables

Variable	Description
Nproduction methods	Binary variable indicating if a firm introduced new or significantly improved methods of manufacturing or producing goods or services (1), otherwise 0
Product innovation	Binary variable indicating if a firm introduced new or significantly improved goods or services that were new to the market (1), otherwise 0
Export	Binary variable indicating if a firm exported (1), otherwise 0
Foreign	Binary variable indicating if a firm is an affiliate of a foreign multinational (1), otherwise 0
Year05	Binary variable which takes the value of 1 if the firm took part in the 2005 survey
Size	Number of employees (natural logarithm)
Sizesq	Number of employees (natural logarithm) squared
Cost	Mean of the scores of importance of the following obstacles to the innovation process [number between 0 (factor not experienced) and 3 (high)]: (1) no suitable financing available internally, (2) no suitable financing available externally, (3) high costs of innovation
ContinuousRD	Binary variable indicating if a firm performed R&D continuously (1), otherwise 0
Skill	Percentage of a firm's employees with a university or technikon degree or diploma
Part_of_ domestic_group	Variable which takes the value 1 if the business unit is part of a domestic grouping
RDcoop_ ForClienSupp	Binary variable indicating if a firm collaborated on innovation activities with foreign clients or suppliers
RDcoop_ ForComp	Binary variable indicating if a firm collaborated on innovation activities with foreign competitors
RDcoop ForUniPubres	Binary variable indicating if a firm collaborated on innovation activities with foreign universities or public research centers

References

[1] Aitken B., G. H. Hanson and A. E. Harrison (1997). Spillovers, Foreign Investment, and Export Behavior. *Journal of International Economics*, 43, 103-132.

[2] Anglo American sustainable development report (2014). Focus: effective partnerships. Retrieved from http://www.angloamerican.com/~/media/Files/A/Anglo-American-PLC-V2/report-builder-2014/sdr/sdr14-interactive-version.pdf

[3] Aragón, F. M. and J. P. Rud (2013). Natural resources and local communities: evidence

from a Peruvian gold mine. *American Economic Journal: Economic Policy*, 5, 2, 1-25.

[4] BHP Billiton (2012). Fostering local supplier development. Retrieved from http://www.bhpbilliton.com/home/society/reports/Documents/2012/ FosteringLocalSupplierDevelopment.pdf

[5] Arrow, K. (1962). Economic welfare and the allocation of resources for invention, in R. R. Nelson (ed.). The Rate and Direction of Inventive Activity, Princeton University Press: Princeton, NJ, 609–625.

[6] Brazilian Agency of Petroleum, Natural Gas and Biofuels (ANP) (2011). Funds of the Clause in R&D Investment. Rio de Janeiro.

[7] Clerides, S., S. Lach and J. Tybout (1998). Is Learning by Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico and Morocco. *Quarterly Journal of Economics,* 903-947.

[8] Cohen, W. M. and D. A. Levinthal (1989). Innovation and learning: The two faces of R&D. *The Economic Journal,* 99, 569-596.

[9] Cohen, W. M. and D. A. Levinthal (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly,* 35, 1, Special Issue: Technology, Organizations, and Innovation, 128-152.

[10] Columbia Center for Sustainable Investment (CCSI) (2014). Local Content Laws & Contractual Provisions, Ghana: Petroleum. Retrieved from http://ccsi.columbia.edu/work/projects/local-content-laws-contractual-provisions/

[11] Crespo, N. and M. Fontoura (2007). Determinant Factors of FDI Spillovers: What Do We Really Know? *World Development,* 35, 3, 410-425.

[12] D'aspremont, C. and Jacquemin, A. (1988), Cooperative and Noncooperative R&D in Duopoly with Spillovers. *The American Economic Review*, 78, 5, 1133-37.

[13] Engen, O. A. H. (2007). The development of the Norwegian petroleum innovation system: a historical overview. TIK Working paper on Innovation Studies No. 20070605.

[14] Farole, T., and D. Winkler (2014). Making Foreign Direct Investment Work for Sub-Saharan Africa: Local Spillovers and Competitiveness in Global Value Chains. Washington, DC: World Bank.

[15] Fosfuri, A., M. Motta, and T. Ronde (2001). Foreign direct investment and spillovers through workers mobility. *Journal of International Economics,* 53, 1, 205.222.

[16] Findlay, R. (1978). Relative backwardness, direct foreign investment, and the transfer of technology: a simple dynamic model. *Quarterly Journal of Economics,* 92, 1, 1-16.

[17] Gana, J. (1992). Determinants of innovation in copper mining. *Resources Policy,* 18, 1, 21-31.

[18] Greenaway, D., N. Sousa, and K. Wakelin (2004). Do Domestic Firms Learn to Export from Multinationals. *European Journal of Political Economy,* 20, 4, 1027-1043.

[19] Gulbrandsen, M. and L. Nerdrum (2007). Public sector research and industrial innovation in Norway: a historical perspective. Centre for Technology, Innovation Culture (TIK), University of Oslo.

[20] Hatakenaka, S., Westnes, P., Gjelsvik, M., and R. K. Lester (2006). From black gold to human gold: a comparative case study of the transition from a resource based to a knowledge economy in Stavanger and Aberdeen. MIT Local Innovation Systems Working Paper 06-002.

[21] Hansen, M. W. (2014). From enclave to linkage economies a review of the literature on linkages between extractive multinational corporations and local industry in Africa. DIIS Working Paper 2014:02.

[22] Hausmann, R. and B. Klinger (2006). Structural transformation and patterns of comparative advantage in the product space. Mimeo, Harvard University.

[23] Hirschman, A. O. (1981). Essays in Trespassing: Economics to Politics and Beyond. *Cambridge University Press.*

[24] Jaumotte, F. (2004). Foreign Direct Investment and Regional Trade Agreements: The Market Size Effect Revisited, IMF Working Paper, WP/04/206.

[25] Kinoshita, Y. (2001). R&D and technology spillovers through FDI: innovation and absorptive capacity. CEPR discussion paper 2775. London: Centre for Economic Policy Research.

[26] Kamien, Muller and Zang (1992). Research Joint Ventures and R&D Cartels. *American Economic Review,* 82(5), 1293-306.

[27] Katz, M.L. (1986). An Analysis of Cooperative Research and Development. *RAND Journal of Economics,* 17, 527-43.

[28] Kokko, A. (1994). Technology, market characteristics, and spillovers. *Journal of Development Economics,* 43, 2, 279.293.

[29] Krugman, P. R., (1989). Exchange Rate Stability. MIT Press, Cambridge, MA.

[30] Lapan, H. & P. Bardhan. (1973). Localized technical progress and transfer of technology and economic development. *Journal of Economic Theory,* 6, 585–595.

[31] Morris, M., R. Kaplinsky and D. Kaplan (2012). One Thing Leads to Another: Promoting Industrialization by Making the Most of the Commodity Boom in sub-Saharan Africa. Lulu.com.

[32] Nelson, R. R., (1959). The simple economics of basic scientific research. *The Journal of Political Economy,* 67, 297.

[33] NTNU-Trondheim Norwegian University of Science and Technology (2014). Norway's Petroleum fairy tale. Retrieved from http://www.ntnu.edu/research/oil

[34] Oyejide, A. and A. Adewuyi (2011). Enhancing Linkages of Oil and Gas Industry in the Nigerian Economy. MMCP Discussion Paper 8. Milton Keynes, UK: University of

Cape Town and the Open University.

[35] Peyerl, D. (2013). Oil professionals training in Brazil: The role of Petrobras in the formation of a national class of geoscientists. Universidade Estadual de Campinas, Brazil.

[36] Pogue, T. E. (2008). Missed opportunities? A case study from South Africa's mining sector. In J. Lorentzen (ed.), Resource Intensity, Knowledge and Development. Insights from Africa and South Africa, Cape Town: Human Sciences Research Council Press.

[37] Porter, M. E. (2014). Clusters and shared value: drivers of competitiveness. Presentation at: Bogota Chamber of Commerce, Bogota, Colombia.

[38] Rodrigues Alonso, P. S. (2014). The PROMINP 10th Anniversary: results, challenges and perspectives for the maritime industry in Brazil. Houston Texas, USA.

[39] Ryggvik, H. (2010). The Norwegian Oil Experience: A toolbox for managing resources? Translated by Laurence Cox. Oslo: Centre for Technology, Innovation, and Culture (TIK-Centre).

[40] Sinani, E. and K. Meyer (2004), Spillovers of Technology Transfer from FDI: the case of Estonia. *Journal of Comparative Economics,* 32, 445-466.

[41] Thurber, M. C. and B. T. Istad (2010). Norway's evolving champion: Statoil and the politics of state enterprise. Freeman Spogli Institute for International Studies. Program on Energy and Sustainable Development (PESD) Stanford. Working paper number 92.

[42] Singer, H. W. (1950). The Distribution of Gains between Investing and Borrowing Countries. *American Economic Review,* 15, 473-85.

[43] Teece, D. J., (1977). Technology transfer by multinational Firms: The resource cost of transferring technological know-how. *Economic Journal,* 87, 242-261.

[44] Tordo, S., W. M. Warner, O. E. Manzano, and Y. Anouti (2013). Local content policies in the oil and gas sector. World Bank Group.

[45] Walker, M. (2005). Supply Relationships in the Mining Capital Goods and Services Cluster: The Case of PGMs', Paper presented at the Trade and Industrial Policy Strategies 2005 Annual Forum Johannesburg.

[46] Wang, J., and M. Blomström (1992). Foreign investment and technology transfer: a simple model. *European Economic Review,* 36, 137-155.

[47] Wise, H. and S. Shtylla (2007). The role of the extractive sector in expanding economic opportunity. Harvard Kennedy School of Government.

[48] World Bank (2014). Human Capital for the Oil, Gas and Minerals Industries: Is Africa Getting the Most out of its Extractive Industries Boom? Science, Technology, and Skills for Africa's Development.

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