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Special Focus:

Resource development in an era of cheap commodities

Resource development in an era of cheap commodities[1]

During the commodities super cycle that began in the early 2000s, many resource-rich countries benefitted from surging exploration, investment, and production activities, which transformed growth prospects. In 2016, with oil and metals prices 50-70 percent below their early-2011 peaks, these patterns have been reversed, adversely affecting many commodity-exporting countries. Project development has already been put on hold or delayed in several Emerging Markets and Developing Economies (EMDEs). It would take ambitious governance improvements in EMDEs—for example, to the levels prevailing in advanced markets—to mitigate the delays in ongoing development of large mines resulting from falling metals prices (up to four years for some of the largest mines in EMDEs). Governments seeking to develop natural resources may consider delaying new initiatives until the price outlook turns more favorable.

Introduction

The post-2000 commodity price increases, in part a reflection of demand growing faster than supply and concerns about the security of supply, set in motion a boom in commodities exploration, investment, and production, especially in mining and hydrocarbons (Figure F1). Less is known about the scale of investment that flowed into agriculture, but private sector investment in farmland in Africa increased significantly (FAO 2012).[2]

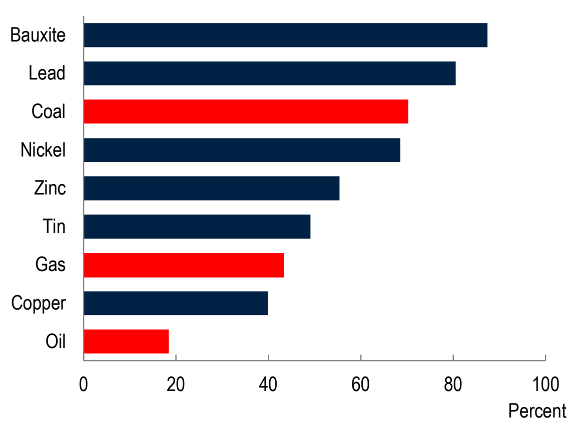
With oil and metals price declines of 50-70 percent between 2011 and early 2016, many resource development projects have been delayed or put on hold. Lead times—the time it takes from resource discovery to production—are a critical issue in many countries as these periods are associated with heightened macroeconomic vulnerabilities. This raises concerns about the ability of commodity-exporting emerging market and developing economies (EMDEs) to withstand shocks in the global economy.

This *Special Focus* addresses the following three question: (1) How did resource development evolve through the post-2000 price super-cycle? (2) What are the main drivers of resource development? (3) What are the implications of the decline in metal prices for resource development?

How did resource development evolve through the post-2000 price super-cycle?

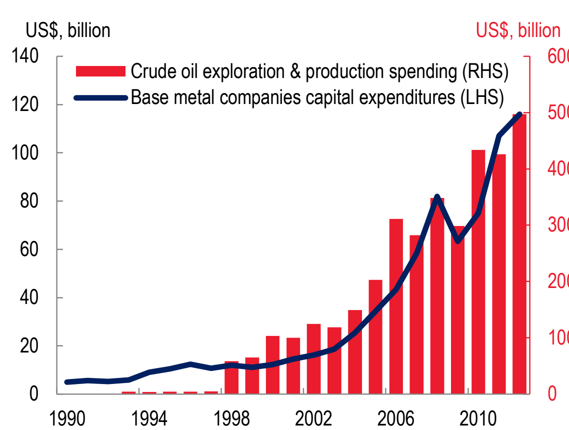
Exploration. Between 2000 and 2012, investment spending by global oil, gas, and base-metal mining companies rose five-fold (Figure F2), especially in Latin American and the Caribbean, and Sub-Saharan Africa. Including investment in other mined products, global investment in 2011–12 amounted to over $1 trillion; in Africa, mining investment alone amounted to $100 billion in 2011 (or 15 percent of global mining investment) and was a key driver of growth (ICMM 2012).

FIGURE F1 Global metal and hydrocarbon production (change from 2000 to 2014)



Source: BP Statistical Review, World Bureau of Metal Statistics.
Notes: Detailed data are reported in the Annex Table. Blue and red bars refer to metals and energy commodities, respectively.

FIGURE F2 Global investment spending on exploration and production



Source: International Energy Agency, MinEx Consulting.
Note: Last observation is 2012.

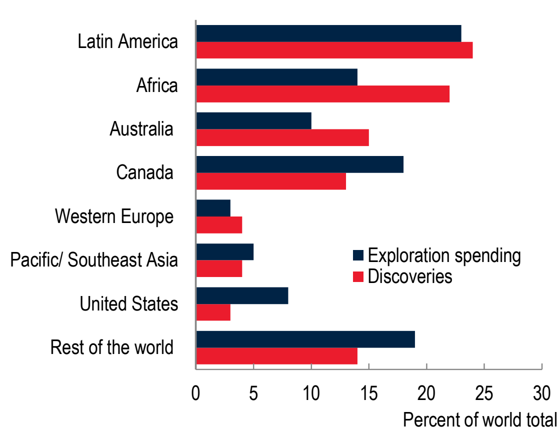
Discoveries. Several major discoveries transformed country prospects in Sub-Saharan Africa, and Latin America and the Caribbean (Figure F3). Since 2000, 120 "giant" oil and gas fields (fields with recoverable reserves of more than 500 million barrels of oil equivalent) have been discovered world-wide, with estimated "proved plus probable" reserves of almost 250 billion barrels of oil. The fields are located in seven clusters (Figure F4), two of which are in Africa, mostly offshore in East and West Africa. In Tanzania alone (which accounts for almost 7 percent of these reserves) there have been 13 giant oil and gas discoveries. Other major discoveries are in Kenya, Madagascar, Mozambique, and Uganda, as well as in six countries in West Africa and in the Gulf of Guinea. Another major frontier for giant oil and gas fields has emerged in the Krishna and Rakhine basins in the Bay of Bengal in South Asia (Bai and Xu 2014; Basu et al. 2010).

Lead times from discovery to production. Bringing discoveries to actual production is a process that requires large upfront and sustained investment that varies across regions and time (Figure F5). Currently, there is high uncertainty about prices, as well as macroeconomic and policy environments (IMF 2012a). The process of developing most mines generally has five major stages. It begins with exploration to establish the existence of a *potentially* commercially viable deposit. Once a deposit is confirmed, feasibility, environmental, and other impact studies are conducted, and financing plans are developed to establish commercial viability. Following confirmation of commercial viability, a mining license is obtained, which can take several years in some countries (on average, three years in Africa; Gajigo, Mutambatsere, and Ndiaye 2012). Finally, investments are made in constructing the physical facility, with the amount of time needed depending mainly on the accessibility of the deposit. All steps depend on the quality of governance, the reliability of institutions, and macroeconomic stability. Investment risks tend to be high in the exploration, pre-feasibility, and feasibility stages, and decline as a deposit gets closer to production.

While resource development tends to have lengthy lead times, there are differences across commodities and regions:

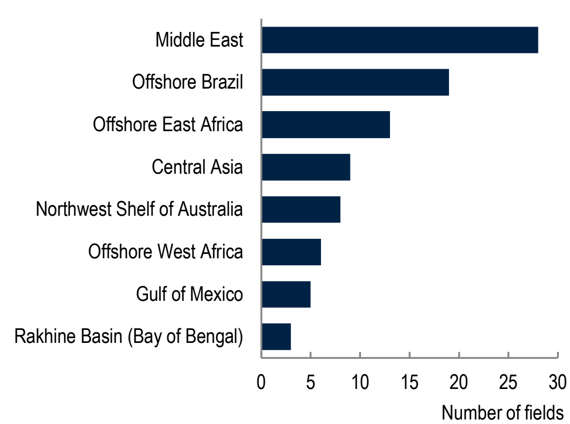
- *Oil and gas.* Conventional discoveries can take 30-40 years to develop (Clo 2000), but lead times for giant oil and gas discoveries can be shorter (Arezki, Ramey, and Sheng 2015). For oil deposits, such as shale, the lead times are much shorter (2-3 years), a reflection of technological improvements and reduced entry barriers for small, agile firms (Wang and Xue 2014, World Bank 2015a).[3] Monetizing discoveries in natural gas is harder than oil because the former require investment in transport infrastructure (in addition to drilling) as well as long-term contractual arrangements with end-users (Huurdeman 2014).
- *Mining.* The time to develop resources ranges from a few years to decades, depending on the type of mineral, the size and grade of the deposit, financing conditions, country factors, availability of key inputs like electricity, and commodity prices (UNECA 2011, Schodde 2014, World Bank 2015b). For example, resource development takes an average of ten years for gold but more than 15 years for base metals such as zinc, lead, copper, and nickel (Schodde 2014). Development of most gold deposits tends to begin immediately, whereas a significant share of copper discoveries takes several decades due to their

FIGURE F3 Mining exploration spending and discoveries during 2003-12



Source: MinEx Consulting.
Note: "Rest of World" includes Middle East, South West Asia (including India and Pakistan) and Mongolia.

FIGURE F4 Giant oil and gas discoveries during 2000-09



Source: Bai and Xu (2014).
Note: "Giant" fields are those with recoverable reserves of more than 500 million barrels of oil equivalent.

complexity and larger infrastructure investment to move ore to export ports (Figure F7).[4] Location has a major impact on processing. For instance, it is less costly to ship concentrates from Chile's copper mines due to their proximity to the sea, than, say, from Central Africa where, because of infrastructure impediments, it is more profitable to smelt and refine the ore locally in order to reduce the volumes transported to ports (Crowson 2011).

What are the main drivers of resource development?

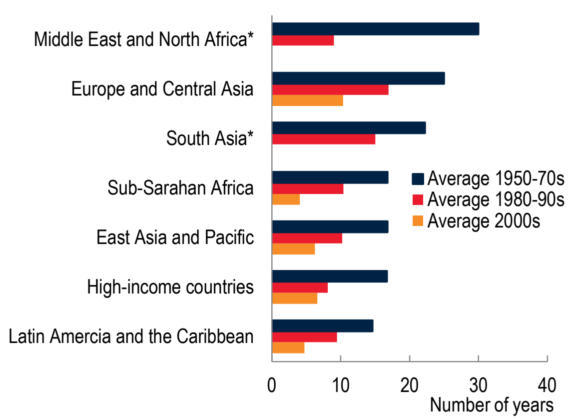
Surging resource exploration and development during the 2000s was driven by rising commodity prices (in part due to increasing scarcity and availability concerns), lower cost of capital, better technologies, and improved domestic policies and investment climates (Arbache and Page 2010). These factors varied by commodity and country over time, and remain important determinants of resource development in general, and lead times in particular.

Commodity prices. Between 2000 and 2010, real energy and metal prices doubled, real precious metal prices tripled, and real agricultural prices increased more than 60 percent. Surging prices stimulated a sharp increase in industry spending on exploration, investment, and production, including in many low-income countries and difficult-to-reach places.[5] For example, mining exploration expenditures in Africa reached an estimated $4.5 billion in 2012, up from just $0.3 billion in 2000 (UNECA 2011, Schodde 2014). Conversely, lower commodity prices have a negative impact on resource development. For example, the rig count in Africa and Latin America responded quickly to rising oil prices, but also declined sharply following the oil price plunge (Figure F6).

Cost of capital. Global mining, oil, and gas production has been dominated by large transnational companies, but the structure of the industry has changed over the past decade. Smaller, younger companies have emerged as risk takers at the forefront of exploration, whereas larger developers and operators tended to enter projects only after the discovery of deposits (UNECA 2011; Gelb, Kaiser, and Vinuela 2012). Spending by junior companies is primarily driven by the availability of funding, facilitated by favorable global financing conditions in recent years (Schodde 2013). In addition, China has emerged as a major source of exploration and development finance in Africa, broadening choices for governments in the region.

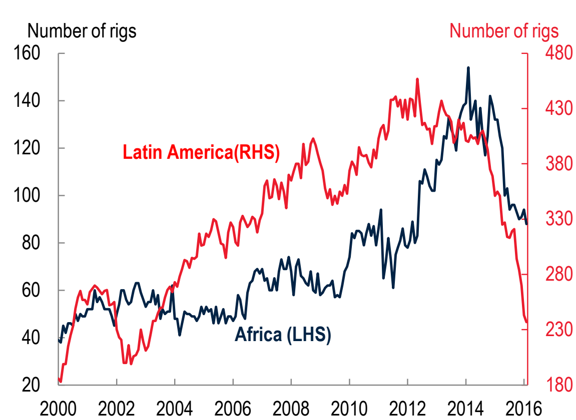
Technologies. Technological innovations have allowed extraction in previously inaccessible or less-developed regions (including deepwater). The development of large shipping carriers has reduced the cost of transporting bulk commodities such as iron ore, coal, and bauxite (ICMM 2012, Lusty and Gunn 2015). As a result, the location of production and exploration has increasingly shifted towards frontier regions such as Africa and the Arctic (ICMM 2012). Mining exploration in Sub-Saharan Africa has been particularly attractive because it is seen as a relatively unexplored frontier with low cost (African discoveries are found closer to the surface than anywhere else except Latin America). Africa had the largest discoveries per dollar of exploration cost during 2003–12; it accounted for 22 percent of discoveries but only 15 percent of global exploration expenditures (Schodde 2013).

FIGURE F5 Number of years from discovery to production for gold and copper



Source: http://pumpkinhollowcopper.com/project-timeline/.
Notes: Based on a sample of 46 countries with copper discoveries and 73 countries with gold discoveries. Regions refer to World Bank classification. (*) indicates that data is not available for 2000s.

FIGURE F6 Rig counts in Africa and Latin America



Source: Baker Hughes.
Note: Last observation is April 15, 2016.

Domestic conditions. The business environment for resource development has benefited from the moderation of conflict and internal political tensions (Central African Republic, Democratic Republic of Congo, Eritrea, Myanmar, and Rwanda) as well as strengthening of investment climate (Eritrea, Myanmar, and Rwanda). Improved macroeconomic policies, including easing of fiscal deficits and debt burdens, have also aided resource developments (World Bank 2015a, IMF 2014a). Anecdotal evidence suggests that lead times for exploration, discovery, investment, and production are shorter in countries with more conducive policy environments.

What are the implications of the decline in commodities prices for resource development?

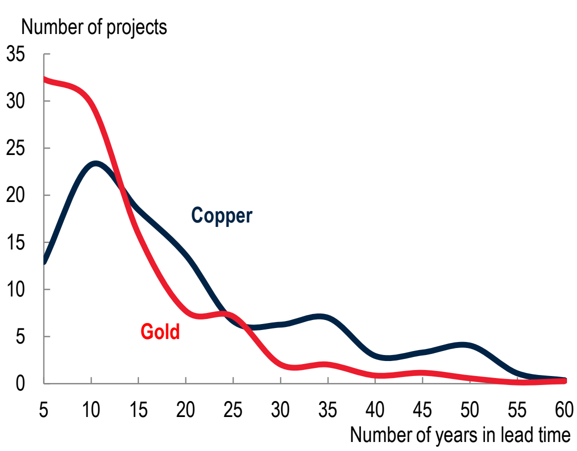
In the same way that high prices spurred activity in the resources sector, the sharp decline in commodity prices over the past few years may delay resource development. Lower commodity prices reduce the apparent commercial feasibility of marginal projects, and could slow the start of development after discovery (Schodde 2014). Once started, however, sunk costs may make mining companies reluctant to disrupt ongoing projects, particularly if development is already well advanced (McIntosh 2015, Crowson 2011).[6] In addition, other drivers like the accessibility and quality of the discovery, as well as the policy environment, play an important role. Larger discoveries that are closer to the surface and in more predictable policy environments appear to see faster development (World Bank 2015a).

A "duration analysis" has been developed to assess the relative importance of these drivers (Jenkins 2006, World Bank 2016). Based on a dataset of 273 copper discoveries in 46 countries and 687 gold discoveries in 73 countries during 1950-2015, the probability of a particular mine reaching production in any given year was examined.[7] Explanatory variables include real gold and copper prices and two indicators of the policy environment. A number of physical characteristics of the deposit were used as controls. The policy environment is proxied by the Worldwide Governance Indicators for Control of Corruption and by the Quality of Government Institute's Index of the Quality of Government. These proxies capture policy conditions that help avoid the "resource curse" – the macroeconomic volatility and stunted institutional development that often plague resource-based economies (Sachs and Warner 2001; Mehlum, Moene, and Torvik 2002; Humphreys, Sachs, and Stiglitz 2007).

Three key results emerge from the analysis.

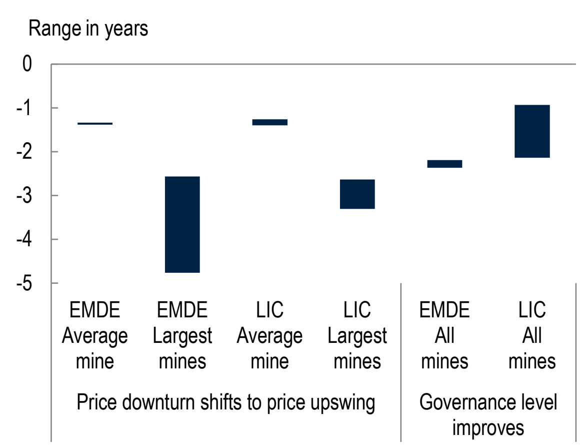
- ***Commodity prices.*** The findings on the role of commodity prices are mixed depending on the commodity. An upswing in copper prices at the time of discovery – the crucial period when licenses are obtained and exploration and extraction rights are negotiated – is found to accelerate development. For example, for the average copper deposit discovered in EMDEs since 2000, rising copper prices at the time of discovery may have shaved off more than a year from lead times. For an EMDE mine in the largest quartile, higher prices can reduce lead times by more than four years. Although mines in LICs tend to be smaller, high and rising prices reduced lead times for aver-

FIGURE F7 Distribution of discovery-to-production time



Source: http://pumpkinhollowcopper.com/project-timeline/.
Note: Number of discoveries for each number of years.

FIGURE F8 Reductions in lead times for copper mines under two scenarios



Source: http://pumpkinhollowcopper.com/project-timeline/.
Notes: The bars indicate a range of reduction in lead times. The governance scenarios are: EMDE governance level reaches that of Canada, and LIC governance level reaches that of Chile.

age sized copper mines by a year, and for their largest mines by more than three years (Figure F8, left panel).

- ***Governance.*** If the average EMDE had the same readings on the Quality of Government Index or Control of Corruption Index as Canada (the world's ninth largest copper producer), the lead times for the development of copper discoveries since 2000 might have been shortened by more than two years. Similarly, if the average low-income country had the same readings on these indexes as Chile (the world's largest copper producer), the lead time of the average copper mine since 2000 might have been shortened by one to two years (Figure F8, right panel).
- ***Macroeconomic policies.*** Lowering government debt below 40 percent of GDP, or reducing inflation below 10 percent, is found to accelerate development times by about 10 percent. Indeed, a more stable macroeconomic environment is typically associated with more predictable tax and expenditure decisions.

Extended lead times prolong the period of inflation, fiscal, and balance of payments vulnerabilities that are often associated with resource development, as governments and private sectors borrow and invest in anticipation of future income growth. Such vulnerabilities are especially sizeable in small, low-income countries where resource development accounts for a sizeable share of economic activity. In countries where resource development is still in initial stages, further delays may contain vulnerabilities and reduce the long-term risk of stranded assets (Stevens, Lahn, and Kooroshy 2015).

Conclusion

Given that resource development, production, and revenue streams take place over decades, with substantial sunk costs along the way, longer term commodity price prospects are critical in deciding whether to develop a discovery into production. In 2016, the outlook for an era of low commodity prices had already set back many resource development projects. Ambitious improvements in business climates along with better and more predictable macroeconomic policies will be needed to offset these headwinds to resource development. Governments seeking to develop natural resources may consider delaying new initiatives until the price outlook turns more favorable.

ANNEX TABLE Global metal, ore and hydrocarbon production

	Metals (million metric tons)						Energy (mb/d equivalent)		
	Bauxite	Copper	Lead	Nickel	Tin	Zinc	Coal	Gas	Oil
2000									
Africa	18.42	0.46	0.17	0.07	0.00	0.29	2.61	2.33	7.76
Asia	17.21	1.90	0.77	0.19	0.15	2.18	18.46	4.45	7.07
Europe	3.87	0.81	0.35	0.02	0.00	0.89	4.73	5.12	6.98
FSU	8.73	1.09	0.05	0.27	0.01	0.46	4.03	11.73	8.03
Latin America	36.17	5.70	0.45	0.16	0.06	1.67	0.79	2.51	10.11
Middle East	0.49	0.15	0.02	0.00	0.00	0.08	0.01	3.73	23.72
Oceania	53.80	1.04	0.68	0.30	0.01	1.42	3.38	0.56	0.82
US and Canada	0.20	2.07	0.60	0.19	0.00	1.83	12.18	13.19	10.44
Total	**138.89**	**13.21**	**3.08**	**1.19**	**0.23**	**8.82**	**46.20**	**43.62**	**74.93**
2014									
Africa	21.31	2.06	0.09	0.10	0.01	0.33	3.04	3.65	8.26
Asia	91.50	2.82	3.09	0.68	0.27	6.28	48.79	8.57	7.88
Europe	2.63	0.87	0.29	0.06	0.00	0.80	3.53	4.36	3.40
FSU	10.10	1.32	0.26	0.26	0.00	0.65	5.31	13.69	13.80
Latin America	53.12	8.07	0.67	0.22	0.06	2.74	1.44	4.20	10.40
Middle East	2.86	0.22	0.05	0.00	0.00	0.16	0.01	10.82	28.55
Oceania	78.63	1.04	0.73	0.44	0.01	1.56	5.67	1.00	0.45
US and Canada	0.13	2.08	0.39	0.24	0.00	1.18	10.89	16.28	15.94
Total	**260.29**	**18.48**	**5.56**	**2.01**	**0.35**	**13.71**	**78.67**	**62.55**	**88.67**
Change, 2000-14 (percent)	***87.4***	***39.9***	***80.5***	***68.9***	***52.2***	***55.4***	***70.3***	***43.4***	***18.3***

Source: BP Statistical Review, World Bureau of Metal Statistics.

Endnotes

1. This section draws from the following: World Bank (2015b, pp. 93-101, "After the Commodities Boom—What Next for Low-Income Countries," authored by Tehmina Khan and Gerard Kambou) and World Bank (2016, pp. 45-60, "From Commodity Discovery to Production: Vulnerabilities and Policies in LICs," authored by Tehmina Khan, Trang Nguyen, Franziska Ohnsorge and Richard Schodde).

2. Total foreign direct investment in agriculture and agribusiness in developing countries was estimated at $13 billion in 2006/07, with Africa receiving $1 billion.

3. The U.S. is by far the largest producer of oil and gas from shale formations, with smaller amounts coming from Canada, China, and Argentina (EIA 2013). A number of other countries possess relatively large shale oil reserves, and several have actively drilled these formations including Algeria, Australia, Columbia, Norway, Mexico, and Russia (IER 2015). Related, the U.S. shale oil industry turned out to be more resilient than originally anticipated following the post-2014 oil price collapse, a reflection of technological advances and lower input costs (Decker et al. 2016).

4. One-third of copper discoveries since 1950 have had lead times to eventual production of 30 or more years, compared with only 4.5 percent of gold discoveries. Similarly, industry estimates place the period from early exploration to final production of copper mines at close to 25 years (McIntosh 2015).

5. Average annual returns for the top ten global mining companies are estimated to have risen from $3 billion in 2005 to just under $8 billion in 2010 (UNECA 2011). Returns in the oil and gas sector are even larger, since country conditions matter less, transportation (including in unprocessed form) is easier, and the sector is less dependent on the conditions of infrastructure such as roads, railways, and power stations (UNECA 2013).

6. In general, the cost of delaying projects may be lower in the resource sector than in non-resource sectors due to a limited number of alternative feasible projects and heavy involvement of the state, which provides some insulation from political shocks (Crowson 2011).

7. The dataset, which is proprietary, was provided by MinEx Consulting.

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