SPECIAL FOCUS

From Commodity Discovery to Production: Vulnerabilities and Policies in LICs

Special Focus
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Major resource discoveries have transformed growth prospects for many LICs. The sharp downturn in commodity prices may delay the development of these discoveries into production. During the pre-production development process, macroeconomic vulnerabilities in these economies may widen as a result of large scale investment needs. This heightens the importance of reducing lead times between discovery and production. Over the medium term, lead times may be reduced by improved quality of governance. Growth has eased in LICs but continued to be robust at about 5 percent in 2015, sustained by public investment, rising farm output and continued mining investments. For 2016-17, strengthening import demand in major advanced economies should help support activity in these countries.

Introduction

The surge in commodity prices over the past decade has played a pivotal role in spurring faster growth in low-income countries (LICs). As industry exploration and investment spending climbed to record highs, a spate of commodity discoveries—notably "giant" oil and gas discoveries in East and West Africa—has transformed the long-term growth outlook in several countries (World Bank, 2015a and b).[1] Mining has expanded rapidly in many LICs in Sub-Saharan Africa over the past decade. For example, the number of active industrial gold mines reached historic highs by 2011 across Sub-Saharan Africa after half a decade of soaring gold prices (Tolonen 2015).

However, with the turn in the commodity supercycle, industry spending on investment has dropped sharply.[2] In Africa the number of oil rigs for on-land drilling has already fallen by 40 percent from their peak in Q1 2014 (Figure SF.1), and mining production has been disrupted in Sierra Leone and Democratic Republic of Congo (DRC). There are risks of delays in major mining and energy projects under development in East African LICs that could affect growth prospects. In Uganda, for instance, slower-than-anticipated infrastructure development has already delayed oil production start dates, from 2016 to as late as 2020. In Tanzania and Mozambique, final investment decisions on major LNG projects have yet to be made (Bennot, 2015).[3] In Afghanistan, investment plans for the development of copper and iron ore mines leased for development in 2008 and 2012 have been significantly scaled back.

Project delays are detrimental for several reasons. They prolong the period of heightened vulnerabilities associated with the pre-production investment and delay the boost to growth that is typically associated with production. Additional concerns arise in hydrocarbon projects where delays may increase the risk of "stranded assets" as global efforts to tackle climate change induce a shift towards less carbon-intensive technologies and greater energy efficiency (Stevens et. al. 2015, Carbon Tracker Initiative 2004, McGlade and Ekins 2015).[4] Such stranded assets pose financial and growth risks to the companies that own or operate them and the governments that back them.

Note: This Special Focus was prepared by Tehmina Khan, Trang Nguyen, Franziska Ohnsorge and Richard Schodde.

[1] "Giant" fields are conventional fields with recoverable reserves of 500 million barrels of oil equivalent or more. Despite the increasing importance of unconventional shale oil and gas fields, current and future oil and gas supply is dominated by conventional giant fields (Bai and Xu 2014).

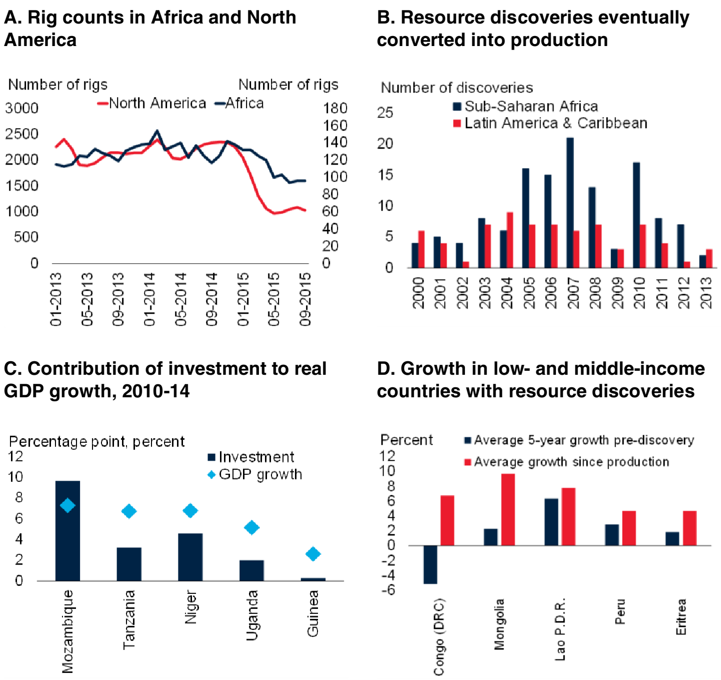
[2] The drop in industry investment has partly reflected growing concerns about misallocation of capital expenditures into exploration over the past decade (McIntosh, 2015).

[3] Coal projects in Mozambique are reportedly losing money, because of the slump in coal prices, and inadequate infrastructure (Almeida Santos, Roffarello, and Filipe 2015).

[4] "Stranded assets" refer to resource capacity, specifically for hydrocarbons (coal, oil, gas), that remains unused as the world reduces its hydrocarbon consumption in order to reduce risks arising from climate change (Carbon Tracker Initiative, 2004, McGlade and Ekins, 2015).

FIGURE SF.1 Prospects and risks from resource investment

Following a decade of major resource discoveries, the drop in oil prices raises concerns that long-planned investment to develop discoveries into production is delayed in low-income countries. This would set back growth.



Source: World Bank staff estimates, World Development Indicators, MinEx Consulting.
A. The rig count is the number of oil rigs in operation.
C. Contribution of investment in percentage point, GDP growth in percent.

This Special Focus discusses the evolution of macroeconomic vulnerabilities during the development of major resource discoveries, the impact of slowing commodity prices on development times, and policies to shorten these times. The analysis rests on a dataset for gold and copper discoveries worldwide since 1950 (proprietary to MinEx Consulting). Over this period, gold and copper discoveries have accounted for two-thirds of non-ferrous discoveries worldwide. The results shown here therefore are illustrative of the impact of policies and commodity prices on project development.

This Focus addresses the following issues:

- What are typical lead times between discovery and production?
- How do economies evolve between commodity discovery and production?
- What factors determine the lead time between discovery and production?
- What are growth prospects for LICs?

Lead times between discovery and production

Typically, developing a resource discovery requires large upfront investments, over a considerable period. During this time, there may be high uncertainty about prices and macroeconomic and policy environments (IMF, 2012a).

Broadly, the process of development of most mines undergoes five major stages. Since cross-country data is not publicly available, four of these stages are illustrated in Figure SF.2 for two copper mines, one in the United States and another in Mongolia. The process begins with exploration to establish the existence of a *potentially* commercially viable deposit (4-5 years in the two illustrative examples).[5] Once such a deposit is confirmed, feasibility, environmental and other impact studies are conducted and financing plans developed to establish commercial viability. Once commercial viability has been confirmed, a mining license is obtained, a process that can take several years in some countries (2-3 years, on average, in Africa; Gajigo et al. 2012). Finally, the duration of construction of the physical facility (3 years in the two illustrative examples) depends on the accessibility of the deposit.

All steps depend on the quality of governance, the reliability of institutions, and macroeconomic stability that facilitates predictable policies. Investment risks tend to be high in the exploration, pre-feasibility and feasibility stages, and decline as a deposit gets closer to production. Stylized facts on lead times by type of commodity and size of deposit are as follows:

- *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 et al. 2015). For oil deposits,

[5] In African LICs, the average duration of an exploration license is for three years (Gajigo et al. 2012).

such as shale, short lead times of 2-3 years reflect technological improvements since the 1980s, and reduced entry barriers for small, agile firms (Wang and Xue, 2014, World Bank 2015a). Monetizing gas discoveries is harder than oil discoveries: final markets are typically far away, so that simultaneous investments in drilling and transport infrastructure are required, and long-term price contracts need to be agreed with end-users (Huurdeman 2014)

- *Mining.* Lead times can range from a few years to decades, depending on the type of mineral, size and grade of the deposit, financing conditions, country factors and commodity prices (UNECA 2011, Schodde 2014).

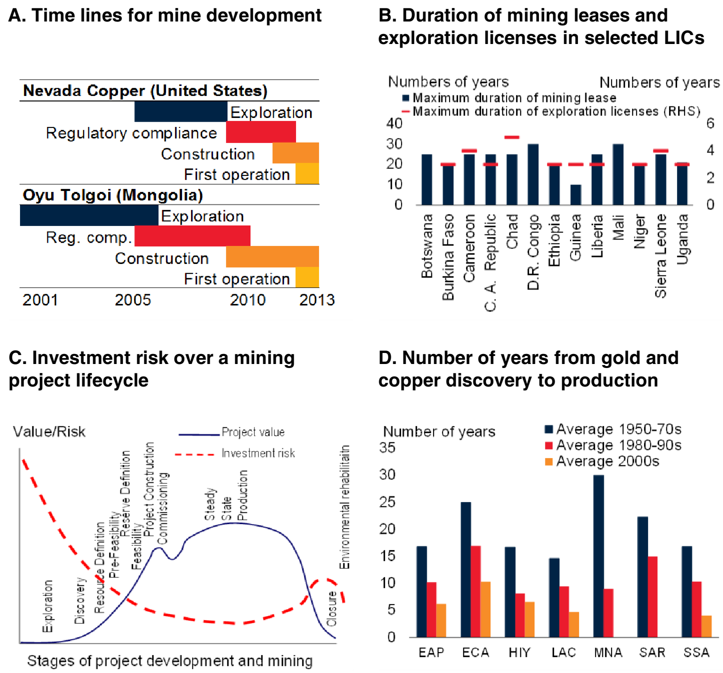
- *Copper mining versus other mining.* Average lead times for gold discoveries are ten years, but more than 15 years for zinc, lead, copper and nickel discoveries (Schodde 2014). Development of most gold deposits tends to begin immediately, whereas a significant share of copper discoveries takes several decades (Figure SF.4). For instance, 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). Longer lead times for copper mines reflect greater complexity and greater infrastructure investment to transport the ore to export markets.[6] Average lead times to production have fallen sharply in recent decades.

Evolution from commodity discovery to production

Resource discoveries matter to the economy only insofar as they can be developed into production. However, since 1950, less than 60 percent of gold, zinc and lead discoveries have made it to eventual production, and less than 40 percent of copper and nickel discoveries (Schodde, 2014). Once developed, the market value of discoveries can be large compared to the size of LIC and MIC economies. For copper mines, for example, production in 2014 alone accounted for 6 percent of LIC GDP and 2 percent of MIC GDP, on average (Figure SF.3).

FIGURE SF.2 The mining project cycle

Most mining projects are characterized by several key stages that include exploration, discovery, feasibility assessments and regulatory compliance (including obtaining licenses), project construction, production and eventually closure.



Source: World Bank, Perott-Humphrey (2011); Gajigo et. al. (2012); http://ot.mn/history, http://pumpkinhollowcopper.com/project-timeline/, both accessed November 4, 2015.
A. Illustrative example of timeline from two copper mines, in the United States and Mongolia. Exploration is not included in lead times discussed in the text.
D. Based on a sample of 46 countries with copper discoveries and 73 countries with gold discoveries. SST denotes Sub-Saharan Africa. EAP = East Asia and Pacific; ECA = Europe and Central Asia; HIY = High-income countries; LAC = Latin America and the Caribbean; MNA = Middle East and Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

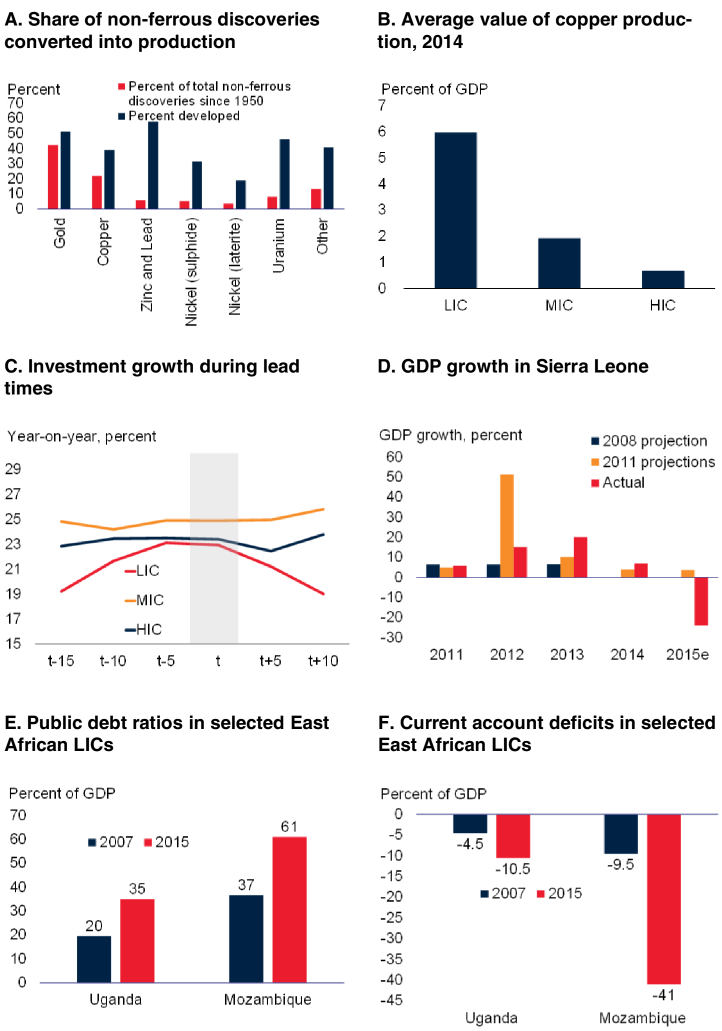
Depending on the commodity and the size of discovery, during the lead time between commodity recovery and extraction, countries can accumulate sizeable vulnerabilities as investment rises and external liabilities grow.[7] In the dataset used here, investment growth increased sharply in

[6] For instance, the location of Chile's copper mines close to the sea has made it easier to profitably ship concentrates, whereas copper mines in central Africa have had to rely on local smelting and refining to reduce the volumes transported to ports (Crowson, 2011).

[7] An event study of macroeconomic developments between discovery and production of copper deposits illustrates the domestic demand pressures that can prevail during these lead times. In a panel regression, inflation, import growth and the current account deficit were regressed on a dummy variable that takes the value of 1 during

FIGURE SF.3 Developments during lead times between resource discovery and extraction

Gold and copper discoveries have been sizeable compared to the size of LIC and MIC economies. However, a significant portion of discoveries never get developed. Between resource discovery and production, investment growth rises sharply and vulnerabilities can increase. Growth can become vulnerable to setbacks in mining sectors.



Source: World Development Indicators, World Economic Outlook, MINEX Consulting, World Bank staff estimates., World Bank Commodity Markets Outlook World Bank (2015d).
A. C. LIC stands for low-income countries, MIC for middle-income countries, and HIC for high-income countries.
B. Annual copper production evaluated at average 2014 price in percent of GDP (World Bank 2015a).
C. Based on a sample of 46 countries with copper discoveries and 73 countries with gold discoveries.
D. IMF projections for GDP growth in Sierra Leone, which discovered major iron-ore deposits in 2009.

the five years that precede the beginning of production. Time and country dummies control for global and country-specific factors. The sample period is 1980-2014. The estimates suggest that on average, lead-time investment associated with resource development contributed to an increase in inflation of 9 percentage points, and of import growth by 1 percentage point. The estimates were somewhat larger for copper than other mineral discoveries. Current account deficits were 3.6 percentage points of GDP wider. These estimated effects were particularly pronounced in LICs: inflation was 14.5 percentage points higher during these episodes and current account deficits 4.3 percentage point of GDP wider.

the five to ten years before actual extraction of the resource began (Figure SF.3). This effect was only apparent in low-income countries. Since they tend to be smaller and less diversified than middle- and high-income countries, the development of a large mine can create significant domestic demand pressures. Using a global database on giant oil discoveries (those exceeding ultimately recoverable reserves of 500 million barrels), including in Africa, Arezki et. al. (2015a) find that investment growth rises immediately upon discovery and current account deficits widen. GDP growth and private consumption growth respond only once extraction begins. The full increase in GDP growth materializes with commercial production, when vulnerabilities unwind as exports expand.

The size of vulnerabilities depends on two factors: how mine construction is financed, whether governments borrow in anticipation of rising commodity revenues in the future, and whether private consumption and investment rises in anticipation of rising incomes. If rising imports and current account deficits are financed by FDI, which tends to be less prone to sudden stops than debt financing, short-term vulnerabilities are more limited (Levchenko and Mauro 2008). Nevertheless, a sudden stop in FDI projects could also disrupt foreign exchange markets and sharply dampen activity. In particular, expectations of greater FDI (including as a result of recent natural resource discoveries) can encourage long-maturity non-resource investment projects. If these expectations are not validated, a sudden stop could follow and trigger fire sales of long-term assets and a collapse in activity (Calvo 2014). Additional, fiscal risks arise if governments expand spending and borrow against future commodity revenues.

The following examples illustrate the heightened vulnerabilities associated with lead times in a number of LICs.

- *Sierra Leone:* The discovery of major iron-ore deposits in 2009 led to a substantial upward revision in growth forecasts to over 50 percent in 2012 as mining production came onstream. However, work stoppages and a breakdown in the railway system delayed the start of the mine, so that actual growth results were much lower than initial projections. Since then, a collapse in global iron ore prices by 50 percent in 2014 has led to severe financial difficulties at the country's two foreign-owned and highly indebted mining operators, with one declaring bankruptcy and the other halting operations (World Bank 2015e, IMF 2012b and 2015a). This and the outbreak of the Ebola epidemic set back activity, with the economy estimated to have contracted by 20 percent in 2015.

- *Uganda:* Oil was discovered in 2006. Although production has yet to start, the government has borrowed in anticipation of future oil revenues. The public debt ratio has nearly doubled since 2007, reflecting loans from Chinese state banks and other lenders to finance large hydropower and other infrastructure projects. With production dates being postponed, infrastructure projects affected by cost overruns, and the current account deficit reaching over 10 percent of GDP in 2015, fiscal risks and external financing risks have increased (World Bank 2015f).

- *Mozambique.* The discovery of massive gas deposits in 2012 has lifted medium to long-term growth prospects. However, the sharp fall in oil and gas prices since 2014, delays in mining infrastructure projects and highly expansionary fiscal policies are generating major short-term challenges. Public debt ratios have risen sharply from 2007, to finance government infrastructure spending. But with finances under pressure, the country has turned to the IMF for a potential loan program (IMF 2015b).

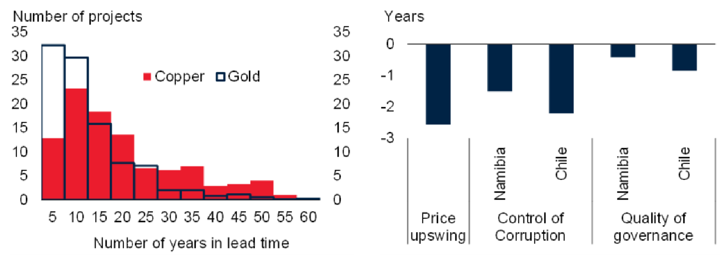
Determinants of the lead time

Lead times to production depend on a wide range of technical, economic, social, and political factors. They include the accessibility and quality of the discovery, commodity prices, and policy environments. Larger discoveries closer to the surface in more predictable policy environments appear to see faster development (World Bank 2015a). Higher commodity prices increase the feasibility of marginal projects, and could

FIGURE SF.4 Lead times between resource discovery and extraction

Lead times between discovery and production are considerably longer for copper deposits than gold deposits, especially when commodity prices are low. However, they can be shortened by improving business environments.

A. Time from discovery to production **B. Scenarios: Reductions in lead times for copper mines**



Source: World Bank staff calculations, MinEx Consulting.
A. Number of discoveries for each number of years.
B. Reduction in average lead times for average LIC mine if price downturn shifts to price upswing, if control of corruption is improved to the level of Chile or Namibia, or if quality of governance was improved to the level of Chile or Namibia. Derived from differences in predicted values predicted by a duration model described in Annex SF.1. "Price upswings" denotes reductions in lead times for the largest quartile of copper discoveries in LIC since 2000 as a result of switching from a commodity price downturn to an upswing. Reductions in other variables for the same mines as a result of raising control of corruption and quality of governance to average levels prevailing in Namibia and Chile.

accelerate 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).[8]

A duration analysis helps assess the relative importance of these factors, using a proprietary dataset for the years 1950-2015 provided by MinEx Consulting. It comprises 273 copper discoveries in 46 countries, and 687 gold discoveries in 73 countries. The methodology is a standard survival analysis (Jenkins 2006, Annex SF.1) to estimate the probability of a particular mine reaching production in any given year. Explanatory variables are global gold and copper prices (World Bank 2015d), and the policy environment at the time of discovery, controlling for the physical characteristics of the deposit.

A "good" policy environment conducive for

[8]In general, the option value of delaying project completion 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).

resource investment—as well as non-resource investment—has many dimensions. It includes sound macroeconomic policies that ensure sustainable fiscal positions (as measured by government debt in percent of GDP at the time of discovery), and domestic demand pressures (as proxied by inflation at the time of discovery). A more stable macroeconomic environment can be associated with more predictable tax and expenditure decisions. A conducive policy environment also includes high quality of institutions, at the time of the discovery, that affect mining operations. This is proxied by the World Bank Governance Indicators for Control of Corruption and by the QOG Institute's Index of the Quality of Government.[9] These are some of the same conditions that would help avoid the macroeconomic volatility and stunted growth in resource-based economies that has been labelled the "resource curse" (Sachs and Warner 2001; Mehlum, Moene and Torvik 2002; Humphreys, Sachs and Stiglitz 2007).

The results suggest an important role for the commodity price cycle, sound macroeconomic management and the quality of governance. Higher commodity prices, on average, are not significant determinants of lead times, probably because of the significant sunk costs involved. However, for copper deposits, an upswing in copper prices at the time of discovery—the crucial period when licenses are obtained and exploration and extraction rights negotiated—accelerates development. For example, in LICs since 2000, rising copper prices at the time of discovery may have shaved off about two to three years from lead times. For the largest quartile of copper discoveries in LICs since 2000, the price boom may have reduced lead times by 2½ years (Figure SF.4). Sound macroeconomic policies also appear to be important: lowering government debt below 40 percent of GDP, or reducing inflation below 10 percent, accelerates development times by about 10 percent. These variables may proxy for generally sounder and more predictable macroeconomic policies.

While lower commodity prices could lengthen lead times for copper mines, their effects can be mitigated by strengthened policies. Had the average LIC had the same quality of government index or the same control of corruption index as Chile or Namibia, the lead times for the development of copper discoveries since 2000 might have been shortened by as much as two years (Figure SF.4).

Policy Implications

Many low-income countries remain at the frontier of resource exploration and they are expected to be a major source of commodity supplies over the long-term (ICMM, 2012). Under the right conditions, new resource production should boost their exports and growth. With fiscal institutions in place to manage the volatility of resource revenues (World Bank 2015a), new resource production could provide a major opportunity for development over the medium to long term.

However, the sharp drop in commodity prices since 2014 is already affecting resource sector investments and could further delay the development of discoveries in several LICs. This, in turn, could prolong vulnerabilities—inflation, fiscal and balance of payments pressures—often associated with resource development as governments and private sectors borrow and invest in anticipation of future income growth. For the largest deposits, a price downturn in the early stages of development, when licenses and extraction rights are negotiated, could potentially delay development by a few years, which could be critical for some LICs with growing fiscal and current account pressures.

Countries, in which resource development is still in initial stages, could consider accepting further delays to contain vulnerabilities and reduce the long-term risk of stranded assets (Steven et. al. 2015). Where development is already far advanced, this option may be unattractive. In these countries, especially, improvements in business environments could offset some of the

[9]The importance of the policy environment is also borne out in anecdotal evidence. For instance, the Oyu Tolgoi mine in Mongolia—despite being one of the largest copper deposits in the world—took nearly a decade to become operational in 2013, following initial exploration in the early 2000s, lengthy feasibility studies and negotiations between the government and Rio Tinto over the financing of the mine's construction.

price pressures on resource development. At the same time, they would benefit non-resource investment and help reduce macroeconomic vulnerabilities (Loayza and Raddatz 2007). Other means of expediting resource developments are likely to be less helpful in the long-run, including increased tax incentives for mining companies. Mining companies have reportedly often negotiated tax exemptions that go above provisions specified in enacted legislation and are higher than warranted by mine profits (Curtis et al. 2009; Gajigo et al. 2012).

Recent developments and near-term outlook in low-income countries

Growth in low-income economies (LICs) eased during 2015, reflecting headwinds from falling commodity prices and security and political tensions (Figure SF.5, Table SF.1). Nevertheless, on average, growth has remained solid at 5.1 percent.

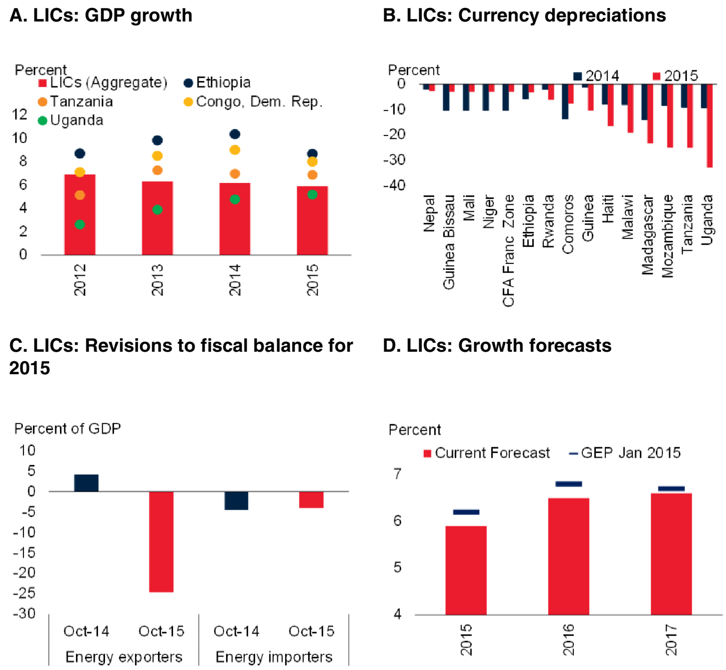
Growth was particularly strong in several of the largest LICs, sustained by public investment, rising farm output and continued mining investments.[10] In oil-importers, including Ethiopia and Rwanda, low commodity prices supported activity. In Ethiopia, the largest LIC economy, growth of 10.2 percent in 2015 was also lifted by good harvests, rising public investment and booming manufacturing and construction. Even in several metal and mineral resource-rich LICs, activity has thus far been resilient despite the commodity price decline, as development of major mining and gas projects has continued (Tanzania, Mozambique, Uganda). Growth in these countries ranged between 5-7 percent during 2015.

In other commodity-exporting countries, in contrast, the fall in commodity prices led to outright disruptions in production. Sierra Leone's economy, already hit hard by Ebola in 2014, is estimated to have contracted by a fifth during 2015 due to the closure of mining operations at

[10]Strong growth over the past few years has lifted four LIC countries (Bangladesh, Kenya, Myanmar and Tajikistan) to middle income status.

FIGURE SF.5 Growth prospects in LICs

Growth remains supported by strong outturns in the largest LICs. However the fall in commodity prices is taking a toll on commodity exporters. Risks lie on the downside.



Source: World Bank World Development Indicators, IMF, World Economic Outlook.
B. A negative value indicates depreciation.
D. "GEP Jan 2015" indicated forecasts published in the January 2015 Global Economic Prospects (World Bank 2015a).

Tonkolili (the second largest iron ore mine in Africa) after its operator when bankrupt. Copper production in the Democratic Republic of Congo has been hit hard, following the suspension of copper and cobalt production at the Katanga Mining unit by Glencore, its mining operator, amid declining profitability and a slump in copper prices to a six-year low. In Afghanistan, large investments associated with the award of copper and iron-ore mining projects have failed to materialize – partly due to unsettled domestic security and political conditions, but also due to the fall in global commodity prices – weighing on sentiment and outlook, and resulting in a downward revision in medium term growth prospects. Monetary tightening has further weighed on growth as policy makers responded to sharp depreciations by lifting interest rates (Uganda) or drawing down reserves (Burundi, Tanzania, Dem. Rep. of Congo, Zimbabwe and Mozambique).

In several LICs, political and social tensions are taking a toll on economic activity. In Afghanistan, growth has slowed as a result of continued political uncertainty and increase in violence, amidst a drawdown in NATO troops. In Nepal, the estimated value of damage from the earthquakes in April-May 2015 amounts to a third of GDP. Since the earthquakes, domestic tensions due to a new constitution, and severe fuel shortages resulting from the closure of land trading routes through India have further weighed on activity. Political tensions remain elevated in several LICs in Sub-Saharan Africa, as a result of insurgencies or unsettled political conditions (Burkina Faso, Burundi, Chad, Niger), upcoming elections (Benin), or labor disputes (Sierra Leone, Niger). This has increased uncertainty and weighed on activity.

Fiscal and current account deficits have widened in most countries. Falling commodity prices (commodity exporters), political tensions (Burundi), or uneven policy direction (The Gambia) have weakened export and fiscal revenues. In several countries, however, large current account and/or public sector deficits reflect rising infrastructure spending or the construction of mining projects that should support potential growth over the medium term. In Ethiopia for instance, the current account deficit has remained relatively well funded by FDI, as is also the case in Mozambique and Tanzania, while aid inflows have been important in Rwanda.

While lower global oil prices have kept inflation pressures muted in some oil importers (Afghanistan, Benin, Rwanda), inflation has remained high in several other countries due to limited spare capacity (Ethiopia); large currency depreciations over the past year (commodity exporting LICs) and those where political and social tensions remain high. Nepal has also seen a sharp acceleration in essential food and fuel prices, due to the severe disruption in trade through India.

For 2016-18, growth in LICs is expected to remain resilient at above 6 percent, on aggregate. Strengthening import demand in the U.S. and Euro Area, which are key trading partners for West African countries, should help support activity in these countries. Large-scale investment projects in mining, energy and transport, consumer spending, and public investment should help keep growth upwards of 7 percent in Ethiopia, Mozambique, Rwanda, and Tanzania. Improvements in electricity supply in Ethiopia and Rwanda but particularly in Guinea—where supply has doubled with the start of production from the Kaleta dam in 2015—will also support activity, but a shortage of power is expected to remain a drag in Benin and Madagascar. The growth outlook remains weak, and only a gradual recovery is projected due to persistent political tensions in Haiti, Burundi, Benin, Guinea Bissau, Burkina Faso, Nepal and Afghanistan.

Risks to the outlook are mainly tilted on the downside. These include:

- *Further weakness in global commodity prices* could require sharper fiscal adjustments in commodity exporters. Several countries have limited reserve buffers to stem depreciation pressures to contain financial stability risks and inflation. Lower commodity prices and high expected investment costs also increase the risk of a delay of investments in energy and mining in East African countries that would weigh on medium-term prospects.

- *Fiscal risks* are elevated in some countries, relating to large infrastructure projects, Public -Private Partnerships, and contingent liabilities (Mauro et. al. 2015). Countries where government debt has risen rapidly in recent years, such as Uganda, to finance mining infrastructure, may find it harder to service debt if production start dates for oil projects are delayed further. Inconsistent and poor macroeconomic management has been accompanied by sizeable fiscal slippages in The Gambia. As a result of growing fiscal pressures from the drop in commodity prices and contingent liabilities in state-owned enterprises, which required government support in 2015, considerable risks remain in Mozambique and have led it into negotiations with the IMF for a fiscal support program (IMF, 2015b).

- *Political risks* could deter domestic and foreign investment in some countries, weigh on tourism, and add to fiscal pressures. Fragmented political situations could also undermine the ability of governments to undertake and implement needed policies.

One-third of the world's poor are located in LIC countries (World Bank 2015c).[11] Their growth prospects are therefore key to reducing global poverty. A robust policy environment can strengthen growth to levels that can make a clear dent in poverty. For commodity-exporting LICs, this includes policies that ensure that the growth potential from natural resources is used effectively: reducing regulatory hurdles, clarifying legislation and strengthening infrastructure.

[11] There remain bright spots among LICs, notably Rwanda: the country is on track to meet all of its Millennium Development Goals, and some 650,000 Rwandans have been lifted out of poverty since 2011.

Table SF.1 Low Income country forecasts[a]
(Annual percent change unless indicated otherwise)

	2013	2014	2015e	2016f	2017f	2018f	2015e	2016f	2017f
							(percentage point difference from June 2015 projections)		
Low Income Country, GDP[b]	6.4	6.1	5.1	6.2	6.6	6.6	-0.7	-0.1	0.1
Afghanistan	2.0	1.3	1.9	3.1	3.9	5.0	-0.6	-1.9	-1.2
Benin	5.6	5.4	5.7	5.3	5.1	5.1	1.1	0.7	0.4
Burkina Faso	6.7	4.0	4.4	6.0	7.0	7.0	-0.6	-0.2	0.5
Burundi	4.6	4.7	-2.3	3.5	4.8	4.8	-7.1	-1.5	-0.4
Cambodia	7.4	7.0	6.9	6.9	6.8	6.8	0.0	0.0	0.0
Chad	5.7	7.3	4.1	4.9	6.1	6.5	-4.9	0.2	0.5
Comoros	3.5	3.0	2.3	2.5	3.1	3.1	-1.1	-1.2	-0.7
Congo, Dem. Rep.	8.5	9.0	8.0	8.6	9.0	9.0	0.0	0.1	0.0
Eritrea	1.3	1.7	0.9	2.0	2.2	2.2	-0.6	0.0	0.0
Ethiopia[c]	10.5	9.9	10.2	10.2	9.0	9.0	0.7	-0.3	0.5
Gambia, The	4.8	-0.2	4.0	4.5	5.3	5.3	1.0	-0.6	-0.8
Guinea	2.3	-0.3	0.4	3.5	4.0	4.2	0.7	1.2	1.5
Guinea-Bissau	0.3	2.5	4.4	4.9	5.3	5.3	0.2	1.0	1.3
Haiti[c]	4.2	2.7	1.7	2.5	2.8	3.0	0.0	-0.7	-0.3
Liberia	8.7	1.0	3.0	5.7	6.8	6.8	..	..	..
Madagascar	2.4	3.0	3.2	3.4	3.6	3.6	-1.4	-1.4	-1.4
Malawi	5.2	5.7	2.8	5.0	5.8	5.8	-2.3	-0.6	-0.1
Mali	1.7	7.2	5.0	5.0	5.0	5.0	-0.6	-0.1	-0.2
Mozambique	7.3	7.4	6.3	6.5	7.2	7.2	-0.9	-0.8	-0.1
Nepal[c]	4.1	5.4	3.4	1.7	5.8	4.5	-0.8	-2.8	0.3
Niger	4.6	6.9	4.4	5.3	9.3	5.7	-0.1	-0.2	1.6
Rwanda	4.7	7.0	7.4	7.6	7.6	7.6	0.4	0.6	0.1
Sierra Leone	20.1	7.0	-20.0	6.6	5.3	5.3	-7.2	-1.8	-3.6
South Sudan	13.1	3.4	-5.3	3.5	7.0	7.0	..	..	..
Tanzania	7.3	7.0	7.2	7.2	7.1	7.1	0.0	0.1	0.0
Togo	5.1	5.7	5.1	4.9	4.7	4.7	0.0	0.0	0.0
Uganda[c]	3.6	4.0	5.0	5.0	5.8	5.8	-0.5	-0.7	0.0
Zimbabwe	4.5	3.2	1.0	2.8	3.0	3.0	0.0	0.3	-0.5

Source: World Bank.
World Bank forecasts are frequently updated based on new information and changing (global) circumstances. Consequently, projections presented here may differ from those contained in other Bank documents, even if basic assessments of countries' prospects do not significantly differ at any given moment in time.
a. Central African Rep., Democratic People's Republic of Korea, and Somalia are not forecast due to data limitations.
b. GDP at market prices and expenditure components are measured in constant 2010 U.S. dollars.
c. GDP growth based on fiscal year data.

Annex SF.1

The duration model used in the multivariate analysis is a standard accelerated-failure-time (AFT) model (Jenkins, 2006), based on the gamma distribution. In AFT models, the natural logarithm of the survival time, log t, is expressed as a linear function of the covariates, yielding the linear model:

$$\log t_j = x_j \beta + z_j$$

where x_j is a vector of covariates and β is a vector of regression coefficients. The choice of z_j determines the regression method. Here, and based on the Akaike Information Criterion to evaluate the best fit across types of distributions, the standard generalized Gamma distribution appears to be most appropriate.

The effects of the explanatory variables on the baseline are given by time ratios (the exponentiated coefficients). These are reported below for each explanatory variable. The magnitude of these time ratios denotes the factor by which the expected lead time to production would be shortened or lengthened by a one-unit change in a variable. A one-unit change in the variable changes the time scale by a factor of $\exp(x_j \ \beta)$. Depending on whether this factor is greater or less than 1, time is either accelerated or decelerated. That is, if a subject at baseline experiences a probability of survival past time t equal to $S(t)$, then a subject with covariates x_j would have probability of survival past time t equal to $S(t)$ evaluated at the point $\exp(x_j \ \beta)t$, instead.[12]

The main explanatory variables x_i are measures for commodity prices (an indicator if prices are rising at time of discovery and the price change between discovery and production); indicators of macro policy environment (dummies if public debt ratios are greater than 40 percent and inflation rates higher than 10 percent); and measures for governance, including the QOG Institute's ICRG Index of Quality of Governance, and the World Bank Governance Indicator for control of corruption (Dahlberg et al 2015).[13] By choosing all these explanatory variables at the time of discovery, i.e. before the lead time begins, concerns about reverse causality are attenuated.[14] Given that data on some of these variables (in particular, the governance variables) is not available for much of the 1980s (QOG) or the mid-1990s (governance indicator), the earliest values are taken to indicate the quality of governance for discoveries that occurred prior to those dates. Control variables are the logarithm of the size of the discoveries, a dummy variable for copper deposits, and dummy variables for middle-income and low-income countries. In the absence of mine specific information on the depth of the deposit and in light of the changing depth over time as deposits get depleted, it is not possible to control for this factor directly. Country dummies proxy for unobserved characteristics like the landlocked nature of the country. In addition, regression results are robust to the use of decadal dummies which could help control for the decelerating time to production since the 1950s (See Annex Table SF.1).

The regression in Column (1) shows that expected times to production are nearly twice as long for copper deposits, and similarly 30-40 percent higher in MIC and LIC countries. High levels of debt and inflation expand the lead times to production. Column (2) shows that high levels of debt and inflation lengthen the lead time to production by 16 and 8 percent respectively. The commodity price cycle measure is not statistically significant, but interacted with copper mine size, shows that copper mines tend to get developed faster when commodity prices are rising.[15] Governance variables indicate that when governance improves (indicated by higher values

[12]Ideally, the regression would have taken into account the selection bias of mines that have been discovered but are not being developed. However, such data is not available.

[13]The QOG Institute's ICRG Index of Quality of Governance is the mean of the ICRG indices of corruption, bureaucracy quality, and law and order.

[14]Prices are evaluated relative to peaks and trough, defined as in Harding and Pagan (2002). Higher values of the quality of governance and control of corruption reflect better governance.

[15]A similar interaction for the price change between discovery and production is not significant.

of the corruption index), expected times to production fall by nearly 10 percent. The quality of government index is not statistically significant on its own, but when interacted with the variable indicating a copper deposit, shows that times to production fall by nearly 30 percent when governance improves.

ANNEX TABLE SF.1 Duration regression of lead times

	Column (1)	Column (2)	Column (3)	Column (4)
Log(size of deposit, mt cu)	1.000	1.000	1.010	1.010
	0.770	0.900	0.660	0.610
Copper	1.74***	1.72***	1.74***	2.29***
	0.000	0.000	0.000	0.000
Comm. price upswing at discovery	0.940	0.950	0.950	0.990
	0.160	0.270	0.290	0.860
Comm. price upswing x Copper mine Size	0.91**	0.92*	0.930 †	0.910 †
	0.040	0.070	0.130	0.100
Comm. price change during lead time to production	1.00***	1.00***	1.00***	
	0.000	0.000	0.000	
LIC	1.33***	1.25***	1.020	1.260 †
	0.000	0.000	0.850	0.120
MIC	1.42***	1.33***	1.11	1.55***
	0.000	0.000	0.290	0.000
Debt>40%		1.16***	1.16***	1.38***
		0.000	0.000	0.000
Inflation>10%		1.080	1.080 †	1.010
		0.160	0.150	0.920
Corruption			0.92**	
			-0.020	
Quality of government				1.120
				0.630
Copper x Quality of government				0.710 †
				0.140
Non-linear interaction terms				
Comm. price upswing x Copper mine size + Comm. price upswing	0.85**	0.87**	0.89**	0.9 †
Copper x Quality of government + Quality of government				0.79
Kappa	0.92	0.88	0.86	0.49
N	948	948	943	921
Log Likelihood	-1080.04	-1072.31	-1059.94	-1166.18
Akaike Information Criterion	2180.09	2168.61	2145.88	2358.36

Note: P-values are given below coefficient estimates. † indicates statistical significance at 15%, * at 10%, ** at 5%, *** at 1%. The Pagan-Harding measure of commodity prices is based on the Pagan-Harding algorithm (2002) which identifies turning points in a times series as local minima and maxima. These are used to identify up-cycles (when gold and copper prices are rising). Higher values of the Corruption indicator correspond to better outcomes (i.e. lower corruption) as do higher values of the ICRG Quality of Government indicator. As interaction terms are non-linear, the combined impact of these is shown separately.

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