The coal mining sector in Mozambique: a simple mode of predicting government revenue

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Conference Paper nº 19

III CONFERÊNCIA INTERNACIONAL DO IESE

"MOÇAMBIQUE: ACUMULAÇÃO E TRANSFORMAÇÃO EM CONTEXTO DE CRISE INTERNACIONAL"

(4 & 5 de Setembro de 2012)

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1. Introduction

Mozambique is on the verge of an economic revolution: two decades after the end of the civil war, with the start of large-scale coal production and the discovery of large natural gas deposits, it is now beginning to exploit fully its vast mineral potential. In a country in which almost 80% of the population works in agriculture (Third National Poverty Assessment, 2010), the rapid expansion of the extractive industries sector is likely to radically change the Mozambican economic landscape. Such resources present huge opportunities for development, but also risks, as illustrated in the literature on natural resource curses (such as Sachs and Warner, 1997, or Collier and Goderis, 2007). Government intervention has a large role to play in maximising the potential benefits of these resources through appropriate management of large new sources of revenue, helping to foment linkages between the mining sector and the rest of the economy to increase its multiplier effect, managing the almost inevitable pressure on the real exchange rate and avoiding rising inequalities.

In order for government to act appropriately, and even if specific values are difficult to estimate, it is important to develop a sense of the expected order of magnitude of extractive industries on the Mozambican economy, as well as some of the wider impacts Mozambique might expect. Natural gas is still being discovered, and it is very early to make projections as to its impact; this paper will focus mainly on the coal industry, where production of some of the main mines has already started. A simple, user-friendly model will be put forward in order to project production levels and potential government revenue - the impact of transport capacity in particular will be emphasised. We will then analyse other possible benefits to the Mozambican economy in terms of direct job creation, as well as other developments resulting from the coal industry, such as new railways, new coal power stations, and possibly coke and steel production. This paper will finish with a more conceptual discussion surrounding broader risks associated with what has been dubbed the natural resource "curse" afflicting many resource-rich countries, and possible broad options for government on how to manage the large surge in revenue to be expected from natural resources.

2. Context

Table 1: Evolution of the Mozambican economy:

	Unit	1996	2000	2005	2010
GDP (constant 2000 USD)	USD Millions	3,242	4,183	6,579	9,481
GDP per capita (constant 2000 US$)	USD	200	236	336	439
General government revenue	USD Millions	516	917	1,324	2,814
Exports of goods and services	USD Millions	228	381	2,153	3,560
Exports of fisheries and seafood	*Percentage of total*	*34%*	*30%*	*5%*	*2%*
Exports of aluminium products	*Percentage of total*	*0%*	*8%*	*60%*	*49%*
Exports of mineral fuels (including natural gas)	*Percentage of total*	*0%*	*6%*	*15%*	*17%*
Imports of goods and services	USD Millions	945	1,238	2,317	4,855
Poverty rate	Headcount	69.4%	69.4%	54.1%	54.7%

Sources: IMF, UN Comtrade, IAF 96/97, IAF 02/03 and IOF 08/09

Mozambique has undergone a relatively rapid economic transition since the end of the civil war in 1992: as we can see in the table above, GDP has been multiplied by about 3, whilst exports have increased by more than 15 times and imports about 5 times. This GDP growth of about 8% on average was marked in

particular with the completion of large scale projects, such as the Mozal aluminium smelter in 1999 and the extraction of natural gas in Pande and Temane by Sasol in 2004. These changed the structure of Mozambique's production: as we can see, whilst fisheries were the largest export sector up to the late 90s, they have since been dwarfed by exports of aluminium and natural gas. In parallel, consumption poverty rates declined from 69.4% in 1996/97 to 54.1% in 2002/03, but have stagnated since, according to the National Poverty Assessments conducted in those years and in 2008/09. Whilst such measures may not give a complete picture of the poverty situation in Mozambique, and large amounts of investments in public services may have changed the quality of life of people in ways which are not quantified in these statistics, they may indicate that large-scale, capital intensive projects with few linkages with the rest of the economy may not have as much impact on poverty reduction as on GDP growth.

The last few years have seen an increasing number of natural resources discoveries soon followed by new mining projects. Prominent amongst these are the various coal mining projects, which, led by Vale and Rio Tinto, are likely to have a profound impact on the Mozambican economy, as explained in more detail further. Another likely contender for the dominant export commodity is natural gas, given the large offshore discoveries in the Rovuma basin in Northern Mozambique, currently estimated at close to 100 tcf (trillion cubic feet)[1], which is likely to be exported as LNG (Liquified Natural Gas) and possibly used locally for projects such as fertilizer manufacturing. Other flagship projects include:

- Kenmare's heavy sands Moma mine, from which ilmenite and rutile (from which titanium is derived) as well as zircon are extracted[2]
- Baobab Resources has a variety of concessions in the Tete regions and has found significant, commercially viable amounts of magnetite deposits[3]
- Noventa is developing its already existing tantalum mining operations in Marropino, Morrua and Mutala, Zambezia province[4]
- Vale has a project for phosphate extraction and beneficiation to produce fertilizer in Evate, in the province of Nampula
- Gemfields has plans for extraction of a ruby deposit in the Montepuez district of Cabo Delgado province
- A new hydroelectric dam, Mhpanda Nkuwa, on the Zambeze, which could produce 1500MW annually[5]

All of these projects present opportunities for economic growth and poverty reduction, given the scale of investment and potential profits; and, as indicated earlier, they also raise risks of a "natural resource

[1] http://www.eni.com/en_IT/media/press-releases/2012/03/2012-03-26-eni-mozambique-area4.shtml; http://www.anadarko.com/Investor/Pages/NewsReleases/NewsReleases.aspx?release-id=1679936; http://www.anadarko.com/Investor/Pages/NewsReleases/NewsReleases.aspx?release-id=1695799

[2] http://www.bni.co.mz/studies/news.aspx?n=kenmare_resources_exports_730,400_tons_of_mining_products_in_2011_in_mozambique&nid=1708

[3] http://www.baobabresources.com/mozambique/overview

[4] http://www.noventagroup.com

[5] http://www.mphandankuwa.com/

curse" presented by extractive industries. Although they are likely to have a large impact, many of these projects are still in a very early phase of preparation. We shall here focus in particular on the coal mining industry, in which a production boom has already initiated.

3. The coal mining industry

There are at present many potential coal mining projects, essentially in the Tete region. However, production is only just starting for a few mines, a few more have been planned in some detail and are likely to be implemented, whilst other potential projects are still a long way from being confirmed, and will most likely depend on the success of the first few mines. We shall here concentrate on 9 mining projects which look likely to go ahead, and for which some data was available:

Table 2: Mining projects with production estimates in Million tons per annum (Mtpa):

Mine	Owner	Production start date	Maximum coking coal production capacity	Maximum thermal coal production capacity
Ncondezi	Ncondezi	2014	0	10.5
Revuboe	Revuboe	2015	5.1	3.4
Minas Moatize	Beacon Hill	2011	0.72	1.64
Benga	Rio Tinto	2012	6	4
Zambeze	Rio Tinto	2014	13.5	9
Moatize phase 1	Vale	2011	8.58	2.6
Moatize phase 2	Vale	2015	8.58	2.6
ENRC Estima	ENRC	2013	6	4
Jindal	JSPL	2013	3	2
Total			**51.48**	**39.74**

A key distinction within the coal production industry is between coking coal and thermal coal, which have different uses and values. Coking coal is, after having been transformed into coke through pyrolysis, a key input in the production of steel, whilst thermal coal is used in the production of electricity. This also translates into price differences, and although predicting prices is very hazardous, we here assume long-term prices of $175 per ton for coking coal (an intermediate between the possibly optimistic estimates of some companies[6] and more pessimistic projections[7]) and $100 per ton for thermal coal[8]. This difference in price makes the estimates in the above table crucial, since differences in proportions of coking and thermal coal will affect the viability of the mining projects, with more coking coal based projects being more able to bear not only the production costs but also the high transport costs inevitable to transport the coal to the coast.

[6] http://www.rns-pdf.londonstockexchange.com/rns/8514X_-2012-2-21.pdf
[7] http://www.smh.com.au/business/old-king-coal-gets-knocked-off-its-throne-20120427-1xpzf.html
[8] http://www.blackgoldglobal.net/upload/CLSA%20Nov%2010%20Full_report.pdf

4. A user-friendly revenue projection model

We shall now outline a simple model which can help to quantify some of the production values and revenues involved in the coal mining industry. This model naturally depends on the quality of the data which is fed into it, and there are currently many variables which must be estimated through educated guesses. Furthermore, in order to be workable, it must make several simplifying assumptions which are not only unrealistic, but also impact the quality of the projections. This means that the estimates will necessarily be inaccurate; the projections should be understood more as orders of magnitude than specific predictions – yet order of magnitudes are needed to start thinking about policy responses to such revenue flows. However, these weaknesses are also the model's strength, which makes a few important points concerning the coal mining industry, and its relative simplicity allows one to easily modify variables in order to assess their impact on coal production and government revenue. Furthermore, its simplicity is what makes it accessible to most users. A simple approach avoids getting bogged down and confused by an excessive number of variables which may or may not increase accuracy given the scarcity of available data, but which may also blur the main messages of the model.

4.1 Company-specific information

The first building block is to try to get plausible cash flows for each mining company. The revenue side is easy, as we have coking and thermal coal maximum production capacities up to 2030 and price estimates. On the cost side, several company-specific aspects of production are taken into account, namely:

- Capital costs, which are very significant given the scale of the mining operations. Some companies have reported estimates of capital expenditures, such as Vale, whose Moatize phases 1 and 2 are expected to cost $1.658 bn and $2.068 bn respectively. In most cases, we have scaled these values to the relative size of their operation.
- Capital costs, where appropriate, include construction of train lines. This point will be expanded further down, but it is very significant for instance in the case of Vale, which has budgeted $4.444 bn for the construction of the Nacala railway, or for the potential third railway that could be built by Rio Tinto, Ncondezi and Revuboè. In the latter case, construction costs are shared between producers in proportion to their relative production sizes.
- Project-specific average operating expenditure per ton of coal produced, taking into account in particular likely differences in transport costs between railway lines.
- The possibility for companies to carry losses forward 5 years in order to offset reported profits. This is an important aspect given the very high capital costs incurred at the beginning of the project, as it delays by several years the reporting of profits and consequently the payment of corporate tax.
- Straight line depreciation of capital investments. We assumed here 100% depreciation over 25 years, implying annual depreciation of 4%, except for Beacon Hill, whose mine has a shorter lifespan than the model.
- Specific fiscal benefits where appropriate

4.2 The transport constraint

The second building block for our model is a transport constraint, which is likely to be one of the biggest challenges to the development of the mining industry. All coal mining projects considered here are located in the province of Tete, located at around 500km (in a straight line) from the coast, wedged between Malawi, Zambia and Zimbabwe. Currently, the only train line linking the area with the coast is the Sena line, around 600km long, to Beira, with a transport capacity of 2 mtpa, currently being upgraded to transport 6 mtpa. The only other option is currently road transport, which is much more expensive (Beacon Hill estimates road transport to be close to 3 times as expensive as rail[9]), unreliable, and not adapted to transport the sort of quantities of coal which are planned to be extracted on the medium and long run. The lack of infrastructure could severely constrain coal production, and even compromise the viability of some coal mines, potentially jeopardising any expectations of economic growth, job creation and government revenue.

Map of Mozambique with railways:

Source: www.africa-confidential.com

Several options are being considered to solve that problem. Vale has taken a first step by initiating the construction of a rail line linking Moatize to the deepwater port of Nacala, in the province of Nampula, over 900 km away. Predictions are for the Nacala line to be operational in 2015, and to have a transport

[9] http://www.rns-pdf.londonstockexchange.com/rns/8514X_-2012-2-21.pdf

capacity of 25 million tons per annum (mtpa), which could later on be expanded further. The capacity of the port of Nacala is being expanded in parallel to more than match these plans. There have also been plans to upgrade the Sena line to 19 mtpa, which could happen by 2015 or 2016. Finally, Rio Tinto, Ncondezi and Revuboè have put forward the idea of a third train line, linking Tete to a new deepwater port North of Quelimane, this option probably not occurring before 2018, possibly even 2020. There have also been talks of barging the coal down the Zambeze River, but this option has so far been rejected by government, and appears unlikely to go ahead.

This model's setup is the following: one can select different combinations of transport infrastructures, along with a date for start of operations. This in turn will constrain the aggregate amount of coal that can be exported, based on the assumption that all the coal is intended to be exported. Naturally, exports are not the only option, as a significant amount of thermal coal is now planned to be used locally to feed power plants, and that road transport is also an, albeit expensive, option. Yet this is useful as it allows us to make some estimates of forgone revenue caused by insufficient transport infrastructure.

The second key assumption is that, given coking coal is more valuable than thermal coal, only coking coal will be exported if the transport capacity is inferior to the maximum production capacity of coking coal. Thermal coal will only be exported if the transport capacity is superior to the maximum production capacity of coking coal. Mathematically, one could express this as follows:

$$PCC_t = min\{T_t; CC_t\}$$

$$PTC_t = min\{T_t - CC_t; T_t\}$$

Where T_t is the transport capacity at time t, CC_t is the coking coal production capacity for the entire industry, TC_t is the thermal coal production capacity, PCC_t is the actual production of coking coal (constrained by transport), and PTC_t is the actual thermal coal production. A necessary condition for the second statement is that $T_t - CC_t \geq 0$.

The third assumption is that all companies will produce in proportion to the relative size of their maximum production capacity; for instance, if Moatize phase 1 represents 17% of the maximum production capacity of coking coal for the whole industry, it will produce 17% of whatever aggregate coking coal production is permitted by the transport constraint. This is clearly unrealistic, seeing as companies operate in an oligopolistic environment in which some larger players are likely to take full control of railway lines (the case of Vale with the Nacala line is the most striking). However, it is a necessary assumption as it would be otherwise very difficult to determine an order of priority between companies. Mathematically one could express this condition as follows, so that the parameters $\alpha_{t,i}$ and $\beta_{t,i}$, which represent production share at time t of mine i in industry-wide maximum production capacity of coking and thermal coal respectively, determine each mine's actual output subject to transport constraint:

$$\alpha_{t,i} = \frac{CC_{t,i}}{CC_t}$$

$$\beta_{t,i} = \frac{TC_{t,i}}{TC_t}$$

$$PCC_{t,i} = \alpha_{t,i}.PCC_t = \alpha_{t,i}.min\{T_t; CC_t\}$$

$$PTC_{t,i} = \beta_{t,i}.PTC_t = \beta_{t,i}.min\{T_t - CC_t; T_t\}$$

We shall use this model to compare four scenarios:

- Scenario 1: Baseline scenario, which involves the current upgrade of the Sena line to 6 mpta by 2013, but no other railway lines.
- Scenario 2: Baseline scenario plus the Nacala line in 2015, with transport capacity of 25 mtpa, bringing maximum transport capacity to 31 mtpa.
- Scenario 3: Scenario 2 plus a further upgrade of the Sena line to 19 mtpa in 2016, bringing maximum transport capacity to 50 mtpa.
- Scenario 4: Scenario 3 plus the third rail line linking Tete to a port North of Quelimane, adding another 35 mtpa by 2020, bringing maximum transport capacity to 85 mtpa.

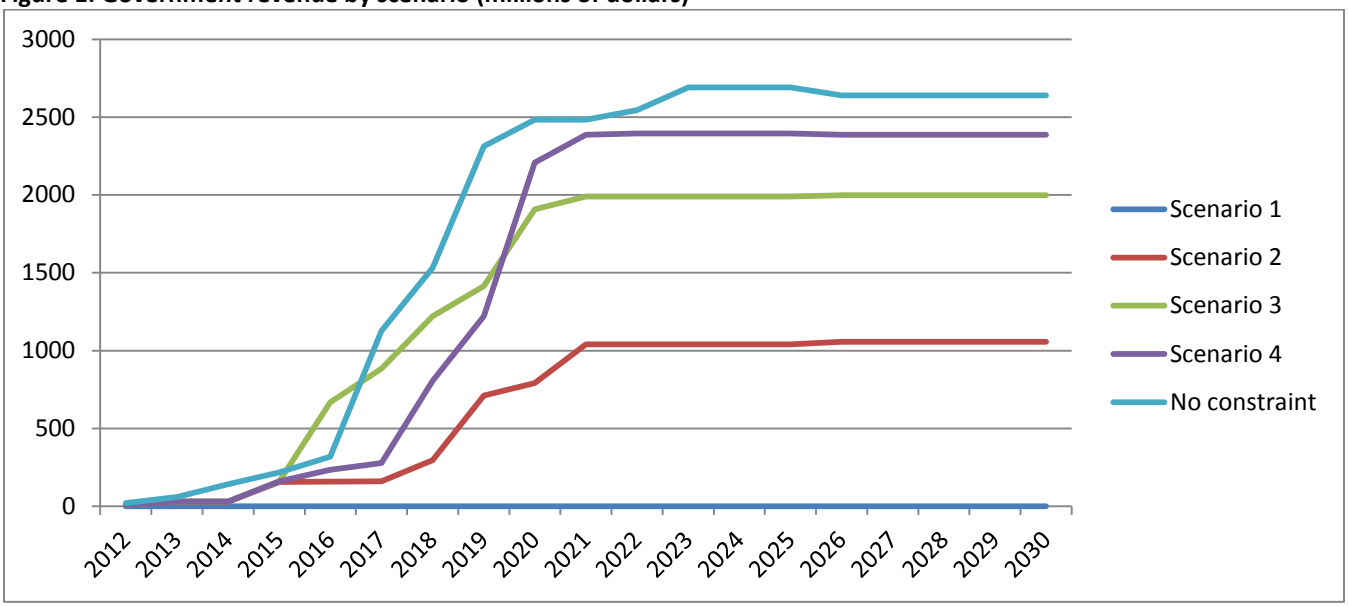
4.3 Tax revenue

Finally, we shall only examine two sources of tax revenue: royalties of 3% on all extracted coal, and corporate tax of 32% on profits. Whilst other taxes, direct or indirect, will clearly have a large impact on government revenue, either the lack of available data or the relative insignificance of their size mean that we have decided to overlook them.

4.4 Results

We shall now observe the impact of the coal mining industry on government revenue in each of the aforementioned scenarios as well as in the hypothetical situation in which there was no transport constraint and companies could export their maximum production capacity:

Figure 1: Government revenue by scenario (millions of dollars)



Several points stand out in these results:

- The introduction of transport constraints has a large impact on potential government revenue. Comparing the best case scenario 4 with the absence of transport constraints, we can observe that whilst, on the long run, the difference is not that large, the loss in revenue associated with the initial delays in transport capacity is significant. Altogether, the loss of revenue associated with the presence of a transport constraint is, in the best of cases (scenario 4), of about $5.6bn from 2012 to 2030. The corresponding forgone value in exports is of almost $23bn over the same period.
- The difference between the various scenarios is considerable: at the peak of production capacity, the difference between scenarios 2 and 3 (a further upgrade of the Sena line up to 19 mtpa) leads to a revenue difference of almost $1 bn annually. During the same period, the difference between scenarios 3 and 4 (a third railway with 35 mtpa capacity) is of almost $400m annually. This lower value reflects the fact that in this model, higher value coking coal is exported in priority, so, at lower levels of transport capacity, improvements have a larger impact, whilst once there is enough transport capacity for coking coal, the extra thermal coal that can be exported makes less of an impact. It is also interesting to note that government revenue in scenario 3 is significantly higher initially than in scenario 4. This is due to the fact that Rio Tinto, Ncondezi and Revuboè are not building a railway, and their capital costs are much lower, so that they become profitable earlier and pay corporate taxes earlier.
- Another notable feature is that in scenario 1 (no improvements beyond the current upgrade of the Sena line to 6 mtpa), there is no government revenue. This reflects the fact that with such low transport capacity, none of the mining projects will be profitable given the high initial capital costs. In reality, it is likely that some of the smaller projects, such as Beacon Hill or Jindal, could be run profitably, but since the model assumes all companies produce constant shares of total output, no company can produce enough to be profitable. However, given how small these

projects are, the message remains the same: without further investments into expanding transport capacity, the coal mining industry in Mozambique will not develop, and the government will miss out on the huge potential revenue that it represents.

- The coal sector could have a larger impact on exports than all other sectors put together. The value of coal exports implied in this model in scenario 4, for instance, would amount to over $12bn annually from 2020, whilst the total value of exports of goods and services reported in the UN Comtrade database was of just over $3.5bn in 2010. In terms of GDP, assuming a value added to output ratio of 30%, this could translate in significant initial increases – an extra 10 percentage points of growth in 2015, assuming an otherwise growth rate of 7.5% - but, absent further linkages with the rest of the economy, would on the long run lead to relatively lower growth rates. Nonetheless, by 2020, in scenario 4, GDP could be almost 19% higher than would have been in the absence of the coal sector.
- Since the increases in government revenue are linked to the availability of new transport capacity, and that the latter leads to sudden large increases in coal output, government revenue will similarly experience rapid surges rather than progressive increases. In scenario 4, for instance, coal mining revenue amounts to under $300m in 2017, but soars to $2.2bn by 2020, that is, a difference of $1.9bn in 3 years for a government whose revenue amounted to $2.8bn in 2010. Such sudden surges are likely to raise new problems in terms of efficiency of public spending, so that smoothing over the increase of government expenditure may be necessary to avoid wasteful spending. In parallel, sudden increases in coal exports are likely to have a significant impact on the exchange rate and pose challenges to macroeconomic policy. This tendency is likely to be exacerbated by price fluctuations which frequently affect natural resource commodities.
- Finally, it is important to note that whilst coal production should already reach high levels by 2015, it is unlikely that revenue will reach any significant levels before 2018 or 2019. This is an important point, since this lapse of time between the start of mining operations (the most high-profile company, Vale, started production in 2011) and the perceived benefits may not be understood and accepted by the Mozambican public, and may fuel resentment at the feeling of not getting a “fair share” of these operations. Beyond actually making sure that tax revenue actually does accrue from such projects, it important to manage the perception that the positive impacts will be felt immediately.

We can compare the main economic impacts in the following summary table:

Table 3: Main economic impacts of the coal mining sector

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	No constraint
Maximum transport capacity (mtpa)	6	31	50	85	Unlimited
Quantity of coking coal exported annually by 2020 (mtpa)	0	31	50	51.5	51.5
Quantity of thermal coal exported annually by 2020 (mtpa)	0	0	0	33.5	36.7
Total value of coal exports from 2012 to 2030 (millions of dollars)	0	89,253	137,829	177,280	200,236
Value of annual coal exports by 2020 (millions of dollars)	0	5,425	875	12,361	12,683
Total government revenue from coal from 2012 to 2030 (millions of dollars)	0	12,835	26,277	28,884	34,512
Annual government revenue from coal by 2020 (millions of dollars)	0	791	1,908	2,209	2,482
Increase in GDP relative to baseline in 2020	0.0%	8.2%	13.3%	18.8%	19.3%

5. Broader Economic Benefits

We have quantified the likely value of coal production and government revenue derived from coal mining, which is likely to dwarf other sectors, at least until the start of natural gas production. We shall now turn to other potential indirect benefits linked to the coal mining industry, in terms of job creation, transport infrastructure, energy and potentially steel.

5.1 Job Creation

Mining, and in particular the kind of open-pit coal mining that will occur in Mozambique, is known to be capital intensive, and as such may not create as many new jobs as the size of the investments could suggest. This may be a cause of concern, as this suggests that direct beneficiaries from such projects will be few, a reproach already made to other "megaprojects" such as Mozal (Castel-Branco, C. N. And Goldin, N., 2003). Based on data from the Ministry of Mineral Resources and some companies, we can estimate long-term direct employment of Mozambicans at about 7,500, a value corroborated by IMF estimates of about 7,000 (IMF, 2011). Given the scale of the mining projects, this is a small impact, although on the short run we can expect much more employment in construction of these mines – possibly up to 25,000 – but that is temporary.

What about indirect employment, through local procurement? This is difficult to quantify, but past experience indicates that local supply for inputs does not arise automatically; in many cases, it may be cheaper to import goods instead of building up local businesses to form a reliable local supply. Mozal, for instance, aimed to develop upstream business linkages through the Mozlink program co-run with the IFC. This succeeded in increasing Mozal's operational spending on local companies from 5$ million in 2002 to $17 million in 2007, covering 240 SMEs (IFC and Mozal, 2007). Although this program boasts a clear increase in local procurement it appears low relative to the weight of Mozal in Mozambican output (Mozal accounted for 7% of Mozambican GDP in 2005 (IFC and Mozal, 2007)). In addition, there are reportedly a significant number of foreign (mainly South African) companies that have set up businesses

in Mozambique in order to benefit from local procurement objectives from Mozal but actually sell imported goods[10]; this obviously undermines attempts to develop upstream linkages in the economy.

Making plans to develop local businesses may be necessary, through long-term commitments on the part of mining companies to be a reliable source of demand for such businesses, and viable exit strategies in order to eventually reduce dependency on the mining industry. The government could encourage this sort of behavior by including local content requirements to mining concession contracts. Currently, the mining law (law nº 14/2002) does not include any disposition on this question, but the petrol law (decree nº24/2004) states that local goods and services enjoy a 10% bidding preference in local procurement. Furthermore, law nº15/2011 states that Public-Private Partnerships, Large Scale Projects and Business Concessions need to create jobs and transfer know-how to Mozambican workers and managers, and must establish partnerships with micro, small and medium size businesses. These are quite vague terms which could be replaced with more specific, progressively increasing, requirements which would give companies time to develop local value chains that could create more jobs.

5.2 Transport infrastructure

Significant developments are already occurring in transport, which due to its crucial role in the export of coal, is likely to be one of the sectors whose development will be most closely linked to the evolution of the mining sector. Currently, the two main new developments undertaken in this sector are the renovation of the Sena line linking Tete to the port of Beira, and the construction (and part renovation) of the Nacala line linking Tete to the port of Nacala through Malawi (undertaken mainly by Vale). Additionally, this includes the renovation and expansion of the port terminals of Beira and Nacala, the construction and rehabilitation of the dry ports of Moatize and Mutarara and Dondo. In total, investments in the transport sector linked to the expansion of the mining industry are likely to be over $6 billion until around 2015[11]. This does not include other plans being discussed to build another railway to a new port North of Quelimane (idea led by Rio Tinto, Revuboe and Ncondezi), an alternative railway line to Nacala without passing through Malawi (idea put forward by ENRC) or barging down the Zambeze river (idea put forward by Rio Tinto). There is still a large amount of uncertainty concerning the feasibility of such projects, yet the viability of the coal mining sector depends crucially on such developments.

Assuming that sufficient capacity is available on the new railway systems and that this capacity is made available to other economic actors, these would significantly lower transport costs for many other sectors and as such could spur the development of many other sectors. This could be, beyond tax revenue, the biggest benefit of the coal mining sector to the Mozambican economy: without such a high value of goods to transport, these railway and port renovations and constructions would not have taken place. However, there appears to still be some uncertainty as to how much capacity will be available for transport of non-coal products. This is a crucial issue that needs to be dealt with, as if there is insufficient transport capacity for coal, it is likely that mining companies could exclude other producers from using the railway lines, either explicitly or simply by outbidding them.

[10] http://allafrica.com/stories/201102010266.html
[11] Caminhos de Ferro de Moçambique (CFM) and Vale

5.3 Energy

Besides the actual mines, mining companies are already planning to build some coal power plants to consume some of the thermal coal. The rationale behind such a move is that thermal coal sells at a relatively low price, and, given the limited nature of the transport infrastructure, it could make sense to use this coal locally, especially given that power plants can be designed to consume high-ash, low-quality thermal coal which could not be profitably exported (Trademark Southern Africa, 2011).

Vale aims to build a power station in two phases, each of which would produce 300 MW, which could consume 3 mtpa of thermal coal, and would cost about $2 billion to build. Rio Tinto also plans to build a power station in two phases, which would eventually produce 1500 MW (Trademark Southern Africa, 2011). Similarly, Jindal announced it would build a $3 billion power plant which would produce 2640 MW[12], and Ncondezi is looking into building a 3600MW power plant.[13]

Using the information that Vale's 600 MW plant would consume 3 mtpa, we can reasonably assume that the 8340 MW worth of power plants could consume altogether about 42 mtpa of thermal coal. This does not necessarily mean that this lowers the amount of exportable coal by 42 mtpa, however, as a certain amount of this coal would be too low quality to be exported. This could nonetheless potentially significantly lower the burden on the transport capacity and make it much more likely that the full potential of the coal mines is exploited.

An analysis of employment in coal power plants in South Africa[14] shows that, on average, about 0.25 workers are employed for every Megawatt produced. Although the nature of the power plants can vary greatly with important implications with regards to employment, using this data can lead us to predict that, given the construction of 8340MW worth of power plants in Mozambique could result in the direct employment of about 2085 workers. Naturally, it would also imply a significant amount of short term employment in the construction of the power plants. Altogether, these are quite small numbers considering the size of the investments. However, the main impact is likely to be through the provision of cheap and reliable electricity to other businesses, contributing to lowering production of businesses for which a constant supply of electricity is essential.

5.4 Coke, pig-iron and steel

A possible spin-off from the coal mining industry which could create more jobs would be to process the coal locally before exporting it. In particular, the process of creating coke through pyrolysis of coking coal could create significant value added whilst developing Mozambique's mineral processing industry further. The key advantages from creating coke locally is that it can be stored for longer than coking coal without suffering from decreasing quality, and it would also reduce the load to be transported through the limited transport infrastructure being built. Furthermore, the process of coke-making generates a number of valuable by-products, such as coal tar - used in a number of chemicals - and ammonia gas

[12] http://www.jindalsteelpower.com/facilities/international/other-areas.aspx, http://www.trademarksa.org/news/mozambique-lets-jindal-study-3-bn-power-plant

[13] http://www.proactiveinvestors.com.au/companies/news/28053/ncondezi-to-publish-definitive-feasibility-study-in-the-autumn-28053.html

[14] http://www.eskom.co.za/c/12/power-stations/

which can be used to produce ammonia salts, nitric acid and most importantly fertilizer – of key importance in a country like Mozambique which has a very low level of agricultural productivity.[15] However, high quality coking coal requires blending of different types of coking coal, and if Mozambique does not have the right blend, it would require importing of additional coking coal (Trademark Southern Africa, 2011).

A further development would be to use the coking coal locally to process iron into steel. Importing iron would be costly; however, mining company Baobab Resources, which holds several mining concessions in Tete province, has reported the discovery of significant amounts of magnetite iron ore, stating that it expected to produce about 3 million tons per year of iron ore by end of 2015, and that it would consider processing the iron ore into pig iron, an intermediate product towards steel.[16] If the company went a step further and decided to take advantage of the cheap local coal supply to process the iron ore into steel in Mozambique, this could have not only a positive effect in terms of employment and value added, but would also potentially have large repercussions on the rest of the economy since steel is a key building material in modern construction.

6. Risks

Several studies (for instance Sachs and Warner, 1997, or Collier and Goderis, 2007) have found evidence that resource-rich countries tend to grow slower than others, causing many to talk of a "resource curse". We shall here outline several channels through which the coal industry could potentially affect the Mozambican economy negatively.

6.1 Dutch Disease

An oft-mentioned risk in resource-rich economies is "Dutch disease", that is, an appreciation of the currency caused by a natural resources' boom, which makes other tradable sectors uncompetitive. This in turn may affect growth, in particular if the penalised sectors, such as manufacturing, have high learning-by-doing benefits; the decline of those sectors may even be exacerbated if the State tries to protect them, as it may reduce investment rates[17]. In the case of Mozambique, the weakness of agricultural productivity, as well as the large fraction of the population employed in that sector, makes this sector crucial in terms of efforts to reduce poverty levels through productivity growth. These could potentially be hampered by an exchange rate appreciation which made it cheaper to import food than to develop local agriculture, especially in a context of needing to lower food prices for the urban poor.

A related issue is that the rapid expansion of such a large industry may cause bottlenecks in the economy which may harm other sectors. For instance, the high infrastructure investments required by the coal mining sector may increase competition for certain resources and labour, making them less affordable for other sectors. In addition, the scale of coal exports could lead to congestion in transport: as previously mentioned, whilst there will be a large expansion in rail and port capacity, there is still

[15] http://www.worldcoal.org/coal/uses-of-coal/
[16] http://www.miningweekly.com/article/miner-baobab-seeks-partner-for-mozambique-project-2011-12-10
[17] ibid

considerable uncertainty as to its extent. In the event of insufficient capacity for coal transport, the mining sector may exclude other sectors from using the railways and ports, and may stifle their expansion.

6.2 Exchange rate volatility

Another potential impact of natural resource dependency is exchange rate fluctuations linked to relatively high volatility in natural resource prices due to low price elasticities of supply and demand (Van der Ploeg, 2010). Exchange rate volatility may be detrimental to investment if returns are difficult to predict due to uncertainty in exchange rates. Aghion *et al* (2009) find that exchange rate volatility has a negative impact on growth of countries with low levels of financial developments, findings that should cause concern for Mozambique, which is still developing its financial system. Furthermore, exchange rate volatility may cause political unrest if (imported) food prices rise rapidly, as in 2010 and 2008.

6.3 Wasteful spending

Finally, another channel through which natural resources may prove a "curse" is corruption and waste. Such surges in government revenue may increase, if unchecked, the power of patronage of politicians, whilst the (relatively) few directly benefitting from natural resources income may be induced to bribe officials for benefits in environments with low quality of public service. The large amount of revenue generated by natural resources thus raises the value of getting power, and may exacerbate tensions not only between political parties, but also between geographical, ethnic or religious groups if some parts of the population feel they are not getting their "fair share" of the revenue. Large increases in revenue may generate demands from the population to spend revenue on short term consumption, which may be difficult to resist, at the detriment of longer-term growth. Several studies suggest that natural resources only truly become a "curse" in the presence of corruption and weak institutions (Sala-i-Martin and Subramanian, 2003; or Collier and Goderis, 2007).

7. How to spend natural resources revenue?

How should government consider the revenue derived from extractive industries? Because of their exceptionally large and temporary (coal and gas resources are not infinite) nature, there are good reasons to treat them in a different way to other sources of revenue. We can summarise some of the key issues to address as follows: a) how to mitigate the volatility of revenue, b) how to transform a finite amount of natural resources into a sustainable source of revenue, c) how to avoid misuse of revenue, d) and how to avoid Dutch disease. We shall discuss some of the options facing government in that respect.

7.1 Place the revenue in a savings fund

A frequent policy recommendation is to place all, or most, of the revenue in a separate savings fund, and consume only the interest derived from such savings. This *bird-in-hand* approach, followed notably by Norway, is a cautious method that presents several advantages beyond ensuring a steady flow of revenue when the natural resources have been depleted. One of the recommendations when creating such a fund is to give it substantial independence as to its investments and a strict mandate to manage

the funds, in order to protect it from politicians who would wish to consume revenue too soon, corruption and wasteful spending. Misuse of sudden surges in revenue, even if politicians have the best intentions, may be inevitable if government capacity does not increase in parallel, as lack of capacity may lead to inefficient expenditure. Frequently, such funds invest in a variety of foreign assets, which is seen as a way of diversifying risk in order to stabilise revenue, but this also has the advantage of counterbalancing to some extent the currency appreciation the frequently accompanies natural resource booms. Collier and Venables (2008) argue that savings funds, if set up, should primarily focus on providing a cushion to shield government revenue from commodity price volatility rather than as a long run savings vehicle as in Norway.

Whilst investing in foreign assets may be the most profitable source of revenue for capital-intensive countries such Norway, where the domestic interest rate is likely to be similar or lower than the world average interest rate, it is likely that in countries such as Mozambique, the low levels of capital intensity and credit constraints provide opportunities for high returns on domestic investment (Takizawa, Gardner and Ueda, 2004). This may be particularly relevant in the case of Mozambique, given the low capital-intensity of the agricultural sector, for instance, which has a high social value due to the large proportion of the population which it employs. However, one should also note that returns on domestic investment may not be as high as they may seem, partly because of lack of information, uncertainty and wasteful spending as discussed previously. The best option is likely to differ from country to country, depending on domestic returns to investment as well as commodity price volatility, which jointly determine in a large part whether savings or domestic investment is the best path to sustainable growth (Cherif and Hasanov, 2012). Another criticism of creating separate funds as "islands of excellence" to protect them from politicians and weak Public Finance Management (PFM) systems is that they tend to "fragment the budget process [...] as well as reduce the credibility and even the quality of the regular budget" (Baunsgaard *et al*., 2012). Instead, it may be more recommendable to focus on strengthening normal PFM channels.

7.2 Adopt constraining fiscal rules

Another method involves the adoption of special fiscal responsibility rules which, either through laws or constitutional changes, constrain government spending in a way consistent with a desirable macroeconomic path. For instance, States can avoid excessive volatility in spending by using a commodity price forecast decoupled from short term fluctuations, either by negotiation or by some mathematical formula. Although this could, in principle, deal with price volatility, it does not address the issue of the finite nature of natural resource revenue and as such is unlikely to be sufficient on its own (Baunsgaard *et al*., 2012). Furthermore, this has in practice led to extra-budgetary spending when forecast prices are conservative, which may result in poor planning and wasteful spending (Ossowski *et al*., 2007).

One way to deal with absorption constraints in the economy is to adopt an expenditure growth rule which constrains expenditure to a percentage of non-resource GDP. This simple rule allows a progressive scaling up of government spending and a significant amount of saving, both to reduce volatility and for long term sustainability purposes (Baunsgaard *et al.*, 2012).

Another option is to adopt a non-resource current balance rule which excludes both capital expenditure and extractive industry revenue from the budget which should be targeted to be balanced. This gives a certain amount of clarity to the reality of recurrent expenditure by eliminating both the short term source of revenue from natural resources and the long term investments it should be financing. In practice, however, separating strictly recurrent from investment budgets is not obvious, as some recurrent spending – such as in education and health – has obvious long-term impacts on growth; this may lead to recurrent spending being reported as capital expenditure, thus undermining the rule (Baunsgaard *et al*., 2012).

7.3 Transfer the revenue straight to citizens

Sala-i-Martin and Subramanian (2003) propose a radical solution: transfer natural resources revenue straight to citizens, thus bypassing entirely government (Sala-i-Martin and Subramanian, 2003). Their reasoning is that, in the context of a highly corrupt government such as in Nigeria (which was the subject of their study), avoiding government entirely is the best way for the revenue to benefit those who should be its ultimate beneficiaries, namely citizens. This would lead government to act "as if" it did not have access to this extra source of revenue, thus eliminating the wastage and corruption which, according to the authors, was the result essentially of the exploitation of oil in Nigeria. Furthermore, it is likely that individuals would use the resources more efficiently and spur longer-term growth, especially in the kind of credit-constrained context which prevails in many developing countries. On the downside, individuals may not care enough as much about future generations as government and may consume too much of this income (Collier and Venables, 2008). Furthermore, this may lead to excessive dependency on the part of the population to this source of income and lead to political unrest as the resource revenue progressively disappears.

8. Conclusion

From an economy whose exports were dominated in the early 90s by fisheries to one in which large-scale, capital intensive projects such as natural gas extraction and aluminium smelting have been important drivers of growth, Mozambique is on the verge of further radical change with the start of extensive coal mining and the discovery of very large natural gas deposits. Adding up the various coal mining projects that look likely to be implemented, coal production capacity could reach close to 100 mtpa by 2020.

However, as our model has shown, actual production is crucially dependent on the development of new transport infrastructure : in the most optimistic of four transport scenarios considered, the shortfall in production incurred is estimated at almost $23bn between 2012 and 2030, with an associated loss in government revenue of $5.6bn. The main message from this simple model is that making sure transport capacity is in place in time to allow coal exports is crucial if the promise of large increases in revenue is to materialise for government.

As with other large-scale projects in Mozambique, the capital-intensive coal mines are predicted to create only around 7000 new jobs directly. More jobs could be created indirectly through local procurement, but weak supply capacity needs to be built up through explicit, long term commitment on

part of the mining companies and the government, as was done with Mozal's Mozlink programme. The government could also include explicit local content objectives for procurement in concession agreements with mining companies, forcing them to focus on developing local businesses.

Other impacts of coal mining include the building of railways and renovation of ports necessary for coal export, which could drastically lower transport costs and improve reliability for many other sectors and spur longer-term growth. Importantly, coal exports will also effectively guarantee that Beira and Nacala ports will be functioning and generally increase shipping volumes. The combination of efficient railways and ports could serve as an important springboard for the production/export of other products, such as agricultural products, and serve as a crucial efficiency offset to the expected currency appreciation.

The planned building of coal power plants by several companies which could reach up to 8340MW of electricity production capacity could employ over 2000 people, but more importantly would contribute to providing cheaper and more reliable sources of electricity to the region. Another possibly important impact is through the potential production of steel, in conjunction with Baobab company's iron deposits discovered in the Tete region.

Beyond these opportunities, natural resource booms have been known to affect negatively many countries, through several channels, be it "Dutch disease" – an appreciation of the exchange rate leading to a loss of competitiveness in other tradable goods with higher social value-, exchange rate and revenue volatility, as well as corruption and wasteful spending. Given the preponderant position that natural resources are likely to occupy in the Mozambican economy, these are issues with which Mozambicans should be concerned.

Finally, a quick reflexion on how to manage the large increase in natural resource revenue led to analyse three possibilities. Firstly, place the revenue in a savings fund that could invest in foreign assets, in order to smooth government consumption and provide long term revenue, as well as reduce exchange rate and revenue volatility and partly offset tendencies for currency appreciation. However, this may not be the most efficient use of the revenue, given capital-scarce countries such as Mozambique are likely to present high returns on investments which may spur long-term growth. The adoption of simple fiscal rules to rein in government expenditure are also an option by for instance using average commodity prices or fixing spending at a specific proportion of non-resource GDP. A more drastic option put forward is to redistribute revenue straight to citizens in order to reduce risks of corruption.

It is important to understand that this is only the beginning of a broader move towards a resource-intensive economy in Mozambique. The next large boom is likely to be in natural gas, where two consortiums, led by Anadarko and ENI, have found so far close to 100 trillion cubic feet of natural gas. Talks so far point at initial production levels of about 20 million tonnes of LNG (Liquified Natural Gas), which, if estimated at a (currently conservative) price of $12 per mmBtu (million British Thermal Units)[18], would amount to annual exports of over $12bn annually, which is comparable to the entire coal mining

[18] FOB price of LNG exports from the Middle East to Asia (very likely market for Mozambican LNG) in 2011, assuming Mozambique is at a comparable distance:
http://www.platts.com/IM.Platts.Content/ProductsServices/Products/lngdaily.pdf

industry at full capacity. This will present further benefits in terms of revenue and potential linkages with the rest of the economy, but is likely to compound the risks associated with natural resource booms which the coal mining is likely to bring.

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