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Downstream activities

The possibilities and the realities

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Abstract: The paper discusses the practical possibilities of achieving increased downstream processing and the policies that are commonly used for this purpose. It reviews the reasons why forward vertical integration is not always an optimal choice for extractive industry companies. It finds little support for the argument that differences in market power dictate the geography of downstream processing. Tariffs on processed products may also play only a limited role. The degree of vertical integration varies and appears to be mainly driven by production economics. Market determined processing margins fluctuate, which raises the risks of investing in downstream processing capacity. Policies for downstream processing are discussed based on experiences in four countries: India, Indonesia, Zambia, and Tanzania. In most of these cases, a very limited amount of analysis appears to have been undertaken to design the policies. Results so far seem to indicate that a number of unintended consequences dominate the outcomes.

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1   Introduction

The possibilities of downstream integration in extractive industries have traditionally been given close attention by policy makers and many governments have made downstream processing an objective of mineral and energy policy. For instance, according to the African Mining Vision: 'The principal resource endowment opportunities are…Downstream value addition: The use of the locational advantage (CIF-FOB) of producing crude resources to establish resource-processing industries (beneficiation) that could then provide the feedstock for manufacturing and industrialisation' (African Union 2009: 13). Similarly, the Amendment of the Broad-Based Socio-Economic Empowerment Charter for the South African Mining and Minerals Industry (the 'Mining Charter') states 'Beneficiation seeks to translate comparative advantage in mineral resources endowment into competitive advantage as [a] fulcrum to enhance industrialisation in line with State developmental priorities' (Republic of South Africa 2010: 2).

The present paper will discuss the practical possibilities of achieving increased downstream processing and the policies used. It will argue that governments need to be cautious about elevating downstream processing to a priority objective. It will also attempt to show, by way of examples, how attempts to 'correct' market outcomes may carry high costs for the economy, and it will discuss the potential of local markets for extractive industry products.

Section 2 will briefly discuss possible alternative explanations for the perceived lack of downstream integration in the extractive industries in lower income countries, thus setting the stage for the empirically oriented analysis in following sections.

Section 3 will provide a description of the economics and geography of downstream processing. Using examples from three industries: aluminium, copper, and iron ore/steel, it will highlight the degree, nature, and economics of vertical integration. Two aspects of this are studied: the geographical and ownership distribution of mining and downstream activities and the evolution over time of processing margins. This section is intended to provide an assessment of some general propositions about the feasibility of downstream activity and to illustrate that value-adding through further processing is a more complex issue than is often realized.

Section 4 will be devoted to a critical review of policies commonly pursued to promote downstream processing. The review will first discuss how downstream processing has formed a part of policy prescriptions for governments of countries with large extractive industry sectors and the role of these prescriptions in the portfolio of policy measures aiming to achieve diversification, industrialization, and development. This will be followed by a review of practical experiences in a few countries where downstream integration has been accorded a high priority by successive governments: India, for iron ore and steel; Indonesia, for all minerals; Zambia, for copper; and Tanzania, for natural gas. The policies pursued in these four countries will be reviewed with a view to drawing conclusions about their effectiveness.

Finally, Section 5 will attempt to draw some general conclusions about the kind of policies that could prove successful, both in diversifying the output of the extractive industry and widening its deliveries to domestic and sub-regional markets.

2 Explanations for the lack of downstream integration in extractive industries

If all locations were equally attractive from other points of view, one would expect downstream processing to take place close to the site of the extraction, simply because processing often involves a reduction in volume, which would tend to reduce transport costs. Since this is clearly not always the case, the reasons for the location of processing activities in other sites have to be explained.

2.1 Declining terms of trade and unequal market power

Much of the intellectual foundation for the emphasis given to downstream processing and one of the most important possible reasons for the location of processing activities away from primary production was provided more than half a century ago by Hans Singer (1950) and Raúl Prebisch (1950) in the form of the Singer–Prebisch hypothesis. According to this argument, in a world system in which poorer nations specialize in primary products, such as raw minerals and agricultural products that are then shipped to industrialized nations that, in turn, make advanced products to be sold to poorer nations, the major benefits of international trade will go to the wealthy nations. The reason for this state of affairs is said to be that primary commodity markets are competitive and so reductions in costs are passed on to consumers in the form of lower prices. Producers of many manufactured products, it is argued, enjoy a better position because they have some market power. This allows them to share the benefits of falling costs between workers in the form of better salaries and shareholders in the form of greater dividends.

As a result, countries that produce and export mineral (as well as other natural resource) commodities have to export increasing amounts over time in order to purchase a given basket of manufacturing imports: i.e. their terms of trade decline (Singer 1950; Prebisch 1950). The phenomenon of tariff escalation, with tariffs on processed products being higher than those on raw materials, is argued to add to this tendency.

The hypothesis has had a strong influence on theories attributing low growth in developing countries to their dependence on unprocessed commodity exports. It has also been referred to as one of the reasons for the 'resource curse'.

The Singer–Prebisch hypothesis attributes the lack of downstream processing in developing countries to the differences in market power between primary producers and producers of processed products. It assumes that developed countries have the power to influence location choices and retain processing capacity in their countries, through trade policy and by other means. Until the 1990s, this view of the world economy did not appear to be in obvious conflict with the observable facts, since prices of manufactures appeared to increase at a higher rate than those of commodities over the longer term—in spite of temporary surges in commodity prices, for instance, during the first oil crisis in the early 1970s—and manufacturing predominantly took place in developed countries. However, with the expansion of manufacturing capacity in emerging economies, particularly China, that has taken place over the past two decades, and the increase in commodity prices during the most recent commodity boom through 2011, this description no longer appears valid. Price developments for energy and metal commodities since 1960 do not provide unambiguous support for the Singer–Prebisch hypothesis after the year 2000.[1] This might imply either that retaining manufacturing capacity is no longer a priority for developed countries or that they are unable to prevent its migration to lower cost locations. In either case, the

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[1] The evolution of margins between prices of unprocessed and processed products will be further discussed in section 3.

conclusion should be that the obstacles to downstream processing that may have existed earlier are less important today.

The predictions concerning the declining terms of trade may of course still be valid for other reasons, such as a slower rate of demand increase for primary than for processed products or limited scope for product diversification and branding in primary products. If the terms of trade are indeed moving against primary products over the long term, that would constitute a powerful reason for governments of the countries concerned to prioritize economic diversification.[2] However, the argument concerning declining terms of trade is by no means concluded. The test of the declining-terms-of-trade prediction depends crucially on the start and end points of the period being measured. It can be argued that the 'super cycle' for commodities provides an effective counter argument, while its reversal reinforces the hypothesis.

There are a number of potential explanations for the absence of downstream processing that go beyond terms of trade. Policy measures to support downstream integration would need to be designed on the basis of an understanding of which of these explanations is most relevant to the particular case at hand. In the following, some other explanations will be briefly discussed.

2.2   Tariff escalation

Tariff escalation (higher import duties on semi-processed products than on raw materials, and higher still on finished products, (WTO n.d.a) is a real phenomenon and it is relevant in situations where the domestic market is not sufficiently large to accommodate the output of downstream processing plants and part or all of the production has to be exported. However, negotiations in the WTO and in the context of regional trade agreements have reduced the level of tariffs and made tariff escalation less significant, particularly if concessions within regional or bilateral trade agreements are taken into account.[3] The large expansion of manufacturing exports from China and other emerging economies could hardly have taken place under the tariffs that were in force in the 1970s or 1980s.

Figure 1 shows import tariffs for metals, including semi-fabricated products, for some selected countries.[4] Tariffs for the *unprocessed products* (iron ore, copper ores, and concentrates and bauxite (aluminium ores and concentrates)) are 0, except in India, where tariffs on all three are 2.5 per cent. Figure 2 shows import tariffs for the same countries for refined oil products and gas. Tariffs on crude oil and liquid natural gas are 0, except in India, where the tariff on natural gas is 5 per cent. It appears that tariff escalation (the difference between the tariffs shown in the figures and those levied on the unprocessed product) is significant, although absolute tariffs are relatively low. The figures do not include tariffs on finished products because the discussion of downstream processing has mainly concerned the first or the first couple of processing stages. The inclusion of more processed products would be unlikely to change the conclusions.

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[2] The economic success of countries such as Australia, Chile, and New Zealand that are strongly dependent on primary commodity exports would appear to argue that decline in terms of trade can be overcome, inter alia, by higher productivity, leading to a competitive advantage.

[3] For instance, the Everything But Arms initiative has abolished tariffs on almost all imports from Least Developed Countries (LDCs), including most African countries, to the EU. The European Partnership Agreements (EPAs) negotiated between the European Union and African, Caribbean and Pacific countries are effectively providing the latter countries with free access to the EU market (European Commission n.d.).

[4] The countries selected are the ones accounting for most of the world imports of the commodities concerned. It should be mentioned that many of the other countries not included have higher degrees of tariff escalation.

Figure 1: Import tariffs for selected metals and countries, per cent
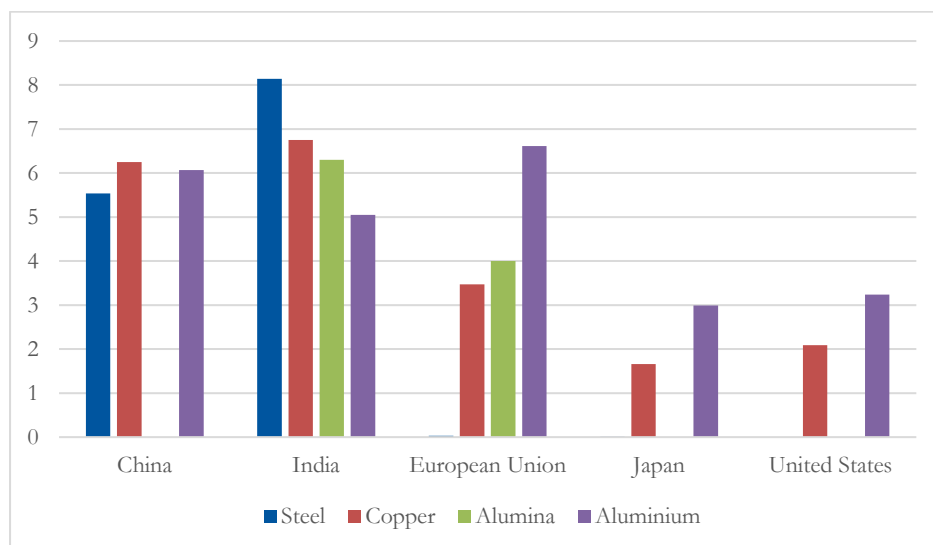
Notes: 1. Unweighted averages of applied tariffs. 2. Average of tariff lines in HS section 72 (iron and steel); average of tariff lines in HS section 74 (copper); tariff on 281820 (aluminium oxide); average of tariff lines in HS section 76 (aluminium). 3. Data for 2014 (China, Japan); 2015 (European Union, India, United States).

Source: Based on tariff data in WTO (n.d.b).

Figure 2: Import tariffs on refined oil products and gases, selected countries, per cent
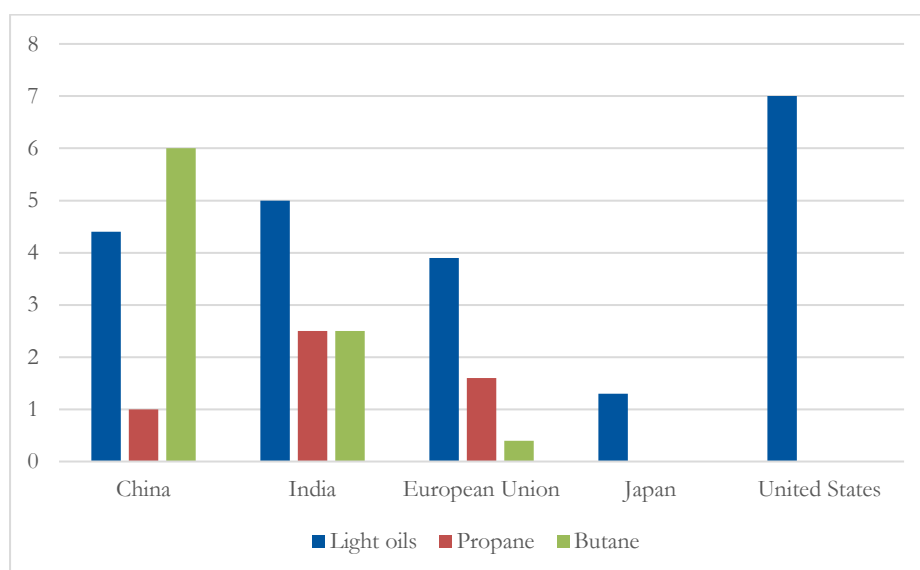
Notes: 1. Tariff on HS 271012 (light oils and preparations); tariff on HS 271112 (propane, liquefied); tariff on HS 271113 (butane, liquefied). 2. Data for 2014 (China, Japan); 2015 (European Union, India, United States).

Source: Based on tariff data in WTO (n.d.b).

In order to provide even a cursory description of tariff escalation—a subject that has been much debated and where there exists a rich academic literature—some qualifications have to be presented. First, simple averages of tariffs as shown in Figures 1 and 2 do not tell the whole story, particularly when the tariffs are not weighted by trade. Products (within a category such as copper) that are deemed to be strategic may be subject to much higher tariffs, thereby effectively reducing imports. However, in the case of metals, the existence of 'tariff peaks' is relatively limited. Table 1

shows the range of applied import tariffs for the same countries as in Figures 1 and 2. The highest tariffs are still relatively low and would seem unlikely to be prohibitive.

Table 1: Import tariff range, selected metals and countries, per cent

	Iron and steel (HS72)	Copper (HS74)	Aluminium (HS76)
China	1–10	0–15	0–10
India	5–10	5–10	2.5–7.5
European Union	0–2.2	0–5.2	0–8.8
Japan	0–2	0–3	0–7.5
United States	0	0–3	1.3–5.7

Source: Based on tariff data in WTO (n.d.b).

Second, it is important to recall that tariffs are levied on the gross value rather than the value-added. If, say, the tariff on copper concentrates is zero and the tariff on refined copper is 5 per cent while the price of copper concentrates is US$5,000 per metric tonne and that of refined copper US$5,500, the tariff on refined copper is US$275 dollars (5 per cent of 5,500). This corresponds to 55 per cent of the price difference between the two products and in all likelihood to a significantly higher proportion of the value-added, since some inputs will be necessary in the refining. The effective rate of protection provided by the seemingly relatively low tariff would thus in reality be very high (actual tariff rates on unwrought refined copper were zero in China, the European Union, and Japan, 1 per cent in the United States, and 5 per cent in India).

Third, transportation costs have to be taken into account. These can be considerable and can outweigh the effects of tariff protection. If, as in the case of Zambia (see section 4.4), the difference in transport cost (between the refined and the unrefined copper to a given market) is US$467 per tonne, other things equal, it would still make sense to produce refined copper and pay the higher tariff.

In conclusion, tariff escalation could be a significant obstacle to downstream processing when exporting to some markets. However, in several cases, the higher tariff on the more processed product may be more than outweighed by the difference in transport costs. Moreover, while access to large developing country markets such as China or India may be hampered by high tariffs on processed products, many developing countries now enjoy tariff-free access to developed country markets (and often to the Chinese market) under various bilateral and regional trade agreements.

2.3   Economies of scale

Many production processes in the extractive industries have significant economies of scale. For instance, an oil refinery needs a capacity of 200,000 to 250,000 barrels per day to be profitable (Institute for Energy Research 2005). A world-class plant for producing methanol from natural gas has a capacity of close to 2 million tonnes per year (Haldor Topsøe n.d.: 2). New crude steel plants using blast furnaces generally have a capacity of at least 2 million tonnes per year (electric arc furnaces can be much smaller but require special inputs in the form of scrap or direct reduced iron that has to be available in sufficient quantity), and a new alumina plant would not be economic unless it produced at least 1 million tonnes per year. As these examples show, processing the output from a relatively small mine or oil field locally may not always be competitive. Accordingly, downstream processing may have to wait until production has reached required levels or may necessitate the pooling of output from several mines or oil wells. The latter alternative is not necessarily easy to realize, since it may require getting owners of mines or oil wells, who probably have very different cost structures, market networks, and product characteristics, to cooperate. It might even need imports of feedstock from neighbouring countries.

2.4 Availability of inputs

It is not enough to have the basic raw material. Many processes also require specialized inputs. For instance, aluminium smelters need access to low-cost electric power in order to be competitive. An iron ore mine located far from the coast and which does not happen to have metallurgical coal deposits nearby would not be a favourable site for a blast furnace—unless local steel demand is sufficiently large and other costs are low enough to justify building a blast furnace using imported coal. Access to low cost energy is usually the main hurdle. It is maybe illustrative that a legal requirement to process copper concentrate in the Democratic Republic of Congo was delayed after copper producers demonstrated that there was not enough electric power available to smelt and refine the copper mined in the country (Creamer Media 2016a).

2.5 Size of domestic market

International markets for energy and minerals are highly competitive and it is difficult to compete without relying on a domestic market where locational advantages in the form of lower transport costs yield higher margins. However, the domestic market for processed energy and mineral products in many developing countries is far too small to provide such a cushion. For instance, while a country may produce enough crude oil to supply a refinery of economic size, local demand for products such as petrol or fuel oil has to be large enough so that the entire production does not need to be exported, much of it in smaller tankers with consequent high transport costs. Similarly, most successful steel plants rely on demand in the domestic market for a large share of their production, which generally includes a range of specialist products. Producing and exporting crude steel is a risky business since most steel plants today are integrated and buy crude steel only when there are temporary capacity shortfalls.

2.6 Closeness to market

Industrial users of raw materials today expect speedy delivery and a broad product range from their suppliers. Many downstream products such as semi-fabricates of steel and nonferrous metals are produced in a wide range of qualities and are used by a variety of industries; it is necessary to be able to supply the needed quality to the customer at short notice, which means that geographic closeness to the market gives a competitive advantage. Accordingly, facilities for producing items such as semi-manufactured copper products (pipes, sheet, etc.) tend to be located close to their customers and not to the mine sites. Producers located far away are at a distinct disadvantage. It is no coincidence that semi-manufacturing of nonferrous products has migrated from Europe and North America to East Asia at the same rate as has the production of manufactured products, as illustrated by statistics over metals use.[5]

2.7 Business environment

No matter how essential, raw materials are only one ingredient in the production of processed products. Availability of skilled labour, logistics, and financial services are also important and indeed, necessary. The institutional environment for business as measured, for instance, by the World Bank's Ease of Doing Business index (World Bank 2016), is often of decisive importance. All of these factors affect the decision of whether to invest in downstream processing.

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[5] Metals use is usually measured as unwrought metal used in semi-fabricated products. Statistics producers, such as the international metal study groups, use this convention.

Moreover, the attractiveness of the investment regime needs to be taken into account. While mines have to be located where there are mineral or oil deposits,[6] processing capacity can, in principle, be located anywhere. Therefore, while the quality of a deposit may compensate for various unattractive (from the investor's point of view) aspects of the host country's investment regime, these aspects may swing a decision of where to locate processing capacity in favour of a 'safer' site out of the country.

2.8 Conclusions

Downstream processing often has an inbuilt advantage of lower transport costs when exporting compared to the export of the unprocessed commodity. However, most other factors such as necessary economies of scale, unavailability of inputs, limited size of the domestic market, distance to export markets, and lack of a favourable business climate may outweigh this advantage. Trade barriers such as tariffs that have often been cited as a major problem appear to play a limited role, particularly when taking into account the preferences now accorded to developing countries under various trade agreements.

3   Economics and geography of downstream processing: some empirical data

3.1   Extent of vertical integration in selected mineral industries

An indication of the economics of vertical integration and the viability of new efforts to achieve greater downstream processing should be provided by the extent to which the industry is in fact vertically integrated. Vertical integration would seem to hold advantages if it is high, particularly if it is high in developed countries, as implied by the Singer–Prebisch hypothesis. Evidently, the total cost of the transformation of a less processed raw material into the next step in the value chain needs to be recovered. But this is not enough. The return on the investment also needs to be higher than the return on any alternative investment. From the point of view of a private investor, the relevant comparison may be with investment in mining in other regions or of other metals, while for the government it might be increased school funding or investment in health care. Requiring mining companies to increase further processing may mean that they pay less in taxes, thus reducing other public spending. Accordingly, in order to shed some light on this issue, we look at two aspects of downstream processing. First, whether the degree of vertical integration is higher in developed countries, as predicted by the Singer–Prebisch hypothesis, which would support the case for promotion of downstream processing. In this context, we also describe how vertical integration has changed over the last decade or so, depending on availability of data. Second, we look at the size and variations in processing margins, in order to determine if they are very large compared to the price of the unprocessed commodity—again, as predicted by the Singer–Prebisch hypothesis—and if they are stable enough not to pose unacceptable risks to possible public investment, directly or indirectly, in downstream processing.

In order to take into account the fact that vertical integration can be measured either on a purely **geographical** basis (processing takes place in the same location or country) or with respect to **ownership** (downstream facilities have the same corporate owner as upstream ones), the following ratios were calculated for three minerals, bauxite/alumina/aluminium, copper, and iron ore/steel:

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[6] This does not mean that extractive industries are insensitive to investment conditions, merely that companies may consider investing even under an unattractive investment regime if the deposit is good enough.

1. Share of output at the unprocessed stage (bauxite, copper concentrate, and iron ore) that is processed into the following stage (aluminium oxide, refined copper, and pig iron) *in the country of mine production*, the share being measured both for world totals and for significant producing countries;

2. Share of output at the unprocessed stage that is processed into the following stage by a facility *controlled by the same owner*, either in the country of mine production or elsewhere, the share being measured both for world totals and for significant producing countries; and

3. Share of output at the processed stage that uses raw material produced in the same country or by a mine controlled by the same owner, the share being measured both for world totals and for significant producing countries.

In the following, a detailed analysis of copper will be presented while results for the other metals will only be mentioned briefly. Tables A1 to A5 and Figures A1 to A5 in the Annex provide more detailed material including, in particular, on the other metals.

Copper is mainly traded in the forms of concentrate and refined copper. To transform copper ore to refined copper there are two ways: either the ore is used to produce a concentrate which is smelted, producing blister copper, and then refined through electrolysis to copper cathodes, or the ore is mined through a solvent extraction electro winning (SX-EW) process which produces refined copper cathodes, making the smelting stage redundant. Of all copper ore mined, some 22 per cent used the SX-EW process in 2014 (up from 21 per cent in 2010 and 18 per cent in 2000) (USGS 2014). In the case of the SX-EW procedure, all downstream processing takes place at the mine and hence the vertical integration is 100 per cent for these mines.

The picture for the other mines is different. For copper concentrate going to smelters there is a well-developed trade. In 2000, some 66 per cent of concentrate produced was smelted in the country of origin (see Table 2). This figure has, however, fallen since and in 2014 it was 55 per cent. One reason for this development is that China has developed large smelting capacities to cater for local demand. In 2014, China accounted for 32 per cent of total smelting production, up from 9.4 per cent in 2000. China can meet only some 37 per cent of its needs with locally produced concentrate, leaving the rest to be covered by imports. The growing Chinese demand for concentrates has led to relatively lower prices for blister copper and to relatively higher prices for copper concentrate (see section 3.2), making it more profitable for mining companies to sell the concentrate rather than investing in smelting capacity. Zambia (as well as the Democratic Republic of Congo, not shown here) shows a slightly different situation from the other large producers of copper concentrate and smelted copper. For reasons having to do mainly with transport costs, the country has kept the smelting of locally produced copper concentrate within the country (see section 4.4).

Table 2: Copper ore smelted within country of origin as per cent of total copper ore produced within the same country

	2000	2005	2010	2014
Australia	54%	47%	48%	50%
Chile	45%	42%	47%	35%
China	100%	100%	100%	100%
India	100%	100%	100%	100%
Japan	100%			
Korea, Rep		100%		
Peru	86%	45%	29%	24%
Russia	100%	99%	84%	88%
United States	100%	89%	89%	62%
Zambia	100%	82%	100%	100%
Total	66%	63%	59%	55%

Source: Authors' calculations based on USGS (2014).

Copper produced through electrowinning as a share of total refined copper production increased during the years 2000 to 2014 from 19 per cent to 23 per cent (USGS 2014). Copper is generally refined within the country where it is smelted (see Table 3). While the figure has varied slightly during the last 15 years, generally some 91 to 93 per cent has been refined in the country where the smelter is located. Among the larger producers of refined copper there are exceptions. Two countries, Chile and Zambia, have seen their share of locally produced smelted copper being refined within the same country decreasing sharply, mainly because of high costs of electric power.

Table 3: Smelted copper (primary excluding electrowon) refined within country of smelter as per cent of total produced refined copper

	2000(%)	2005(%)	2010(%)	2014(%)
Chile	89	80	74	65
China	98	100	100	100
India	91	98	87	100
Japan	97	93	96	100
Korea, Republic of	100	100	100	98
Russia	100	98	100	100
United States	100	100	100	100
Zambia	74	90	69	55
Total	93	91	92	92

Source: Authors' calculations based on USGS (2014).

Bauxite/alumina/aluminium

Bauxite is a heterogeneous, naturally occurring material used to produce alumina (aluminium oxide), which is then transformed through electrolysis into aluminium. The bauxite/alumina/aluminium industry shares many of the characteristics of the copper industry, with the difference that the degree of vertical integration has varied more. While energy costs are always important in downstream processing of minerals, it is especially so for the alumina to aluminium process which has in part dictated the structure of the industry. The other strong influence has been the rapid expansion of alumina and aluminium production in China, using imported bauxite.

Iron ore/steel (rebar)

A high proportion of the world's iron ore production is exported, and this proportion has increased over the last couple of decades. Accordingly, the portion that is processed locally has decreased. This process is the result of China absorbing increasingly large quantities of iron ore as its steel production has grown to account for more than half of the world's output (UNCTAD

2015). Less than a third of the world's iron ore production is now processed in the country where it was mined compared to almost half ten years ago.

Why vertical integration between iron ore and steel is declining globally has to do with the way that steel and its raw materials are produced and traded. The product immediately following iron ore in the production process, pig iron, is traded very little because it is brittle and not easily transported. Like the following stage, crude steel, it is also preferable to keep it hot so that it does not have to be reheated when processed into the next product in the processing chain. Thus, production economics in the form of energy costs serve to keep the process from pig iron to finished steel products integrated within one plant. If the steel could be sold close to the iron ore mines there would be clear advantages to geographical vertical integration. However, since steel is produced in many different qualities and since economies of scale are important, steel production tends to take place close to major steel-using industries such as vehicle manufacturing or construction. As a consequence, a high and growing proportion of iron ore is exported.

Table 4 summarizes the results of the analysis and shows trends over the 2000–14 period. It is interesting to note that vertical integration has decreased for all the first steps of the supply chain: bauxite to alumina, copper ore to smelted copper, and iron ore to steel, while the next step shows either increased or stable vertical integration over the period studied. Partly, this is due to the rise of China as a consumer of raw materials and the country's investments in downstream processing. The other main reason is the location of demand for the processed products, such as steel, which determines where the final step in the processing chain is located. If there are advantages to vertical integration, they may be more important going backward from the final stage than going forward from the first stage.

Table 4: Vertical integration, less processed raw material transformed into more processed material within the same country

	Bauxite/alumina	Alumina/ Aluminium	Copper ore/ smelted copper	Smelted copper/ refined copper	Iron ore/ steel
	2000–14	2000–14	2000–14	2000–14	2000–14
Average over period	61.8%	57.5%	60.6%	92.1%	45.6%
High/low	67.5/54.4%	69.0/50.4%	66.3/54.9%	93.8/90.9%	52.6/32.5%
Trend over period	Decreasing	Increasing	decreasing	Stable	decreasing
Standard deviation over period	4.7%	7.5%	2.8%	0.8%	5.9%

Source: Authors' calculations based on data from Raw Materials Data (n.d.) (bauxite, alumina, and aluminium); USGS (2014) (copper ore, smelted copper, and refined copper); World Steel Association (2015), UNCTAD (2015) (iron ore and steel).

3.2 Processing margins

The commercial viability of any processing industry depends on the processing margin, that is the difference between the prices of the raw material and the processed product. Margins may be inflated by monopoly positions. But in a globalized world with low tariff barriers it may not be possible to maintain processing margins that contain a large element of monopoly rent for an extended period. It would also be difficult to establish statistically the existence of such rents without detailed calculations on the basis of production cost data, which are notoriously unreliable and subject to influences that vary from one plant to another. It is, however, possible to assess if margins are stable or subject to large fluctuations. In the latter case, it would be reasonable to conclude that investment in downstream processing is associated with large risks: a key

consideration for any lower income county that was seeking greater engagement with the downstream activities.
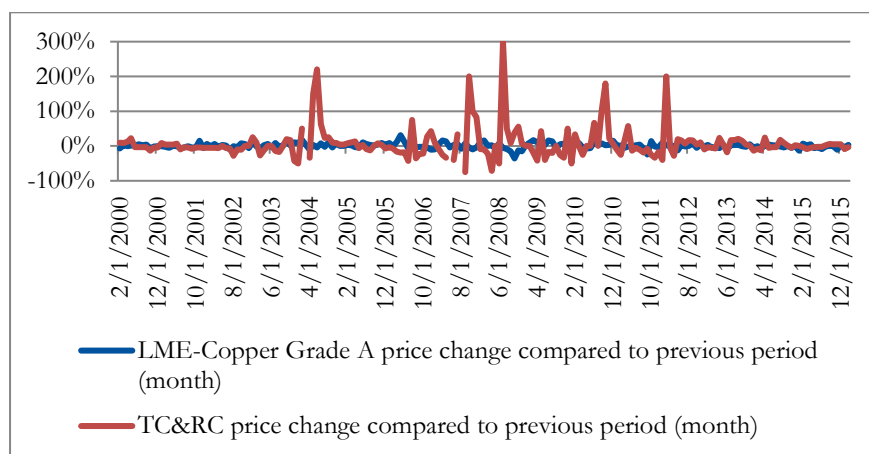
Copper

As seen from Figure 3, total processing charges for converting copper concentrate to refined copper have on average been relatively low over an extended period, both in absolute dollar terms and also as a proportion of the refined copper price.[7] However, the share of the charges as a proportion of the refined copper price shows violent fluctuations (the right-hand scale). This implies that the returns from downstream processing of copper are highly uneven and that a decision to process copper concentrate requires that any company considering the processing option has to have adequate financial buffers.

Figure 3: LME copper price and TC & RC, 2000–February 2016, US$/tonne
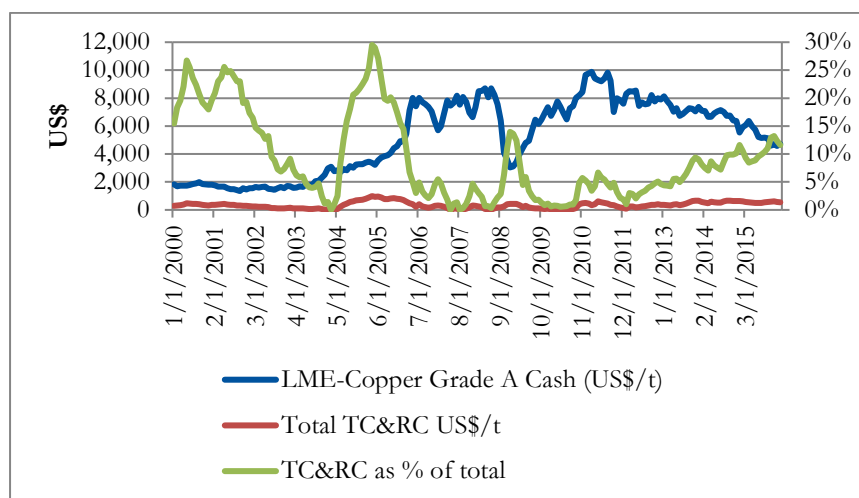
Source: Authors' calculations based on data from London Metal Exchange (n.d.).

Figure 4: Change on previous month, LME copper price and TC & RC, 2000–February 2016, per cent

Source: Authors' calculations based on data from London Metal Exchange (n.d.).

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[7] TC stands for 'treatment charges' and refers to the charge for smelting copper concentrate to blister copper. RC stands for 'refining charges' and refers to the charge for refining blister copper to copper cathodes. While blister copper is traded, the bulk of international copper metal trade is in the form of copper cathodes.

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The fluctuations in the charges are highlighted even more strongly by Figure 4, which shows monthly changes in both the LME copper price and the charges. Variations are considerably larger in amplitude for the charges than for the copper price itself.

Bauxite/alumina/aluminium

A comparison of the prices of bauxite, alumina, and aluminium over time shows that the bauxite price as a portion of the alumina price fluctuates more than the alumina price as a portion of the aluminium price.

This comparison does not look at other input prices that could shed more light on the bauxite/alumina/aluminium relation, especially as energy accounts for a substantial part of the cost of producing both alumina and aluminium.

Looking at price changes instead of absolute prices shows a fairly steady market with moderate increases and decreases. Bauxite prices show some larger amplitude fluctuations, but even those are fairly limited compared to copper and iron ore (see following section). The amplitude of both alumina and aluminium trends in between +/-10 per cent compared to the previous period and seem to follow each other fairly well. This would seem to imply that the risk associated with additional processing in the bauxite/alumina/aluminium industry is relatively low.

Iron ore/steel

Both iron ore and rebar[8] prices showed large amplitude fluctuations. However, unlike in the case of copper, the variations over time in the implicit 'processing charge', that is the difference between rebar and iron ore prices, and in the iron ore price itself, are of roughly similar magnitude. Accordingly, the additional processing would not appear to increase the price risk.

From the analysis of the processing margins some conclusions concerning the stability of these margins can be drawn (see Table 5). Across the board, the treatment charge, whether explicit or implicit, is seen to be on a decreasing trend as a portion of the price at the following processing stage. Moreover, for both copper and iron ore, the standard deviation is high and increasing, with increased uncertainty and higher risk as a result.

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[8] The price of rebars (also known as reinforcing rods, used with concrete in construction) is used since this is the most basic and lowest priced form of commonly traded steel. Import prices for the Middle East were used since they are broadly based and can be taken as roughly representative of the prices paid by most developing countries for imported steel.

Table 5: Processing margins, cost of turning less processed material into next stage as per cent of more processed price

	(Alumina – bauxite)/ alumina	(Aluminium – alumina)/ aluminium	TC & RC/LME grade copper price	(Rebar (steel) – iron ore)/rebar
	Aug 2010–15	Aug 2010–15	2000–15	2007–15
Average over period	80.5%	82.8%	9.3%	70.5%
High/low	85.6/73.2%	86.5/79.7%	29.5/0.3%	83.0/55.7%
Trend over period	decreasing	decreasing	decreasing	decreasing
Standard deviation over period	2.9%	1.6%	7.6%	7.9%

Sources: Authors' calculations based on data from London Metal Exchange (n.d.) (copper); S&P Global (n.d.a), Metal Bulletin (n.d.) (bauxite to alumina); London Metal Exchange (n.d.), Metal Bulletin (n.d.) (alumna to aluminium); UNCTAD (2015), S&P Global (n.d.b) (iron ore to rebars).

3.3   Some conclusions from the empirical data

The degree of vertical integration varies within the extractive industry and between the three metals studied. In all three cases this appears to be mainly driven by production economics resulting from technology and transport costs and less by corporate strategies or trade policies. For the bauxite/alumina/aluminium complex, access to low cost energy is a major determining factor, along with an advantage for aluminium smelters that are located close to markets. For copper, the transport cost for copper concentrate has meant that copper is often smelted and refined close to the mine, except where economies of scale, access to low cost energy, and the surge in Chinese demand has generated a trade in concentrate and, to some extent, in smelted blister copper. Finally, in the case of iron ore, developments over the past two decades have been completely dominated by the dramatic expansion of steel use in China, which has provided Chinese steel mills with a competitive advantage based on location. It should be noted, however, that even discounting the influence of China, a very high proportion of iron ore production has traditionally been exported because the steel markets of most large iron ore producing countries are far too small to accommodate processing of more than a share of the iron ore output. It is notable that the degree of downstream processing is relatively low in high income countries that would be expected to be able to exert some influence over markets, for instance, Australia in bauxite and iron ore, Chile in copper, and Sweden in iron ore. It would certainly be technically feasible for these countries to increase downstream processing. The fact that they have not done so would appear to argue that the attraction of downstream integration is not self-evident.

Based on the evidence of price series, processing margins do not appear to have followed any particular trend in the past two decades. The surge in Chinese processing of all three metals could have been expected to change price behaviour. But this has not happened. Longer price series would have allowed more definite conclusions on this point, but they are unfortunately not available. The time series used are probably in any case sufficiently long to reflect accurately the effects of the Chinese expansion of processing. There is considerable variation in the processing margins over time. In cases where the raw material accounts for a large portion of the total production cost and its price is subject to large fluctuations, downstream processing is exposed to considerable risk. This is the case in particular for processing of bauxite, copper concentrate, and iron ore, but less so for the processing of alumina. The high risk of periodically seeing margins squeezed dramatically should give pause to any company or indeed government that might consider investing in processing capacity.

4   Review of policies

4.1   Policy objectives and means

Government policies aimed at increasing downstream processing are rarely introduced with reference to clearly defined and quantifiable objectives. Nevertheless, it is possible to distinguish three broad categories of objectives:

1. *Employment*: It is sometimes argued that increased downstream integration will add a significant number of employment opportunities. In principle, one would expect this argument to carry relatively little weight in the case of extractive industries, where, apart from exceptions such as jewellery production, downstream processing is usually very capital intensive.[9]

2. *Economic diversification and skills development*: While the number of jobs created in downstream industries may be relatively small, incentives to create such industries could be justified if they made the economy more diversified, or if the general skill levels were raised. This would be the case in particular if the skills were portable and could be applied in industries outside the extractive sector.

3. *Appropriation of rent*: If there are monopoly rents in processing it would be reasonable for the government to try to correct the situation in order both to raise economic efficiency and also to increase government income from the extractive sector.

As already mentioned, specific policy measures to support downstream integration would need to be designed on the basis of an understanding as to why downstream processing is not taking place without government intervention, and which of the three objectives above might be achieved by using any government intervention that is contemplated—while also considering if the objective in question can be achieved by an alternative route.

As concerns employment, a recent WIDER Working Paper on local content (Östensson 2017) argues that measures aimed at strengthening *backward linkages* (e.g. via higher levels of local content) may yield significant results in terms of employment generation and that many of these jobs are likely to be associated with portable skills. It is difficult to see how *downstream processing* could have a comparable impact, since most mineral or energy processing facilities are highly capital intensive and require little of the low skilled labour in, for example, construction and services, that is needed in mining itself or in supplier industries (although less so in oil or gas production). It is true that some of the jobs in downstream processing are highly skilled. However, the required skills are often relatively specialized and thus not easily portable.

Backward linkages are also likely to offer greater scope for economic diversification than do downstream activities, since the enterprises involved in the former are usually less specialized and also since scale requirements are less demanding. Moreover, if the profitability of the downstream processing of extractive industry commodities is dependent on the local availability of raw materials, its survival would be jeopardized by the eventual exhaustion of local deposits of these materials. The existence, actual or potential, of local markets for extractive industry products would

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[9] Later processing stages may be more labour intensive, but it is difficult to argue that a country needs to have all the intermediate stages in order to arrive at this later, more labour demanding stage, particularly in the light of the changes that have taken place in international trade patterns in recent years. For an informative analysis of trade patterns for copper contained in semi-fabricated and finished goods, see Tercero et al. (2016).

appear to change this calculus since the development of such markets would reduce dependence on raw material exports and may result in greater economic resilience. However, the mere existence of such markets is not a guarantee that they will benefit fully from the availability of the raw material since the processor may be in a monopoly position with price setting power.[10]

The existence of large rents that can be appropriated would appear to be a valid reason for promoting downstream processing. However, as discussed in the previous section, the rents in downstream processing appear to be limited and precarious, with large fluctuations over time. Accordingly, policies based on the perceived existence of such rents and aimed at promoting downstream processing could carry large risks: risks both to the financial solidity of the resource company and, in the case of positive tax incentives or government subsidies, a risk of wasting taxpayers' money.

Governments typically attempt to influence downstream processing decisions in one or more of three ways:

- Consultation with investors aimed at identifying and remedying obstacles to downstream integration;

- Economic incentives, which can be divided into four categories:

    o Export taxes on unprocessed products

    o Tax credits for exports of processed products

    o Provision of cheap inputs via subsidies

    o Other changes to taxation such as differing calculations of the tax base; and

- Bans on the export of unprocessed products.

Government measures may be contained in legislation or may form part of agreements negotiated with investors depending on how mineral rights are awarded under the country's mineral and energy investment regimes. While agreements are almost universally used in the oil and gas sector to define rights and obligations of government and companies, they are less common and often more restricted in scope for nonfuel minerals, where conditions are instead usually defined in law. Nevertheless, even where taxation is defined in law, many countries use Mineral Development Agreements to define other obligations of investors. These obligations may cover various aspects of the investment, including employment, local content, and downstream processing. Targets may be defined, or a process for achieving unquantified objectives set out. Consultation processes where plans are worked out and agreed are common in the cases of employment and local content, but less so when it comes to downstream processing. Where the legislation and any agreements are silent on downstream processing, it is of course still possible for the government to try to persuade the investing company to integrate forward. Any government disposes of a number of instruments that can be used to influence companies' behaviour in this regard. It is of course possible that companies' desire to maintain a good relationship with the government may provide

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[10] As the African Mining Vision expresses it: '...TNCs, who often prefer to…only make the semi-processed resource available to the local market at a monopoly price (import parity price=the alternative imported price of the resource (CIF) in a particular country), if they have a monopoly or oligopoly position in the country concerned.' (African Union 2009:14)

the final push that is necessary to go ahead with a decision to invest in downstream capacity, where the situation in other respects is broadly favourable.

Economic incentives to influence companies' decisions with respect to downstream processing are relatively common, particularly in the form of taxes on the export of unprocessed materials.[11] Although such taxes are not forbidden by WTO rules, other restrictions, including conditions surrounding the taxes, may be against the rules. However, in most cases, export restrictions are not challenged by other countries, mainly because other countries do not consider that they suffer any damage. For instance, the injured party in the case of India's taxes on iron ore exports is the Indian iron ore industry, while the taxes probably do not have a significant influence on world market iron ore prices and can therefore be ignored by the rest of the world. However, as demonstrated by much-publicized WTO cases against China, other countries may take action when they feel their interests are threatened. Their complaints are then upheld in the WTO dispute settlement procedure (see Box 1).

Box 1: WTO Dispute concerning Chinese export taxes on minerals

In June 2009, the EU and the United States both filed requests for consultations with China. In August, they were joined by Mexico (DS394, 395, and 398). According to the requests, China imposed quantitative restrictions on the export of bauxite, coke, fluorspar, silicon carbide, and zinc, and it also imposed export duties on bauxite, coke, fluorspar, magnesium, manganese, silicon metal, yellow phosphorus, and zinc. These measures were considered to be in contradiction to Articles VIII:1(a), X:1, X:3(a), and XI:1 of the GATT 1994. On 5 July 2011, a dispute panel found in the complainants' favour. Both sides appealed, and the Appellate Body upheld most of the dispute panel's findings. In particular, China had argued in its defence that some of its export duties and quotas were justified because they related to the conservation of exhaustible natural resources for some of the raw materials. But China was not able to demonstrate that it imposed these restrictions in conjunction with restrictions on domestic production or consumption of the raw materials so as to conserve the raw materials. On 28 January 2013 China notified that it had implemented the dispute panel's recommendations. A similar case brought by the United States, the EU, and Japan in 2012 concerning restrictions on Chinese exports of rare earths, tungsten, and molybdenum also resulted in victory for the complainants in 2015 (DS431, 432, and 433).

Source: WTO (n.d.c).

It can be noted that processing facilities that depend on the continuation of an ***export tax*** for their survival lead a fragile existence. Examples of processing operations that were unprofitable under normal circumstances include the small copper smelters set up in Katanga in the Democratic Republic of the Congo, which could exist only because of the DRC export tax on copper concentrates and the high transport cost. Most of these smelters closed rapidly when copper prices fell in late 2008.

Positive incentives, for instance, in the form of ***tax credits*** for downstream processing, have been discussed, but no current examples are known to the authors. However, downstream processing can be favoured by provisions in tax codes that do not obviously aim at providing incentives for downstream processing. An interesting example of how an incentive for downstream processing arises as a result of legislation with another objective is provided by Kazakhstan. In addition to corporate income tax (CIT), mining profits are subject to an excess-profits tax (EPT) on so-called 'excess profits' (Article 347 of the Kazakhstan Tax Code). The rules for calculating the EPT are complex, but, in essence, the taxpayer is in a position of having to pay EPT in a particular taxation year when after-tax net income exceeds 25 per cent of costs claimed in that year for CIT purposes.

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[11] See Price and Nance (2009) for a number of examples.

Investing in downstream capacity greatly increases the deductible costs, thus reducing the likelihood of having to pay the EPT (Östensson et al. 2014).

Another positive incentive is **duty exemption** on imported inputs, which is used both at the primary and downstream processing stage by many countries.

Export bans on unprocessed products are uncommon, but there are a few examples. The most recent example is the ban that was introduced in Indonesia in 2014, which is discussed in the following section.

4.2 Indonesia's unprocessed mineral exports ban

The example of downstream processing policies that has attracted most attention in recent years is the Indonesian export ban on unprocessed minerals. This ban took effect in January 2014. It applies to both metal-based and non-metal-based components of unprocessed minerals and specifies certain minimum levels of processing that are required to avoid the ban. The nominal intention of this intervention is to help preserve the country's supplies of the affected resources (Nathan Associates 2013). While mineral ore exports such as nickel and bauxite were banned outright, exports of mineral concentrates—including copper, iron ore, manganese, lead, zinc, and ilmenite—are permitted for a period of three years, during which export taxes will be levied at rising rates (Bloomberg 2014).

In order to back up the bans, positive incentives have also been provided for companies that invest in processing facilities. These include (Bellefleur 2014):

- 0 per cent import duty on imports of capital goods;

- 0 per cent import duty on imports of goods and materials required for processing;

- An investment tax allowance in the form of a taxable income reduction of as much as 30 per cent of the realized investment, spread over six years;

- An exemption from CIT for 5 to 10 years beginning from the date commercial production commences (CIT measures apply only to investments over US$100 million);

- A two-year 50 per cent reduction in CIT liability after the end of the tax holiday period; and

- An extension of the exemption or reduction in CIT depending on the competitiveness and strategic value of the industry.

These measures have had a dramatic impact on Indonesia's mineral exports. The value of unprocessed exports of bauxite, copper, and nickel fell from US$7 billion in 2013 to just under US$2.9 billion in 2014 (UNCTADstat n.d.). Nickel exports, which declined by 97 per cent, were particularly hard hit. The fact that the rules were introduced at a time of falling prices and widespread excess capacity for the minerals concerned, has exacerbated these impacts. Some modifications of the rules have already been negotiated with companies. For instance, it has been reported that bauxite exporters who are in the process of building alumina refineries will be allowed to resume exports, although they will have to pay an export tax (Indonesia Investments 2015). Freeport-McMoRan, which operates the huge Grasberg copper-gold mine, has been accorded a reduction in the export taxes. Meanwhile, a number of projects to build processing plants have been announced and a few have started construction.

It is too early to definitely assess the Indonesian experience since 2014. An estimate made for USAid before the rules came into effect found that the economic losses would be very large (Nathan Associates 2013).[12] In the light of the implementation of the legislation and market developments since early 2014, these initial estimates today appear too optimistic. While it is possible that some of the processing capacity now being built will be profitable, this may be due only, or in part at least, to the very generous incentives provided.

4.3   Export taxes on iron ore in India

Indian policy with respect to the iron ore mining example is a good illustration of the difficulties of achieving a balance between the interests of primary producers and processors by using regulations in a situation where downstream processors are politically favoured. Export restrictions to protect the steel industry's raw materials supply have jeopardized the viability of the Indian iron ore mining industry and so deterred investment in new mines

In 2011 and 2012, the courts banned mining in the Indian provinces of Goa and Karnataka because of mining outside concession areas and breaches of environmental regulations. The ban has since been lifted, but there is still a cap on production (Creamer Media 2012b). According to mining industry officials, the reason why mining was carried out outside concession areas was that it takes at least five years to secure all mining clearances and approvals from federal and provincial governments and the companies chose not to wait for formal approval, possibly in anticipation that approval would be forthcoming.

There have been reports that the provincial government of Karnataka planned to issue new mining leases where leases had been cancelled for illegal mining operations but that the new leases would be allotted only to steel plants and not to merchant miners engaged only in ore production and sales (Creamer Media 2013b). The province of Odisha was reported to be in the process of implementing a new iron ore mining policy under which second and subsequent renewal of mining leases would be granted only for captive mining or miners who had downstream value additional investments (Creamer Media 2013a).

Iron ore consumption by the Indian steel industry is dominated by lumps and sinter, with most fines that are not suitable for sintering being exported since they cannot be directly used for iron making in the absence of sufficient capacities for agglomeration through pelletizing (Creamer Media 2012a). Most steel producers are equipped to use iron ore pellets from fines as feedstock but do not have pellet-making facilities at their plants (Creamer Media 2012c). As a consequence, the fines have been left in dumps or, when possible, the material has been exported. In order to assure the domestic steel industry of iron ore supplies, railway freight rates are no less than 3.6 times higher for iron ore for exporters than for ore for domestic use (Creamer Media 2015);

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[12] In the most optimistic of three scenarios, where all the new processing capacity projected by the Ministry of Energy and Mineral Resources is assumed to be operational by 2020, 'yearly net welfare effects of the ban finally become positive. But total net welfare gains are modest, totalling just $832 million per year, given all the new processing capacity. Total export earnings increase by $1.3 billion. Furthermore, large accumulated net welfare losses will have been incurred over the years of the investment timeline. Accumulated total revenue losses to miners range between $47 billion and $42 billion, depending on assumptions about the domestic price decline of unprocessed minerals after the ban. Gains to processors range between $15.7 billion and $11.1 billion. Deadweight efficiency costs due to the ban policy range between $10 billion and $5 billion. In aggregate, accumulated net welfare losses amount to somewhere between $34 billion and $33 billion in 2020—a hefty price to pay for a policy that generates such modest social benefits.' (Nathan Associates 2013: 2).

auditors have initiated lawsuits against iron ore producers who, in order to save on freight costs, declared ore for export as being intended for domestic customers (Creamer Media 2014b).

The Indian government has banned the domestic sale and export of iron ore fines from captive mines leased to steel producers. According to a notification to all provincial governments issued by the Mines Ministry, invoking the Mineral Concession Rules, 'the entire ore produced in mining operations shall be exclusively for own consumption in iron and steel making and cannot be either sold within India or exported to other countries' (quoted in Creamer Media 2012c).

In order to assure the steel industry of a secure raw material supply, a levy on outward shipments of fines was first imposed in December 2009 at 5 per cent. A 15 per cent export tax on lumps followed in April 2010. A uniform rate of 20 per cent was imposed on both lumps and fines in March 2011 and was increased to 30 per cent in December the same year (Creamer Media 2015). The tax was lowered to 10 per cent for lower grade ores in 2016 (Creamer Media 2016b). Royalties on iron ore were raised from 10 to 15 per cent in August 2014 (Creamer Media 2014c). Pelletizing provided a possible way to exploit lower grade fines since there was no export tax on pellets. However, a tax of 5 per cent was introduced in January 2014 in response to pressure by the steel industry (Creamer Media 2014a, 2014e). Capacity utilization in pelletizing fell to 50 per cent later the same year (Creamer Media 2014d).

In mid-2016 there were about 150 million tonnes of iron ore fines in stockpiles (Creamer Media 2016c). This material has been discarded by the mines because it is too low grade to be sold to domestic users. But nor can it be exported because of the export tax and the higher railway freight charges.

Figure 5: Iron ore and steel in India 1993–2015, million tonnes
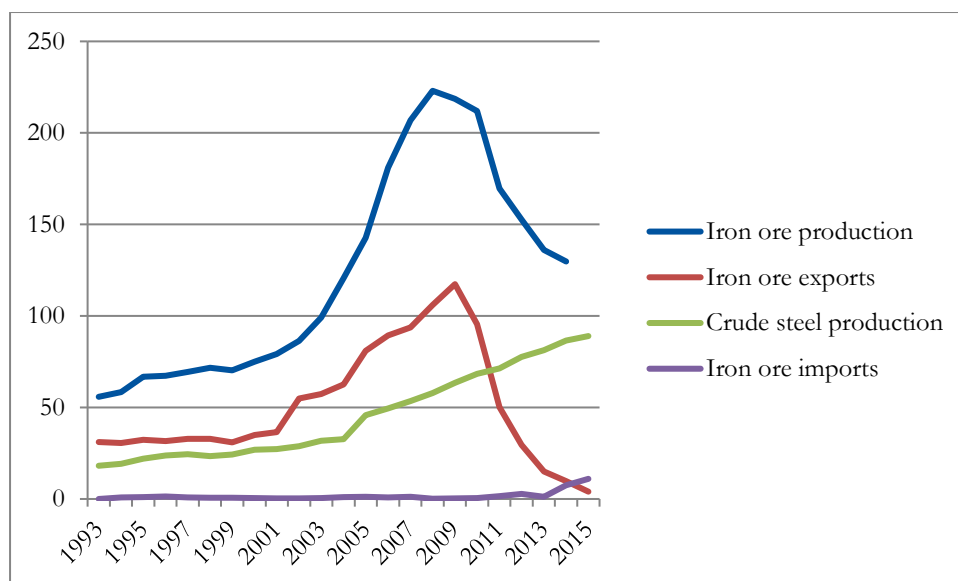
Source: Authors' calculations based on UNCTAD (2013, 2015), TEX Report (2016).

The combined result of these various policy interventions can be seen in Figure 5. The peak in export and production in around 2008 to 2009 was partly the result of companies exporting from stockpiles of fines. However, once the most easily accessible stockpiles had been exhausted and prices fell following the financial crisis, this activity came to an end. A couple of years later, the court-ordered mine closures strongly influenced the figures. Nevertheless, production and exports would have been expected to recover once mines could be reopened. This did not happen, due to

the policies pursued. Consequently, and remarkably, from being the world's third-largest iron ore exporter, India has become a net importer of iron ore.

However, it should be noted that the policies pursued have not been totally in favour of the steel industry. Instead, they appear at times to have been influenced by contradictory impulses on the part of government: the steel industry's repeated request that the 2.5 per cent import duty on iron ore be lifted has so far been denied, in spite of the relief that this would provide to coastal steel producers located at a distance from iron ore mines (Creamer Media 2013a).

4.4 Processing of copper in Zambia[13]

Zambia levies an export tax on copper concentrate. The tax is intended to promote the smelting and refining of copper concentrate from mines in the country. The tax is 10 per cent of the sales value, which corresponds to about US$470 per tonne of contained copper at present prices (mid-2016). According to mining companies in Zambia (Muller 2013), the treatment charge, that is the cost of smelting concentrate in Zambia to produce blister copper (see footnote 7) is US$70–75 per tonne of concentrate, while the cost of transporting the concentrate from the mine to an overseas smelter is about US$200 per tonne depending on the route taken. Table 6 shows the net revenue earned by the mining company in three cases:[14]

1. The case where the concentrate is exported without the charging of any export tax;

2. The same as 1. but with the export tax added; and

3. The case where the smelting process takes place in Zambia so that what is exported is blister.

Because the cost of transporting concentrate is three times as high as that of transporting blister copper, the mining company will be better off processing the copper even in the absence of the export tax. The smelting charge has to be paid in any case and it does not matter to the miner if it is paid to a smelter in Zambia or overseas. Most of the copper concentrate produced in Zambia is treated in smelters belonging to the same company. Given the very low margins in copper smelting, the costs of smelting can be assumed to be equivalent to the smelting charge.[15]

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[13] Most of this section is based on Chamber of Mines of Zambia and ICMM (2014: Annex I). Copper prices and smelting charges have been updated to, respectively, February 2016 and the average for the 2000–15 period.

[14] The smelting charge is deducted from the sales price if the concentrate is exported. In order to simplify the example, only the smelting stage is taken into account here. Including the refining stage (to produce copper cathodes) does not change the conclusions.

[15] The largest cost elements involved in smelting copper are fuel and the depreciation of equipment. Because these elements both rely almost completely on imports in Zambia's case, the imposition of the tax may well cause domestic value added to be negative in some cases.

Table 6: Net revenues from exporting copper concentrate or blister copper, US$/tonne contained copper[16]

	Exporting copper concentrate without tax	Exporting copper concentrate with tax	Smelting copper concentrate in Zambia and exporting blister copper
Copper price	4,490	4,490	4,700
Smelting charges			210
Transport cost	667	667	200
Export tax		470	
Net revenue	3,823	3,353	4,290

Source: Chamber of Mines of Zambia and ICMM (2014: Annex I), and authors' calculations based on updated prices.

A comparison of the first and third columns shows that no mining company would export concentrate if smelting capacity is available. Thus, the export tax does not affect the actions of mining companies. On the other hand, the tax deters investors who for one reason or another are not in a position to smelt concentrates, for example if a mine is too small to have its own smelter and there is no spare capacity in existing smelters or if a mine produces concentrate that for mineralogical reasons cannot be smelted in existing smelters. This could be the case, for instance, if the concentrate contains impurities such as arsenic that are difficult to handle in most smelters. Because of the export tax, most such mining projects will not be economically viable in Zambia. The resulting loss of potential production could be easily avoided by eliminating the tax, which does not influence companies' decisions in the way intended and does not provide significant government revenue.

Would this conclusion hold if the level of the smelting charge were to change? As was noted in section 3, smelting charges have trended downwards for a long time due to persistent over-capacity at the smelting stage. There are two reasons for the tendency towards excess capacity. First, several governments have introduced legislation similar to the Zambian export taxes, leading to over-investment in smelting capacity and downward pressure on smelting charges. Second, smelters that were originally built to process ore from mines that are now closed often continue operating since the original capital investment has been paid back and running costs can be covered. There are several such smelters in the world, particularly in developed countries.

Are there, then, any prospects of processing the refined copper that is now produced in Zambia? A World Bank study (World Bank 2011) does not hold out much hope. There are currently a limited number of companies engaged in copper processing in Zambia, producing wire rod, wire, cable, and cast products. Since South Africa's market is largely self-sufficient, apart from some imports of wire rod and wire from Zambia, the total open market for all copper and copper alloy semis in sub-Saharan Africa (excluding South Africa) can be estimated at around 10,000 tonnes per year, which corresponds to a tiny portion of Zambian refined copper output of over 700,000 tonnes per year. Given the location of Zambia, the principal exit shipment ports and the main shipping routes, the markets outside Africa which could be best served from Zambia are the Middle East and Southeast Asia. The Asian market is, however, well served by substantial large-scale local capacity. Even for some initially niche and high added value products, Asian margins have been pared down due to excessive capacity being installed after the initial market was established. A major barrier to Zambia accessing these markets is transport, since Zambia is a landlocked country. South Africa is clearly in a better position to service customers within the country and in export markets outside Africa.

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[16] The smelting charge is assumed to be US$210 per tonne of copper in concentrate and the concentrate is assumed to hold 30 per cent copper.

Accordingly, market prospects do not appear to justify further industrial scale copper and copper alloy semi-manufacturing capability in Zambia in spite of regular political pressures to do just that. There may, however, be scope for some gradual scaling-up of existing output and/or product diversification by existing operations and for some small-scale artisanal processing, probably based on scrap metal.

4.5   Exports or local use of natural gas in Tanzania

Tanzania has been producing natural gas from its Songo Songo fields on the Indian Ocean since 2004. This gas is used to provide about 50 per cent of Tanzania's electricity generation, with the remainder used for industrial purposes (AfDB and BMGF 2015). However, more recent discoveries have radically changed the future perspective for gas in Tanzania. In the past decade, there has been very large exploration activity in the concessions so far granted by the Tanzanian Petroleum Development Corporation.[17] These have already resulted in vast commercial finds that are only now beginning to be developed. The discoveries on-shore and near-shore at Mnazi Bay delivered their first gas into a major new Chinese-financed pipeline from Mnazi Bay in August 2015. They will quickly have the capacity to deliver more than 100 mmscfs/d.[18] i.e. significantly more than doubling the existing through-put from Songo Songo which itself is expected to increase (Roe 2016).

The gas can be used in three ways: (i) natural gas can be exported to earn foreign exchange revenue, with the gas revenue to be used as a catalyst for broader economic growth; (ii) it can be used to generate energy (electricity) in the domestic economy, and abundant, reliable, and cheap energy would offer comparative advantage to those industries that use energy as well as raise living standards for the Tanzanian population; and (iii) it can be used to produce a number of products, including fertilizer, compressed natural gas, and petrochemicals.

The choice between the different uses for the natural gas is partly a technical one that will be dictated by project economics. Mainly, however, the choice is a political one. A large portion of the gas in the largest deep water wells will in any case have to be exported, both because the volumes are too large to realistically be absorbed by the national economy and because producing companies will have to export very large volumes to justify their investment in extraction and liquefied natural gas (LNG) plants. A large share of the export revenues will strengthen the government budget. Although large in absolute terms, revenue from gas is expected to account for a relatively small share of the economy. It has been estimated that the additional income will amount to US$1.4 billion per year on average over the first ten years of production, corresponding to 1.9 per cent of gross domestic product and 9 per cent of government tax revenue from all sources (AfDB and BMGF 2015: 31). There is, however, potential for the contribution to growth to be significantly larger. The Tanzanian economy is capable of delivering at least some of the goods and services needed for gas exploration and extraction and for LNG production. The government has launched an ambitious local content policy which, if successful, should raise the proportion of nationally sourced goods and services significantly (United Republic of Tanzania 2014).

With respect to the possibility of improving access to electrical power, it should be noted that at present only 24 per cent of the Tanzanian population, and about 11 per cent of the rural

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[17] The largest finds are in deep Indian Ocean waters, but the more recently exploited finds are on-shore or in near-shore locations.

[18] mmscf/d=million standard cubic feet per day.

population, are connected with electricity services. The government plans to increase the connectivity level to 30 per cent by 2015, 50 per cent by 2025, and at least 75 per cent by 2033 (United Republic of Tanzania 2015: 2). Using the natural gas from the Mnazi Bay fields for this purpose would mean that the national energy supply company will imminently be able to further reduce its dependence on expensive imported feed stocks of diesel,[19] and also reduce further its use of ageing and unreliable hydro plants. In addition, it would be possible to reduce power tariffs, thereby improving living standards and the competitiveness of domestic industry.

A range of processed products can also be produced from the gas and especially from the large deep water resources if these are eventually developed. Their economic feasibility differs, however. Certain processes for downstream products have considerable economies of scale and for this reason a large part of the production would have to be exported if production was to be on a commercially viable scale. Moreover, as seen from Figure 6, several of the uses would require a considerably lower cost of input than, for instance, would LNG production.[20]

Figure 6: Uses for natural gas in Tanzania, maximum input prices, circles proportional to volumes
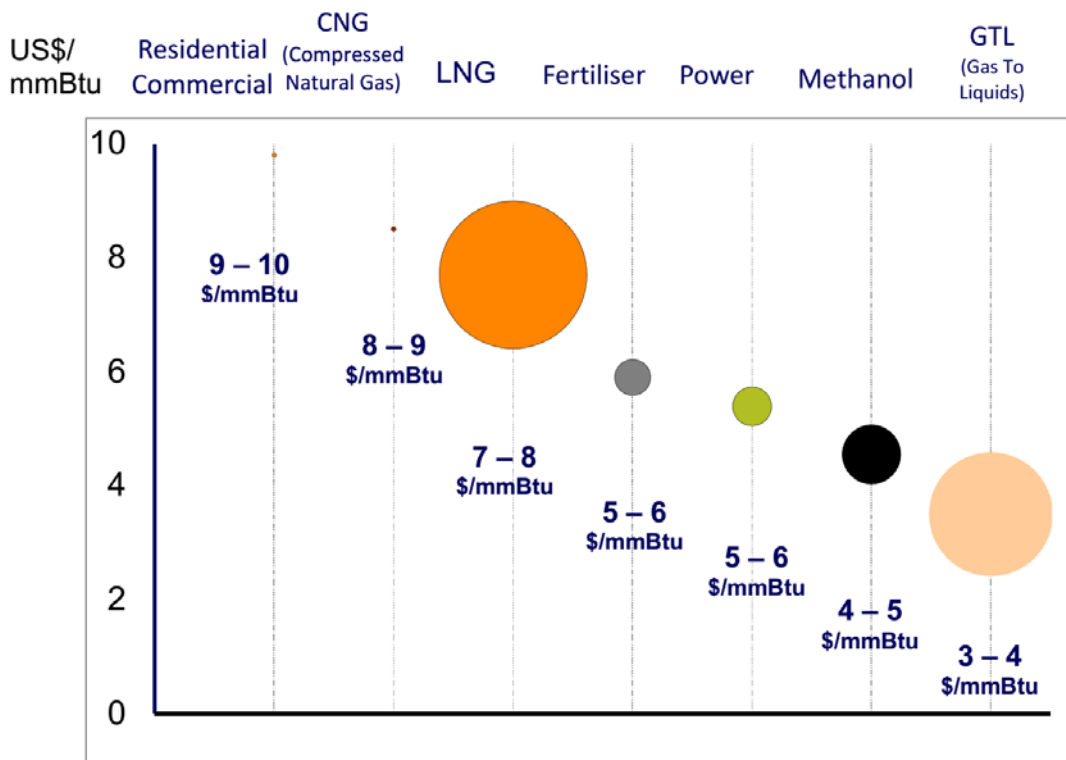
Source: Henstridge (2014).

A domestic fertilizer facility could make a significant potential contribution to Tanzania's large agricultural sector which at present has a low rate of fertilizer use as well as an expensive subsidy policy to help farmers. A large ammonia/urea plant could be competitive if it could be supplied with gas at US$5–6 per mmBtu: a figure that is more demanding than the US$7–8 supply price needed for a viable LNG export activity. Fertilizer production would also encounter the problem

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[19] This process already began in 2015 because of the deliveries of near shore gas from Mnazi Bay to the new gas-fired power plant near Dar es Salaam—Kinyerezi I.

[20] The following assessment of the feasibility of different types of downstream processes is based on BG Tanzania (2013).

of a very large capital cost of circa US$1.6 billion and it would need a large volume of gas if it were to operate at near full capacity: circa 60mmscf/d. That full capacity output would be significantly higher than the anticipated future demands in East Africa as a whole. So the investment could only be justified if Tanzania had real prospects of also finding large export markets outside the region. That in turn confirms the need for a world-standard production facility (Roe 2016).

A competitive methanol plant would consume even more than a fertilizer plant and it would probably need a gas supply price as low as US$4–5. But the real danger for Tanzania in going down this route comes from its very small domestic market for the product (methanol being used mainly as a feedstock into chemical industries). Hence a very large export market would also need to be found to justify such a large capital outlay (Roe 2016).

Converting gas to liquid fuels would be an even more challenging investment for the country. Production facilities to produce naphtha and high quality diesel need to be very large and they are very expensive. Such a facility would only work competitively if it could acquire gas at a price of around US$3-4 mmBtu—half the price that would be possible for an exporting LNG facility. Although this type of project would have some attraction in being able to save Tanzania's large petroleum import bill, the investment needed to achieve this saving would be very large (Roe 2016).

The Tanzanian government has made it clear that it assigns a high priority to downstream processing of natural gas and has stated:

> The Government shall: (i) Ensure that domestic market is given first priority over the export market in gas supply; … (iv) Promote and facilitate the establishment and growth of industrial parks utilizing natural gas; (v) Strategically invest in the GTL and LNG value chain, efficient cross border trading of the natural gas products and other natural gas projects. (United Republic of Tanzania 2013: 9–10).

However, our own brief analysis points to the difficulties of some of these ambitions. In addition, investors have expressed some concern that the 'domestic market obligation' should not be so large that it threatens the viability of projects and it appears that the government is prepared to discuss the issue.

In conclusion, the case of Tanzania's natural gas illustrates the complex weighing of alternatives that has to take place in order to satisfy several different objectives at the same time. It also illustrates that there are rarely any simple solutions.

5   Conclusions

This paper has attempted to provide some basic information and analyses that could inform policy choices concerning downstream processing of both metals and oil and gas, and to show both the risks of policy decisions that are oriented towards meeting one single objective as well as the complexities that need to be taken into account in order to arrive at solutions that are both practical and sustainable.

Section 2 reviewed the reasons why forward vertical integration is not always an optimal choice for extractive industry companies and is certainly not one that will guarantee clear success for producers in lower income economies. While transport costs often argue in favour of such

integration, other technical factors, including economies of scale, availability of inputs, size of domestic market, and distance to markets, may outweigh this natural advantage. There appears to be little support for the argument that differences in market power dictate the geography of downstream processing. Relatively high tariffs on processed products may also play only a limited role and it is by no means certain that removal of all tariffs on processed goods for all countries would result in a major shift of processing capacity.

The review of vertical integration and processing margins in section 3 showed that the degree of vertical integration varies from product to product within the extractive industry. It appears to be mainly driven by production economics resulting from technology and less by corporate strategies. It is notable that the degree of downstream processing is relatively low in high income countries that would be expected to be able to exert some influence over markets, for instance, Australia in bauxite and iron ore, Chile in copper, and Sweden in iron ore. It would certainly be technically feasible for these countries to increase downstream processing. The fact that they have not done so would appear to argue that the attraction of downstream integration is not self-evident.

Processing margins tend to fluctuate, in some cases dramatically, which should give pause to all those companies or countries that consider investing in processing capacity. There is no evidence of systematic market failure in the processing industry; indeed, if anything, the trend of margins for the commodities studied appears to be declining.

Section 4 discussed government policies for downstream processing. Following a brief description of objectives and instruments, the rest of the section was devoted to a review of four country cases: India, Indonesia, and Zambia on nonfuel minerals, and Tanzania for natural gas. The three nonfuel mining cases all illustrated a linear policy approach to industrialization: if a raw material is produced in the country it should also be processed in the country. But they also illustrate the substantial pitfalls that can and do arise from this sort of approach. A common factor in the four cases is that a very limited amount of analysis appears to have been undertaken to justify the policies pursued: instead, political imperatives seem to have been driving the agendas.

In Zambia, a simple arithmetic example serves to show that the policy studied—the export tax on copper concentrates—is unnecessary and does not significantly influence processing decisions. It may, however, preclude the exploitation of some mineral deposits, thus needlessly limiting mine production.

In Indonesia, more effort seems to have gone into the formulation of the policy underlying the ban on exports of unprocessed minerals. While it can be argued that the government's forecasts of future processing capacity may be optimistic, the problem with the policy lies more in the abruptness with which it has been implemented.[21] In addition, the government has decided to provide very generous incentives to investors in processing capacity, and it is legitimate to ask who pays the cost in the final analysis: the investor or the Indonesian tax payer.

The Indian policy concerning iron ore mining and exports illustrates the difficulties of satisfying competing industrial interests who all turn to the government for solutions to their various problems. In trying to help the Indian steel industry to retain international competitiveness and, while probably believing that high iron ore prices would last long enough to limit the damage to the iron ore mines, the government succeeded in badly damaging a once successful export industry while leaving the steel industry in an uncertain situation with regard to its raw material supplies.

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[21] In all fairness, it has to be admitted that the law in question had been on the books for a considerable time.

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The Tanzanian example, finally, brings to light an important consideration that is usually absent from the debate about downstream processing, namely, the domestic market. In Tanzania the choice may be not between exporting unprocessed or processed products but between satisfying domestic needs—in this case, of rural electrification—and maximizing export revenues. This illustrates a basic and simple argument: that downstream processing policies should not be about how to maximize export revenue but about how to meet the needs of the economy. Downstream processing can be a successful operation if it is of the right size for the economy and grows out of a desire to meet a need rather than an ideology.

In conclusion, it is probably reasonable to point out that the presence of raw material resources constitutes only one of the factors that need to be taken into account when taking a decision on the location of a particular type of plant. Incentives or directives to promote downstream processing thus represents only one variation on the familiar theme of picking winners—and one based on a particularly narrow set of criteria. It would probably be more productive in most country cases to instead emphasize industrial policies that focus on removing constraints and bottlenecks that stand in the way of the economy reaching its full potential, including those relating to skills, credit, energy supply, transport infrastructure, and inappropriate regulation.

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Annex

Tables and graphs on vertical integration

The following tables and graphs provide more detailed background to the analysis made in section 3. Since tables and graphs for copper were included in the main text, only the data for bauxite/alumina/aluminium, and iron ore/steel are shown here.

A1. Vertical integration

Table A1: Bauxite processed into alumina within country of origin as per cent of total bauxite produced within the same country

	2000	2005	2010	2014
Australia	74%	82%	69%	59%
Brazil	69%	65%	78%	69%
China	100%	100%	100%	100%
Greece	70%	86%	84%	96%
Guinea	8%	10%	8%	0%
Guyana	0%	0%	0%	0%
India	83%	66%	53%	70%
Indonesia	0%	0%	0%	21%
Jamaica	86%	79%	44%	43%
Kazakhstan	86%	86%	73%	70%
Malaysia	0%	na	0%	0%
Russia	100%	100%	100%	100%
Surinam	100%	100%	100%	98%
USA	100%	100%	100%	Na
Venezuela	100%	90%	100%	98%
Total	63%	68%	62%	54%

Source: Authors' calculations based on Raw Materials Data (n.d.).

Table A2: Bauxite processed into alumina within country of origin as per cent of total alumina produced within the same country

	2000	2005	2010	2014
Australia	100%	100%	100%	100%
Brazil	100%	100%	100%	100%
China	71%	75%	64%	51%
Greece	100%	100%	100%	100%
Guinea	100%	100%	100%	0%
Guyana	0%	0%	0%	0%
India	100%	100%	100%	100%
Indonesia	0%	0%	0%	100%
Jamaica	100%	100%	100%	100%
Kazakhstan	100%	100%	100%	100%
Malaysia	0%	0%	0%	0%
Russia	67%	72%	81%	96%
Surinam	72%	90%	100%	100%
USA	2%	1%	1%	0%
Venezuela	94%	100%	88%	100%
Total	63%	68%	62%	54%

Source: Authors' calculations based on Raw Materials Data (n.d.).

Table A3: Alumina processed into aluminium within country of origin as per cent of total aluminium produced within the same country

	2000	2005	2010	2014
Australia	100%	100%	100%	100%
Bahrain	0%	0%	0%	0%
Brazil	100%	100%	100%	100%
Canada	24%	23%	21%	0%
China	67%	54%	84%	92%
Greece	100%	100%	100%	0%
Iceland	0%	0%	0%	0%
India	100%	100%	100%	100%
Indonesia	0%	0%	0%	0%
Jamaica	0%	0%	0%	0%
Kazakhstan			100%	100%
New Zealand	0%	0%	0%	0%
Norway	0%	0%	0%	0%
Oman			0%	0%
Qatar			0%	0%
Russia	42%	44%	34%	34%
Saudi Arabia				0%
South Africa	0%	0%	0%	0%
Surinam	0%	0%	0%	0%
United Arab Emirates	0%	0%	0%	0%
USA	61%	100%	100%	100%
Total	50%	51%	59%	69%

Source: Authors' calculations based on Raw Materials Data (n.d.).

Table A4: Iron ore processed into pig iron within country of origin as per cent of total iron ore produced within the same country

	2000	2005	2010	2014
Sweden	24%	25%	21%	17%
Kazakhstan	42%	34%	19%	24%
Russian Federation	83%	84%	79%	78%
Ukraine	71%	70%	53%	45%
Canada	43%	46%	34%	29%
United States	100%	100%	83%	84%
Brazil	21%	18%	13%	10%
Bolivarian Rep. of Venezuela	..	65%	42%	37%
Mauritania	0%	0%	0%	0%
South Africa	36%	31%	18%	14%
India	55%	42%	46%	89%
China	100%	100%	100%	100%
Australia	7%	4%	2%	1%
Total	47%	49%	41%	30%

Source: Authors' calculations based on data from World Steel Association (2015) and UNCTAD (2015).

Table A5: Iron ore processed into pig iron within country of origin as share of total iron ore produced within the same country by the same company

	2000	2005	2010	2014
Sweden	0%	0%	0%	0%
Kazakhstan	42%	34%	19%	24%
Russian Federation	83%	84%	79%	78%
Ukraine	71%	70%	53%	45%
Canada	43%	46%	34%	29%
United States	100%	100%	83%	84%
Brazil	21%	18%	13%	10%
Bolivarian Rep. of Venezuela	..	65%	42%	37%
Mauritania	0%	0%	0%	0%
South Africa	0%	0%	0%	0%
India	55%	42%	46%	89%
China	100%	100%	100%	100%
Australia	7%	4%	2%	1%

Source: Authors' calculations based on data from World Steel Association (2015) and UNCTAD (2015).
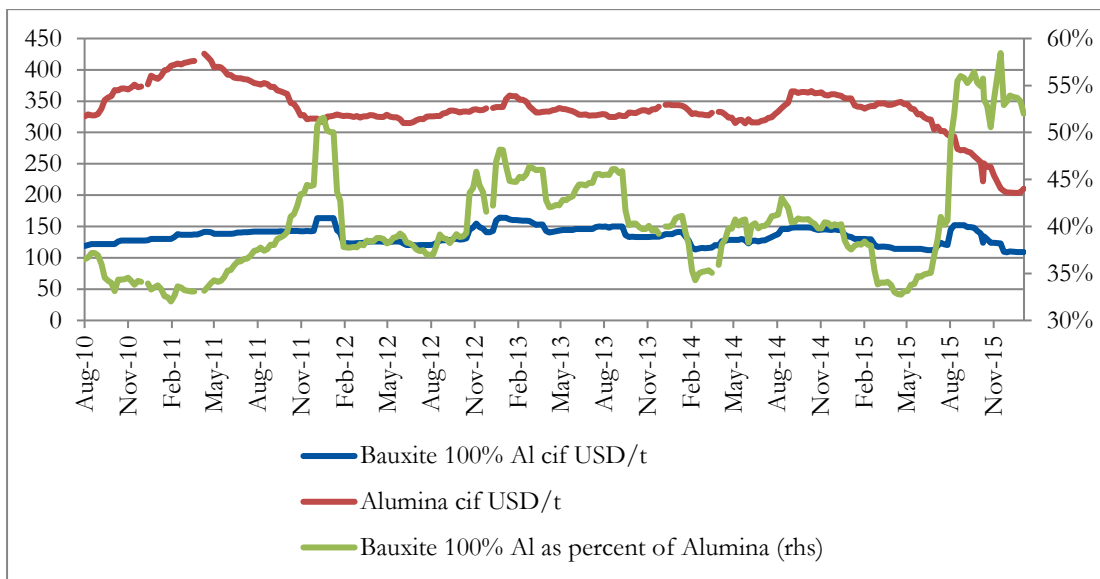
Figure A1: Share of world iron ore output produced by steel companies
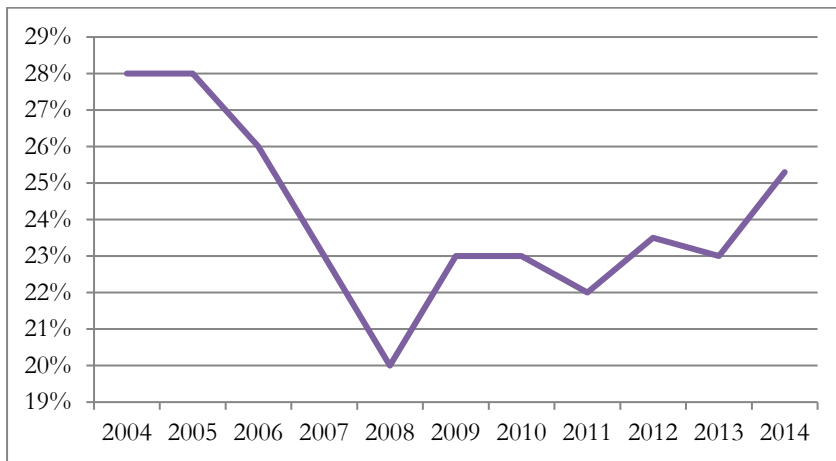
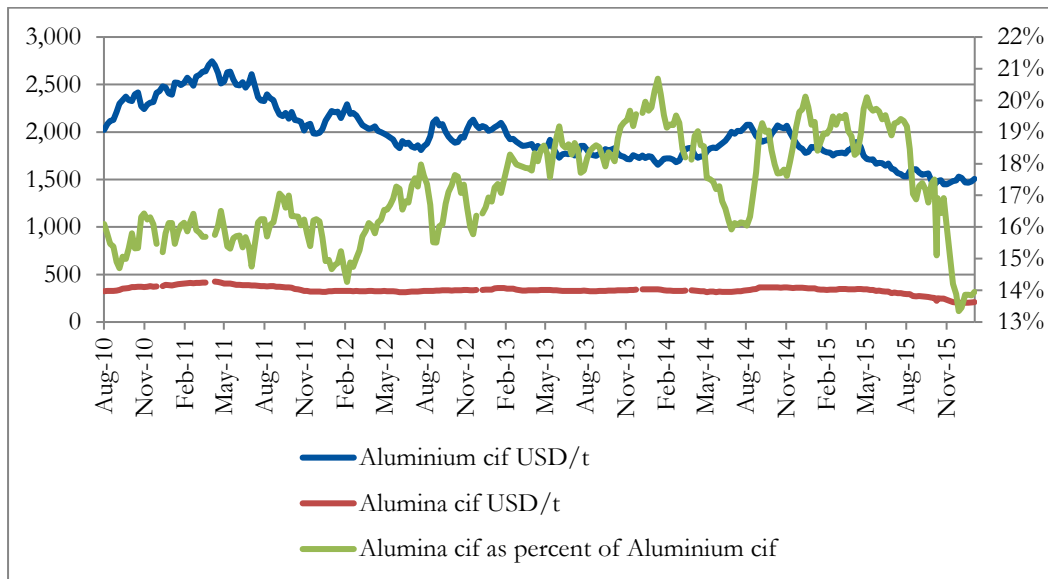Source: Authors' calculations based on data from UNCTAD (2015).

A2. Processing margins

Figure A2: Bauxite price and alumina price, August 2010–January 2016, US$/tonne

Bauxite 100% Al cif USD/t
Alumina cif USD/t
Bauxite 100% Al as percent of Alumina (rhs)

Sources: Authors' calculations based on S&P Global (n.d.a), Metal Bulletin (n.d.).

Figure A3: Alumina price and aluminium price, August 2010–January 2016, US$/tonne
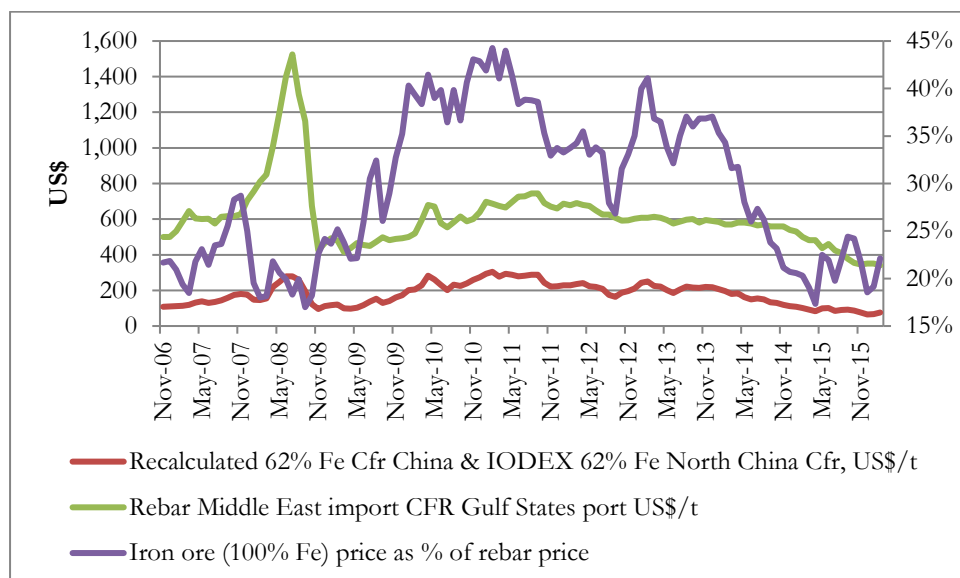

Source: Authors' calculations based on London Metal Exchange (n.d.), Metal Bulletin (n.d.).

Figure A4: Change on previous period (monthly), bauxite price, the difference between alumina price and bauxite price and the difference between aluminium price and alumina price, August 2010–January 2016, US$/tonne
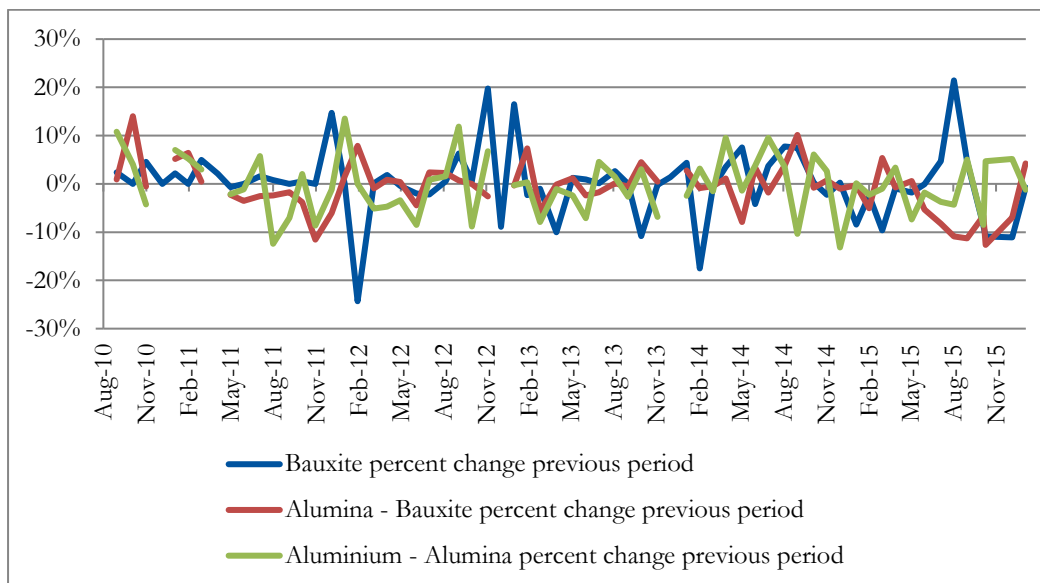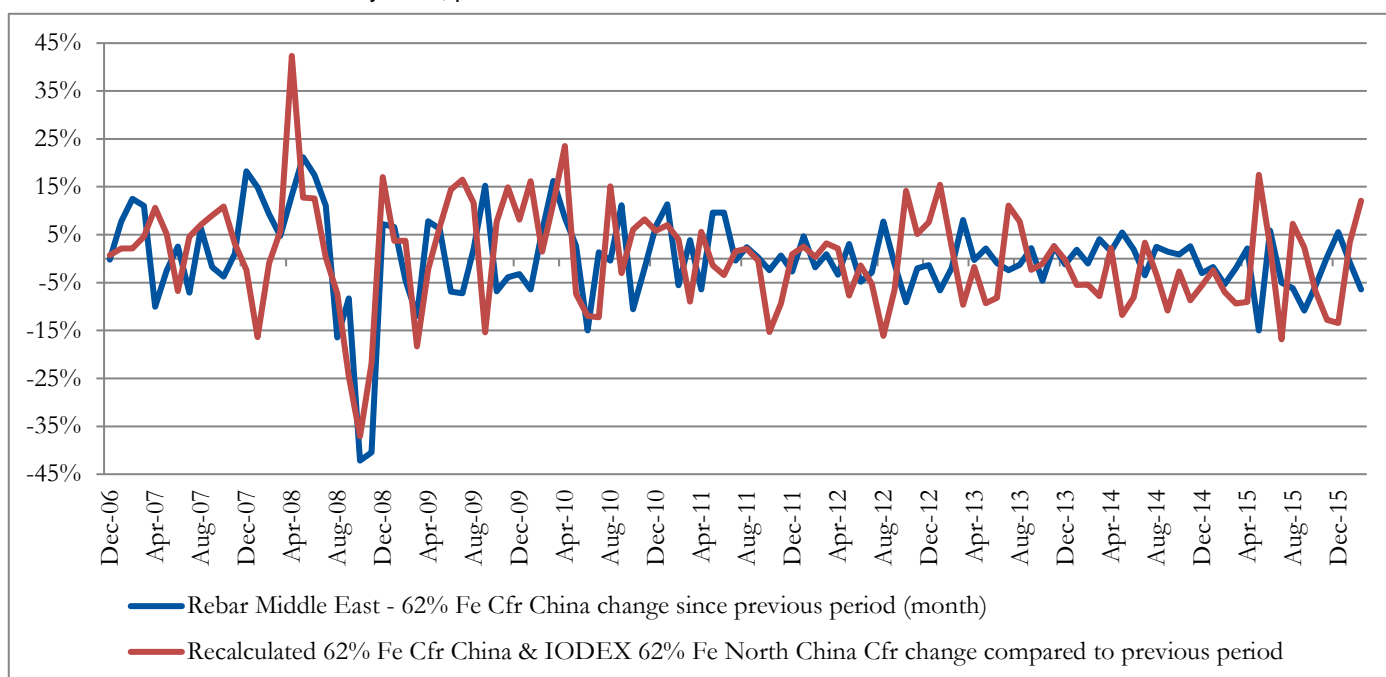

Source: Authors' calculations based on S&P Global (n.d.a), Metal Bulletin (n.d.), London Metal Exchange (n.d.).

Figure A5: Prices of iron ore and rebars, November 2006–February 2016, US$/tonne Fe

Source: Authors' calculations based on UNCTAD (2015), S&P Global (n.d.b), S&P Global (n.d.c).

Figure A6: Change on previous month, iron ore prices, and the difference between rebar and iron ore prices, November 2006–February 2016, per cent

Source: Authors' calculations based on UNCTAD (2015), S&P Global (n.d.b), S&P Global (n.d.c).