Economic Effects of Indonesia's Mineral-Processing Requirements for Export

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Cover photo courtesy of PT Vale, Indonesia.

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Abbreviations

CGA	Chemical-grade alumina
COW	Contract-based concessions
FOB	Free on board
HPAL	High-pressure acid leaching
kt	Kilo tonne
kWh	Kilowatt-hour
LME	London Metal Exchange
MT	Metric tonne
MEMR	Ministry of Energy and Mineral Resources
NPI	Nickel pig iron
PGM	Platinum group metals
SGA	Smelter grade alumina
Rp	Indonesian rupiah
TC/RC	Treatment and refining charge
Te-CU	Telluride Copper
USD	U.S. dollar (= 9,600 Rp)

Introduction

Under Indonesia's Law on Mineral and Coal Mining No. 4/2009 and Implementing Regulation No. 7/2012 issued by the Ministry of Energy and Mineral Resources (MEMR), a ban on export of unprocessed mineral resources will take effect in January 2014. This regulation applies to metal-based minerals, nonmetal based minerals, and rocks and sets out minimum processing requirements for various minerals. The stated purpose of this mandatory in-country processing requirement is to increase the value of the minerals for export and preserve the country's resource supplies.

This study examines the economic implications of the approaching export ban and looks at alternative policy approaches to realizing more from the country's resource endowments and improving export quality. Section 1 considers the financial feasibility of downstream processing investments in Indonesia in three of the country's most important export minerals—bauxite, copper, and nickel—because the mineral processing requirement will compel miners and processors to consider investments in additional processing capacity.

The financial feasibility of processing, however, is only part of a full evaluation of the impending export ban. Judging the benefits and costs of such a trade policy requires an assessment of welfare gains and losses to economic agents and efficiency costs to the economy. Therefore, section 2 investigates welfare effects of the processing requirement under various assumptions about the probable impact of the ban on domestic prices of unprocessed minerals and on increases in processing capacity.

Finally, the idea behind the export ban strategy is that it is a logical, natural progression for a country exporting raw materials to move downstream into the processing of these materials, and therefore policies encouraging such downstream processing can improve trade performance and accelerate structural transformation of the economy. Section 3 looks at the wisdom of this notion and the forward-linkage approach to export development, given international experience and the structure of world trade today. Section 4 sets out policy conclusions that emerge from the study.

We find that the export ban is a poor policy instrument for achieving the stated goals of the export restrictions. First, the ban is a blunt instrument that does not recognize the significant differences among important export minerals in the financial feasibility of downstream processing. Neglecting these differences in investment prospects does not make sense if the goal is to increase export value added and export earnings. Copper smelting, compared with the other minerals, is shown to generate very little value added and may, in fact, actually produce negative value added in Indonesia, given the cost structure of greenfield copper smelters. In addition, if no new copper smelting capacity is forthcoming after the ban, because, as section 1 of this study shows, it is not financially feasible in Indonesia, there would be large export revenue losses in copper concentrates that could not be offset by increased processing capacity in other minerals.

Second, the ban inflicts large net welfare losses on the mining industry and creates deadweight efficiency distortions in the economy. Miners would experience large revenue losses from a decline in exports and from falling prices of unprocessed minerals on the domestic market. Total net welfare losses would also include substantial government revenue losses in royalty and income taxes. We look at three scenarios about new investments in processing capacity, based on the MEMR's list of planned new processing investments in copper, nickel and bauxite that could occur after the ban and estimate the welfare effects of each: (1) no additional processing capacity; (2) some new processing capacity; and (3) all of MEMR's Planned New Processing Investments Become Operational in 2020. In addition, we present assumptions about the extent of decline in domestic prices of unprocessed minerals after the ban. In addition to offering insight into the welfare effects of the ban according to level of processing capacity and domestic price decline, the scenarios together produce a timeline of processing investments through 2020.

The largest net welfare losses occur in scenario 1, when no new processing comes on stream and domestic prices of unprocessed minerals decline by 50 percent. Net annual welfare losses total $6.3 billion per year, and a deadweight efficiency cost to the economy of $1.5 billion per year is produced. Total export earnings, the direct professed target of the ban policy, fall by $6.0 billion per year. In scenario 2, three years after the ban, when some processing capacity is forthcoming in nickel and bauxite, net welfare losses decline to $5.2 billion per year, but the deadweight efficiency burden to the economy due to the ban policy continues at a level of $1.5 billion per year. Total export earnings decline by $4.9 billion per year. In scenario 3, when all MEMR's planned processing capacity is assumed to be operational in 2020, yearly net welfare effects of the ban finally become positive. But total net welfare gains are modest, totaling 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.

A better approach than a sweeping export ban on unprocessed minerals would be a selective policy, aimed at downstream processing in specific minerals with profitable investment profiles and with some competitive promise in raising export earnings. The policy should be based on first-best economic principles to avoid collateral damage, which call for targeted interventions directed at the competitiveness of downstream processing, rather than indirect interventions, such as an export ban on all unprocessed minerals, to subsidize downstream processing through declining domestic prices of these minerals.

The overall best approach to getting more out of the country's natural resource endowments is to focus on the fiscal side of the minerals industry, rather than on the production side of the industry where distortions can be costly. Changes in the royalty and income tax regime would appear to be the most effective, least-costly policy approach.

There is also a question of whether one wants to direct policy to downstream minerals processing at all when other, lateral (rather than vertical) competing economic activities may be more cost effective in improving export quality, raising export earnings, and fostering employment. As this study argues, forward-linkage strategies, such as an export ban to stimulate downstream processing, are a poor guide for formulating export development policy. International experience shows that forward linkage–based policies do not work as intended, and they do not make much sense in a world where trade costs have fallen substantially and supply chains make it easier to insource and outsource links in the production chain.

1. Financial Feasibility of Mineral Processing

The restriction on exports of unprocessed minerals under MEMR Regulation No. 7/2012 compels mining companies and mineral processors to consider investments in additional smelting and refining facilities. One of the first questions about the impact of this export restriction is whether under normal conditions before the ban such investments would be commercially viable. And, if not, what would be the size of subsidy needed to entice investors to build the required processing capacity? In examining these questions, we abstract from the fact that an export ban will cause domestic prices of unprocessed minerals to fall, providing an incentive to processors. We address the impact of a fall in domestic prices in the analysis of welfare gains and losses in the next section.

The legislative environment in which mining and mineral processing firms will be operating in the next few years affects our analysis. First, uncertainty exists about the implementation of the requirement for in-country processing for mining and mineral processing companies with contract-based concessions. Interviews with the industry suggest the possibility of exceptions being granted to contract-based concession holders, whose contracts appear to shield them against the pending processing restriction. We simplify the analysis by assuming that all producers will be subject to the same treatment irrespective of the licensing and contract form under which they operate. Second, we assume that the authorities will implement the export restrictions on unprocessed minerals fully in 2014, as spelled out in MEMR Regulation No. 7/2012.

Indonesia has substantial mineral wealth and supplies significant amounts of minerals and metals to the international market. The purported objective of the proposed in-country restriction on exports of unprocessed metal minerals is to strengthen incentives for metal miners to integrate further downstream and so to add to the value of their exports. Any assessment of the restrictions to be introduced must keep in view some key characteristics of the metal mineral processing industries: These industries are exceedingly capital and energy intensive; they are intensive users of environmental resources; investments in individual facilities are typically large to reap benefits of scale; and they add little employment.

Table 1-1 provides figures for the top seven export materials, divided into those potentially subject to the export ban and those sufficiently processed and therefore not subject to the export ban. The table also includes tin to demonstrate its importance. The top four materials together cover more than 90 percent of the exports of all metals and minerals covered by the legislation, or 75 percent if tin is excluded. One-half of the total export value of the four materials comes from products meeting the intended legislative requirements. The table also shows that strict implementation of the ban could disrupt $7 billion of exports. Copper exports would decline the most, while tin exports would not decline at all, although the new regulation to increase the purity of processed tin exports could cause problems.

Table 1-1

Value of Main Minerals Subject to Processing Regulations, 2011 (US$ 000)

Mineral	Total	Unprocessed[a]	Processed[b]	Unprocessed Share of Total (%)
Copper	7,243,646.27	4,700,354.00	2,543,292.27	65
Nickel	3,108,097.60	1,428,040.11	1,680,057.49	46
Tin	2,428,696.25	-	2,428,696.25	0
Bauxite, aluminum	1,141,728.53	773,199.85	368,528.68	68
Iron	926,048.44	348,600.73	577,447.71	38
Lead	12,055.14	3,420.13	8,635.00	28
Zinc	1,054.30	1,054.30	-	100
Total	14,861,326.53	7,254,669.12	7,606,657.40	49

[a] *Potentially subject to ban*
[b]*Exportable*

Source: World Bank WITS database, 2012

For tractability, the feasibility analysis has to be selective, because many of Indonesia's exportable minerals are subject to the ban. Our analysis, therefore, covers only aluminum, copper, and nickel, three of the most important metals in the world economy and in Indonesia's mineral sector production and exports. Tin is excluded despite its importance in Indonesia's metal mineral industry because export restrictions on unprocessed tin have been in force since the early years of the present century. These restrictions established a tin-export processing requirement of 99.85 percent purity, but the restriction tightened recently to require 99.99 percent purity. Although the change is expected to have an impact on tin mining and processing, the change occurred after our visit to Indonesia, so data on the effects of the change were not available for analysis.

Table 1-2 presents the quantity and unit values of bauxite, copper, and nickel exports. It highlights the differences in quantities and unit values of raw materials and processed metals—the difference in unit value between raw and processed metals is in all cases large.

Table 1-2

Processed and Unprocessed Bauxite (Aluminum), Copper, and Nickel, 2011, Quantity (tons) and Value (000 USD)

Product Description	Quantity	Unit Value	Trade Value
Aluminum ores and concentrates[a]	**40,643,852**	**19.02**	**773,199.85**
Aluminum, not alloyed, unwrought	136,149	2,386.89	324,974.32
Bars, rods, and profiles of aluminum, not alloyed	372	5,222.35	1,947.71
Bars, rods, and profiles (excluding hollow profiles) of aluminum alloys	10,248	4,059.61	41,606.65
Copper ores and concentrates[a]	**1,471,420**	**$3,194.43**	**4,700,354.00**
Cathodes and sections of cathodes, of refined copper, unwrought	130,170	8,979.74	1,168,897.13
Nickel ores and concentrates[a]	**40,792,164**	**$35.01**	**1,428,040.11**
Ferronickel, in granular or powder form	78,837	5,963.15	470,120.74
Nickel mattes	82,216	14,716.40	1,209,936.75

[a]*Will be subject to in-country processing requirements*
Source: World Bank WITS database, 2012

An evaluation of the benefits of a policy that aims to promote forward processing must cover the size of the value added in the processing of each material, the reduction in transport costs as the material becomes more compact, and the added employment created by the processing activity. It also must assess the costs of generating market value at each stage of the processing chain, including financial costs, and potential costs in terms of (1) environmental damage; (2) absorption of capital for the processing plant and ancillary facilities—capital that could otherwise have been spent elsewhere; and (3) miners' negative reactions to the policy, such as unwillingness to invest in mining, which might result ultimately in contraction of the metal mineral sector. These and other benefits and detriments are considered in our analysis.

Downstream processing often has clear-cut advantages arising from the geographical proximity between the processor and the raw material source. Under normal market circumstances, no special incentives should be required for establishing a processing plant close to a mine. In two respects, however, the years since 2005 have been far from normal.

First, prices of minerals rose to historically high levels and have remained there. This has resulted in high profits from mining, which often creates tension between the partners in exploitation. Miners have been eager to invest in expanding mining capacity, because mining has generated large profits through sales in international markets. Indonesia's MEMR asserts that the country's bauxite exports rose fivefold between 2008 and 2011, while copper concentrate exports increased eleven-fold, and exports of laterite nickel ore increased eightfold in the same period. But the government's inability to share in the profits generated in the years of high prices has created a feeling that the nation is being defrauded of its patrimony. This is part of the reason for the government's outcry for increased value added through downstream processing.

Second, smelting and refining of most metal minerals around the world have expanded, and much faster than mining output has expanded. This expansion has created substantial surplus capacity and depressed return on investment for mineral processors. China has been in the vanguard of this expansion, but even the Chinese smelting and refining installations, established at internationally low costs, can barely scrape by on the low returns that they receive. This is therefore *not* an opportune time for investing in metal mineral processing capacity. In present circumstances, substantial public support is needed to make new mineral processing plants commercially viable, even those in attractive, low-cost locations.

This background should be kept in mind in the analysis of investment in processing installations in Indonesia's aluminum, copper, and nickel sectors. Our analysis is predominantly based on the figures collated in Tables 1-3, 1-4 and 1-5. The data refer to indicative conditions in the 2009–2011 period. They were obtained from official Indonesian statistics, mining and smelting companies in Indonesia and elsewhere, the U.S. Geological Survey, international study groups such as CRU International, and similar organs catering to the three materials.

Our assumptions differ from those used in a recent Bandung Institute of Technology (ITB) study, commissioned by the Indonesian Mining Association (IMA), that examines the feasibility of smelters based on the assumption of steady annual increases of 1 percent in mineral prices[1] because given the volatility of commodity prices (volatility is a high risk in

[1] Technical Assessment and Economic Feasibility of Smelters for Five Main Minerals, November 2012

mining industry investment),[2] this assumption is overly optimistic. The study also assumes a 2 percent increase in smelting costs over time. Other studies have shown that smelter construction costs have increased rapidly in recent years, faster than the assumed 2 percent rate. Differences in greenfield construction costs for different minerals, and how these costs have changed in the past few years, are discussed in detail in the sections below. We also report the ITB/IMA study results for each mineral in the tables below as more data for consideration.

ALUMINUM

Aluminum is produced in three stages. Bauxite, the raw material, is generally mined in shallow, open-pit deposits. Bauxite contains 25 percent alumina, which is high compared to the 1–4 percent metal found in the ore of most nonferrous metals, so there is no need for the common metal processing step of concentration. Instead, after mining, the next processing step is refining bauxite into alumina, which means raising the metal content to 50 percent. The third and last step is smelting, an extremely power-intensive process, to obtain pure aluminum, typically in the form of ingots. Here again, aluminum processing is different from most nonferrous metal processing, because most other metals require further refining after smelting. Beginning in 2014 Indonesian exports will have to be alumina (more than 99 percent pure alumina), or aluminum metal.

Indonesia's aluminum industry is fragmented. The bauxite industry consists of many small miners operating under local licenses, and one large government owned firm, PT Antam. The country has one large smelter, Inalum, producing aluminum from imported bauxite. PT Antam is also building a chemical-grade alumina (CGA) plant, which will use domestic bauxite. It is also planning a smelter-grade alumina (SGA) plant, as is Harita Prima Abadi, another company considering investment in smelting. Table 1-3 shows production and planned production for bauxite and alumina in Indonesia. Even if all planned refineries come on stream, 80 percent of the country's bauxite will remain unabsorbed domestically, which will lead to the large-scale exit of small miners.

Table 1-3
Current Bauxite Production and Planned Processing in Indonesia (tons)

	Amount	Companies
Mining production (2011)	40 million	PT Antam, small miners (hundreds)
Exports (2011)	40 million	
Planned processing—underway (2014)	1.1 million	PT Antam
Planned processing-potential (after 2014)	6 million	PT Antam, Harita Prima Abadi
Balance	32.6 million	

Source: Indonesia MEMR, 2012

Our assessment, based on indicative FOB and London Metal Exchange (LME) market prices (see Table 1-4), indicates that bauxite mining adds 6 percent or approximately $144 per ton to the final aluminum product; alumina refining adds 32 percent, or $774 per ton; and smelting contributes 62 percent, or $1,501 per ton. While the smelting stage of processing adds the lion's share of market value, it also incurs the lion's share of costs.

[2] Ernst & Young "Business risks facing mining and metals 2012-2013", 2011.

Approximately 85 percent of the cost incurred in producing a final ton of aluminum ingots is sustained at the smelting stage. As a result, smelting is a low-margin activity compared with the other stages of production. The gross margin in smelting is only about 20 percent, while alumina refining is 40 percent, and mining bauxite is 100 percent.[3] These estimates of margins do not include the costs of complementary infrastructure—i.e., new power plants, roads and other facilities—that would be required to make refining and smelting commercially viable in Indonesia. The costs of such complementary investments could drive margins in refining and smelting much lower and perhaps even into negative territory

Table 1-4
Aluminum Processing Chain

Product Stage	Bauxite	Alumina	Aluminum
PROCESSING STAGE VALUE			
Process	Mining	Refining	Smelting
Metal Content (%)	25	50	100
Market FOB price ($/t)[a]	36	376	2,419
Market value ($/t in final metal product)	144	774	1,501
% of market value in final metal product	6%	32%	62%
PROCESSING STAGE COST CALCULATIONS			
Total investment for new plant: mine/alumina (1.4 kt /smelter 700 kt)	500 million	2 billion	3.5 billion
Investment capital, ($/t metal)		1,400	5,000
Interest + depreciation cost on capital ($/t) [a]		210	750
Power costs, ($/t) [b]		90	621
Mining, processing, smelting operating costs ($/t)[b]	18	269	2,003
Gross margin[c]	18	107	416
Gross margin (%)	100	40	20
Employment, number of workers		500	1,000
GLOBAL MARKET DATA			
Global output (2010 mt metal content)	52	46	44
Global capacity (mt metal content)		57	56
Excess capacity (% of output)		24	27
Indonesia exports (mt, 2011)	40.6	0	0.136

Notes
t=metric ton; kt=000 tons; mt=million tons; bn=billion; met=metal

Processing requirements for exports from 2014: Either pure alumina (>99% alumina content), or pure aluminum metal (>99% metal content).

Bauxite (Trombetas FOB), alumina (Australia FOB), aluminum (LME-3month). Bauxite prices vary according to grade and quality, and according to a formula linked to alumina or aluminum prices. Alumina prices are set in yearly contracts or on the basis of a formula linked to the LME aluminum price.

[a] Assumed at 15% of investment capital per ton of metal capacity.

[b] Based on average power costs for smelters and power and fuel costs for typical alumina refinery from CRU International.

[3] A study of alumina smelting by ITB/IMA, shown in table1-4, found that a greenfield alumina plant would have a net present value of $133 million, an internal rate of return of 13 percent, and a 20-year payback period.

[c]*Gross margin—Indicative market prices from (a) minus indicative operating costs for (b).*
Source: Average operating cost per ton estimates from CRU International (2011).

Sources: British Geological Survey, World Bureau of Metal Statistics, Wood MacKenzie, and Comtrade.

Alumina refining and aluminum smelting plants have substantial economies of scale and are highly capital intensive. An alumina plant refining 1.4 million tons per year (weight after refining) requires investment of $2 billion; an aluminum smelter with 700 kt capacity would require about $3.5 billion. The alumina plant therefore requires an investment of $1,400 per ton of refined metal and the aluminum smelter an investment of $5,000. Assuming interest and depreciation at 15 percent of these investments, capital costs would amount to $210 per ton of alumina and $750 per ton of aluminum in the two processing stages. Energy requirements are also onerous. Power costs in aluminum smelting average 31 percent of total cost, or about $621 per ton of metal. In alumina refining, energy costs average approximately 33 percent of total cost, or $90 per ton of metal. But these energy-intensive processing activities generate exceedingly small employment numbers. Labor costs are only 9 percent of total cost in a typical alumina refinery, which generally employs about 500 workers, and 7 percent in an aluminum smelter, which employs an average of only about 1,000 workers.

Global output at the three stages of aluminum production and estimates of world excess capacity in processing are presented in the final rows of Table 1-4. World alumina refining data show excess capacity equal to 24 percent of output, while excess capacity in smelting is estimated to be 27 percent. And there is more new alumina and aluminum capacity slated to come on stream in the next 5 to 10 years, with an additional 8 million tons per year planned in China and a similar amount elsewhere in low-cost power regions, such as the Middle East, Iceland, and Malaysia (CRU International 2012). Overcapacity at these levels helps to explain the weak economics of greenfield alumina and aluminum processing plants.

Table 1-4 shows Indonesia's current output. Bauxite does not undergo any processing in country. In 2010, Indonesia's bauxite production of 40.6 million tons accounted for 13 percent of the world total, and total production was exported.[4] There is no domestic alumina production, and all the alumina needed by the country's single aluminum smelter, Inalum, located in Northern Sumatra, is imported. A refinery to produce 550 kt of chemical alumina, to be run by state-owned Antam, is scheduled to become operational in 2013 according to press reports, but this alumina is not suited for aluminum metal smelting. The MEMR also expects an Antam SGA plant that would use 4 million tons of bauxite to be in production by 2014. But, as with many of MEMR's projected investments in processing capacity, it is doubtful that this plant could become operational by the 2014 deadline for domestic processing. Even if these two plants open by 2014, more than 32.6 million tons of bauxite production will still be threatened by the export ban on unprocessed mineral.

The relatively low margin on greenfield aluminum smelting projects can be juxtaposed against local press coverage in October 2012 of the government's intention to take over full ownership of Inalum, the aluminum smelter, from the Japanese majority owner, and the Japanese offer to finance an expansion of capacity from 250 to 320 kt, subject to the maintenance of their ownership position. This indicates on both sides that the operation and its proposed expansion must be reasonably profitable. Three arguments can reconcile this apparent profitability with the smelter economics numbers elaborated in Table 1-4. First, the Inalum smelter is about 30 years old. When it was built, construction costs were

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[4] Figures for Indonesia's bauxite production and trade conflict.

substantially lower than they would be today, and since then most of the invested capital has been written off. Second, the expansion considered by the Japanese is construction of installations internal to the complex. Last, the Inalum smelter has the substantial advantage of all the external infrastructure it needs, and in particular, low-cost, dedicated electricity from the Asahan hydropower plants at the remarkably low cost of less than $0.01 per kWh (while the industry average in Indonesia is $0.8 to $0.9 per kWh).

The success of any future investment in mining or smelting and refining in the aluminum production chain will depend on a number of factors. In bauxite mining, a key factor is access to land and mineral rights. Indonesia's challenges with decentralization and the mine permitting process present constraints to sustainable new mine development and management of government trade policy in such minerals. Additional business environment issues affecting mining investment decisions are taxation and requirements for domestic processing of raw materials. If enough domestic alumina refining capacity is not forthcoming by 2014, a ban on unprocessed bauxite exports will cause domestic bauxite prices to fall, reducing incentives for local mining.

Access to low-cost bauxite is a key competitiveness factor in alumina refining. Declining domestic bauxite prices should therefore be a major plus in the longer run in decisions to locate new alumina refineries in Indonesia. Working against this incentive for plant location, however, will be lack of infrastructure, particularly power supply, which is a major input in alumina refining, as well as access to technology and finance. And, while China is an important determinant of rising international demand for alumina, it is also a major low-cost competitor in refining and a source of excess capacity. Feasibility assessments for new capacity in alumina refining will have to take into consideration China's low-cost, surplus refining facilities. New capacity would have to compete with existing plants and not end up a high-cost producer vulnerable to the historic volatility in alumina prices.

Low-cost power is the main determinant in locating an aluminum smelter—Inalum provides a prime example with its subsidized power. Considering Indonesia's power development deficits, greenfield investments in aluminum smelting do not appear commercially viable. Besides this, several other factors should rule out aluminum smelting as a significant policy option: (1) low margins in aluminum smelting compared with returns in other segments of the aluminum value chain; (2) China's low-cost, excess capacity in aluminum smelting, which has grown 10-fold in the past decade; (3) the opportunity cost of huge capital investments required to establish a smelter complex; and (4) the lack of major contribution to employment.

COPPER

Copper mining in Indonesia is dominated by two major companies—Freeport McMorRan and Newmont Mining Corporation. Freeport's Grasberg mine is one of the largest copper mines in the world, controlling almost three-fourths of Indonesia's total copper production. Some lower-quality ore is produced by smaller mines, but these mines' share of the market is insignificant. Both Freeport McMorRan and Newmont Mining process their copper ores into concentrates, and supply part of it to the only smelter in the country—P.T. Smelting. The remainder is exported. Table 1-5 presents details of current and planned production and processing in copper.

Table 1-5
Production and Planned Processing of Copper in Indonesia (kt)

	Amount	Companies
Mining production (2011)	2,380 kt	Freeport McMoRan (73%), Newmont (24%), Others (3%)
Exports (2011)	1,480 kt	N/A
Current processing	900 kt	PT Smelting
Planned processing—underway (2014)	0	N/A
Planned processing—potential (post-2014)	1,986 kt	Nusantara Smelting (20 million kt ore), Global Investindo (34 million kt ore), Indosmelt (11 million kt ore)
Balance	0	N/A

Source: Indonesia MEMR, 2012

Copper processing is different from aluminum processing in several ways. Copper is obtained from very meager ore, often containing less than 3 percent metal. Therefore the first processing stage is to transform the ore into a concentrate with a metal content of about 30 percent. The concentration stage is conducted near the mine to obviate prohibitively high transport costs for the raw ore. All Indonesian copper output is concentrated at the mine.

In the ensuing smelting process, the material is upgraded to blister, a brittle material that is useless in itself, containing 98–99 percent metal, which has to be sent for refining, the next stage, often in the same processing complex, to obtain refined copper, the final product containing in excess of 99 percent metal.

Most important for the feasibility of further downstream processing is the fact that 96 percent of copper market value is created in the mining and concentration stages of processing (see Table 1-6). Only 4–5 percent, or about $352 per ton of a total refined copper price of $8,800 per ton, is realized in the smelting/refining stage, where the metal content of the product is raised from 30 percent to 100 percent. When selling concentrates to smelters, miners sell the metal value of copper, and also sell 99.7 percent of gold value, 98.6 percent of silver value, and most of the metal value of other metals, such as platinum and palladium in by-products. The small remaining percentage of gold and silver and other metals goes to the smelter (PT Smelting 2012). This contrasts sharply with aluminum processing, where about two-thirds of the final market value of the product is created in the smelting stage, albeit at exceedingly high cost.

Smelting and refining charges, or treatment and refining charges (TC/RC), for processing copper concentrate are low and have fallen by 60 percent in the past 15 years, mainly because of growing Chinese smelting capacity, which has been expanding at the rate of more than 10 percent a year for two decades. As a result, long-term, contractual TC/RCs averaged just 14.4 cents per pound ($317 per metric ton) in 2011 and have not exceeded 25 cents per pound since 1997 (Brook Hunt 2011). At this level TC/RCs are generally inadequate to cover the full cost of processing. Smelter revenues, as a consequence, rely on by-products created in this final processing stage—sulfuric acid, free metal in concentrate, and precious metal.

Table 1-6
Copper Processing Chain

Products	Concentrate	Copper Cathode
PROCESSING VALUE		
Process	Mining and concentrate	Smelting and refining
Metal content	30%	100%
Market LME price ($/t)a	8,400	8,800
% market value in final metal product	94–96%	4-6%
PRODUCTION STAGE COSTS		
Investment for new 200 kt smelter ($)		1.2 billion
Investment $/t metal		6,000
Capital cost = interest + depreciation		518
Operating cost ($/t)[d]		608
Of which, power cost $/t (5, 000 Kwh)[c]		250
Smelting/refining credits ($/t)[e]		315
Net smelting costs ($/t)[f]		811
Mining/smelting and refining cost ($/t)	1,700–2,500 (new mines 3,800)*	317**
Gross margin ($/t)[b, c]	5,900–6,700 (new mines 4,600)	-494
Gross margin (%)	100–350% (depending on mine age)	n/a
NPV; IRR; payback period[g]		-$963 million, <0, 30 years
Employment, number of workers		800
GLOBAL MARKET DATA		
Global output 2011 kt	14,000	
Global smelting excess capacity 2011 kt[j]		7,100
Excess capacity (%)		51
Indonesia exports mt 2011	1.47 (metal content 524 kt)	0.13

Notes:
t=metric ton; kt=000 tons; mt=million tons; bn=billion; met=metal
Processing requirements for exports from 2014: Refined cathodes (>99% metal content).
[a] *Based on average 2011 LME copper price for smelted copper and concentrate price of 96% of the LME price.*
[b] *Cost estimates and gross margins for mines and smelters from CRU International 2011 and PT Smelting. When selling concentrates to smelters, mines realize metal value of copper, gold, silver less negotiated TC/RCs, which averaged $0.144 per pound in 2011, or $317 per ton (2204.62 lb = 1 mt).*
[c] *Gross margin in smelting = net smelting cost (see f below) - TC/RCs. Data from CRU International 2011, Brook Hunt 2011, and PT Smelting 2011.*
[d] *Based on average 2010 costs of 50 international smelters, Brook Hunt 2012; total operating cost of a typical new brownfield investment in Europe (including interest and depreciation but excluding credits) is about $1,100/t and for a greenfield investment in China, $892/t (CRU International 2011).*
[e] *Smelting credits = copper cathode premium, $55/t; copper credit, $183/t; sulfuric acid credit, $62/t; other credits, $15/t.*
[f] *Net smelting cost = operating costs + capital costs (interest and depreciation)—smelting credits (PT Smelting 2012).*
[g] *Source: ITB/IMA Study*

** Mining costs for new mines today run as high as $3,800/t.*

*** Because TC/RCs are low, smelter revenues and margins depend on by-product credits, such as sulfuric acid, free metal in concentrate, and precious metal by-products, such as silver and gold.*

**** Assumed at $0.05/Kwh. The average power price paid by the industry in 2011 was $0.8–$0.9/Kwh.*

[j] *Data from CRU International 2012*

The full costs of smelting and refining in a typical greenfield plant are shown in Table 1-6. Operating costs average $608 per ton, while capital costs in the form of interest and depreciation add another $518 per ton, for a total cost of $1,126 per ton. By-product credits are then subtracted from these costs to arrive at the net cost of smelting and refining. Smelting credits tally up to $315 per ton—copper cathode premium, $55/t; copper credit, $183/t; sulfuric acid credit, $62/t; other credits, $15/t. Subtracting credits from operating and capital costs yields net smelting and refining costs of $811 per ton. Comparing these net costs with TC/RC revenue of $317 per ton highlights the problem with greenfield copper smelters today. Given this cost structure and prevailing TC/RCs, it is an exceedingly low-return business—for copper, as presented in Table 1-6, gross margin is a negative $494 per ton. According to CRU International figures, only Chinese greenfield copper smelters, which operate with net costs of about $570 per ton, appear close to breaking even. Even these plants, however, would have negative gross margins of approximately $250 per ton given current international TC/RCs.[5]

On top of poor operating margins, a greenfield copper smelting complex with capacity to treat 200 kt of metal is substantial would require capital expenditure of $1.2 billion—$6,000 per ton of capacity. This is a 70 percent increase in over what it cost six to seven years ago and a major reason why few greenfield smelters are being constructed outside China—most investment today is in brownfield plant expansions. Capital requirements for a greenfield copper smelter in China have not risen as fast and remain about half those in the rest of the world. Reasons for lower smelter capital requirements in China include lower land acquisition fees, special tax treatment for locating in special industrial zones, low construction costs (because of low labor costs and low-interest loans), large markets for by-products such as acid and metals, low complementary infrastructure investment needs (electricity, ports, rail), infrastructure often provided by local governments, and low social and environmental costs (Brook Hunt 2011).

Copper smelting and refining also consumes a lot of power, though not as much as aluminum smelting. An estimate of the power needs in smelting and refining combined at 5,000 kWh yields a cost of $250 per ton of metal. And because smelting is so capital intensive, the employment benefits of investments in further downstream processing are trifling. Labor requirements are only about 800 workers for a $1.2 billion investment, and labor costs are a relatively small proportion of total operating costs.

Low margins in smelting/refining copper are important because of extreme competition among smelters for copper concentrate, caused by substantial excess capacity in copper smelting/refining. Mine disruptions in some parts of the world also have hampered increases in concentrate supplies. Data on global concentrate supply for 2011 indicate that world concentrate supply reached almost 14,000 kt. In the same year, world smelter excess capacity averaged about 7,100 kt or 51 percent of total concentrate output. China's smelting capacity alone was responsible for almost 4,900 kt.

In Indonesia, the copper smelter/refinery Gresik, in Eastern Java, absorbed about one-third, 280 kt, of the country's copper concentrate output of 880 kt of metal content in 2010. The

[5] A study of a typical greenfield copper smelting investment in Indonesia by ITB/IMA, shown in table 1-6, indicates a net present value of -$963 million, a negative internal rate of return, and a 30-year payback period.

rest, about 600 kt, has been exported.[6] Gresik operates at near capacity of 300 ktons per year and its revenues are dominated by its copper export sales, with small amounts derived from precious metal and sulfuric acid by-products contained in the concentrate treated. Gresik survives in the low-return smelting business because it was constructed more than a decade ago and its shareholders support it financially. Gresik was constructed for $600 million in 1998, when construction costs were half current costs, and much of the depreciation of the plant has been written down. Its operations have also been supported in past years by higher long-term contract TC/RCs than available now, and energy costs, particularly for natural gas, historically were much lower. Today natural gas costs are three times what they were in 1998. Shortfalls in Gresik's operations have been covered by its shareholders—Mitsubishi, PT Freeport Indonesia, and Nippon Mining and Minerals—and the smelter has subordinated debt converted into equity, which pays no dividends. If not for these factors, Gresik would be competitively challenged. Several smelters—in Australia, Thailand, Japan and Canada—have had to close in the 2000s because of their weak economics. This situation does not bode well for projected future new facilities, particularly given the poor economics of new greenfield smelters outlined above.

The MEMR anticipates three new copper processing complexes to become operational in the near future. The first, with a capacity of 200 kt of refined copper, is projected to be launched by Nusantara Smelting, which is said to be seeking financing. The second, to produce 100 kt, has been initiated by Indosmelt. This project is said to be "under prefeasibility study," begun early in 2012. Both are expected to be operational by 2014, according to MEMR documents. A smelter processing 34 million tons of copper ore by Global Investindo in Papua is also undergoing feasibility studies. If these expectations were to come to fruition, there would be surplus capacity in smelting but no additional mining output.

For several reasons the ministry's expectations for new copper smelting and refining facilities are overly optimistic. First, given the development stage of the projects, it is highly unlikely that they could be operational by 2014. "Seeking of finance" by Nusanta Smelting is bound to be a cumbersome and drawn-out process in current circumstances in the copper smelting market. Also, the process from prefeasibility to project start-up takes no less than three years in the most fortuitous case; hence, great luck is needed to put the Indosmelt venture into production before 2016. The second reason is the appalling current economics of this industry. Gresik barely breaks even. To be successful, any new copper smelting facility in Indonesia would have to confront (1) the paucity of market value addition in copper smelting compared with mining and concentration, (2) low TC/RCs and negative gross margins in greenfield copper smelters, (3) excess worldwide smelting capacity, and (4) low operating costs and capital costs of greenfield smelters in China. The numbers in Table 1-6 suggest that substantial public subsidies may be needed to develop new smelter projects in Indonesia: for example, an annual subsidy of about $100 million would be required for a 200 kt smelter to break even—an annual loss of $494 per ton times 200 kt equals $98.8 million.

Several other factors mitigate against further greenfield smelter investments in copper. First, signals from the market provide prospective guidance on the viability of such investments.

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[6] Indonesian concentrate production fell in 2011 almost 30 percent, to less than 600 kt (see Table 1-6). Concentrate production in Indonesia has been volatile over the years but has been on a declining trend since 2002, when it hit its peak of 1,200 kt.

Private investors have financed very few greenfield smelters outside China in the past six to seven years. Brownfield expansions have been the preferred way to go, and the list of projected investments around the world is indicative of this (Brook Hunt 2011). Moreover, many smelter projects in other countries have not been built because feasibility studies show insufficient returns, and a number of smelters have closed down. Only three custom smelter/refinery projects have stayed in business in the past 15 years (Brook Hunt 2011). Second, current smelter/refinery production capacity at Gresik is estimated to meet Indonesia's domestic demand for the next 10 years. Third, Indonesia's mine production is projected to peak in 2015, which could result in a concentrate deficit for the two new greenfield copper smelting projects MEMR anticipates. In this event, these facilities would have to enter world markets and compete for limited supplies of concentrate in a world market with huge excess smelting capacity. Fourth, there is no excess demand in Indonesia for smelter by-products, specifically sulfuric acid. Supply and demand are balanced, and industrial demand is not expected to grow much in the next 10 years (Brook Hunt 2012). Considering that smelter revenues depend on the sale of by-products, such as sulfuric acid, lack of demand for by-products would greatly constrain the commercial viability of any new smelter investment.

An export ban on unprocessed minerals would not only require more local investment in copper smelting, it would also require additional processing capacity further downstream for copper smelting by-products. Refining anode to copper cathode creates anode slime as by-product. This slime contains important elements of metals such as gold, silver, selenium, platinum, palladium, and lead. Because Gresik does not have the capacity to process anode slime, PT Smelting, the company managing Gresik, exports anode slime to Japan for further processing. When exporting anode slime on world market terms, PT Smelting realizes the value of all the metals in the slime minus TC/RCs. TC/RCs for processing anode slime are determined by supply and demand in the world anode slime market, which, as in copper smelting, are low. Furthermore, because mining companies are paid 98 to 99 percent of the value of all the metals in anode slime when they sell concentrate to the smelter, PT Smelting seller's margin for these exports is small.

For PT Smelting to comply with ministerial regulation No. 7/2012, it would have to stop anode slime exports. All unprocessed metals in the anode slime would have to be processed in Indonesia to the required 99 percent purity by 2014. To achieve this, three new processing facilities would have to be built: (1) an anode slime processing plant to extract gold, silver, and selenium; (2) a platinum group metals (PGM) plant to extract platinum and palladium; and (3) a lead smelter and refinery to separate lead from anode slime smelting slag. Without this facility some gold and silver will remain in the slag, along with lead, and will not be sold. These facilities would require large capital investments, as well as additional complementary investments in infrastructure, such as power, water, and transportation. And, these capital-intensive facilities still would not generate much employment. Most important, anode slime processing is an extremely low-margin business. Almost all the value in anode slime goes to mining companies, as noted above, and the margins involved in processing are small. Today TC/RCs of anode slime processing facilities are 0.3 percent for gold, 0.9 percent for silver, 1.2 percent for platinum, 2.7 percent for lead, and 14 percent for selenium.

Thus, the economics of anode slime processing shows that investments to facilitate processing in Indonesia would be poor commercial ventures. Prevailing world TC/RCs make exporting anode slime to smelters elsewhere much more profitable. In addition, if the ban on unprocessed minerals stops anode slime exports and local anode slime processing capacity is not forthcoming, PT Smelting will suffer a significant loss because of its inability to sell this important by-product.[7] This could push Gresik to the point of going out of business, considering its current financial position.

NICKEL

Nickel mining in Indonesia is dominated by two companies, PT Vale Indonesia Tbk and PT Antam, a state-owned diversified mining company, but also contains many small miners exporting ore directly. PT Vale and PT Antam are vertically integrated, with Vale producing nickel matte, and Antam producing ferronickel. Almost a quarter of Antam's revenue comes from exporting ore directly; another 36 percent comes from the export of ferronickel.

Total production, planned processing, and exports of nickel ores are presented in Table 1-7. Despite the planned increase in processing capacity by PT Antam and Weda Bay Nickel (in which Antam has a 10 percent ownership stake), there would continue to be substantial excess capacity in the mining industry, amounting to 14.2 million tons of ore. Because Antam and PT Vale are both vertically integrated, and Weda Bay plans to exploit its own nickel ores, the export ban would have a significant impact on small miners dependent on ore exports for their livelihoods.[8]

Table 1-7

Production and Planned Processing of Nickel Ore in the Indonesian Nickel Industry (kt)

	Amount	Companies
a. Mining production (2011)	33,000	PT Antam; PT Vale Indonesia, small miners
b. Exports (2011)	24,050	Various
c. Current processing	8,950	PT Antam (ferronickel), PT Vale (nickel matte)
d. Planned processing—underway (2014)	2,950	PT Antam (ferronickel)
e. Planned processing—potential (post-2014)	6,900	Weda Bay Nickel, PT Antam
Balance (= a – c – d – e)	14,200	

Source: Indonesia MEMR, 2012

Nickel processing is more complex than aluminum or copper processing, primarily because of the variety of intermediate and final products made and the many alternative technologies used to reach the final stage in the processing chain. The nickel processing chain presented in Table 1-8 provides a less-complete picture of processing than do table 1-4 for aluminum and table 1-6 for copper. Most nickel ores, containing 1–4 percent nickel, are exported directly. The remainder is upgraded through concentration to a metal content of about 7 percent and then sent for smelting to obtain matte nickel or ferronickel and final (and intermediate) products in a multitude of qualities with a metal content varying between 37 percent and 75 percent. These forms of nickel are priced at discounts to the LME nickel price and are used mainly as inputs for the production of stainless steel, an activity that dominates nickel consumption. Europe and China take up about 70 percent of total world

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[7] Gresik also produces 30 million to 40 million tons of Telluride copper per year. Given this small output, it would not be commercially viable to set up a facility to smelt and refine Te-CU locally. Telluride copper would also have to be exported or its value could be lost.

[8] Details on processing plans were obtained from individual company websites. The plight of small miners when the new export rules came into effect was noted by Reuters (June 15, 2012)

demand. Lesser quantities of nickel concentrate (and some matte) are refined into pure metal in a variety of forms—cathodes, pellets, briquettes, powder—for special uses. Indonesia has no involvement as producer at the refined metal stage. Table 1-8 reveals that most of the value in the processing chain, $12,500 per ton, or roughly 60 percent, is created through smelting, and much less is created in refining.

Table 1-8
Nickel Processing Chain

Product Stage	Nickel Ore	Final and Intermediate Products	Final Product
PRODUCTION STAGE VALUE			
Process	Mining	Smelting	Refining
Products	Ore	Matte, ferronickel	Metal
Metal content	1–2%	Matte 38–74% Ferro 37–42%	> 98%
Market price ($/t)[a]	36	Matte 15,000 Ferro 6,000	18,000–22,000
Value of London Metal Exchange (LME) metal price (%)	0.2	30–70	100
Added market value $/t	16	3,500–12,500	5,000
PRODUCTION STAGE COST CALCULATIONS			
Investment for 27 kt plant		1. 7 billion	
Investment 27 kt plant ($/t)		63,000	
Capital charges($/t)[b]		6,750	
Power cost for 11,000 Kwh ($/t)		550	
Operating costs ($/t)[c]	16	7,000–9,750	n/a
NPV, IRR, payback period		Ferronickel—$639 million, 20%, 8 years HAPAL—$284 million, 15%, 12 years	n/a
Employment—no. of workers		450	
GLOBAL MARKET DATA			
Global output 2010 metal content (kt)		1,500	
Global capacity metal content (kt)		1,800	
Excess capacity % output		20%	
Indonesia exports mt 2011	40	0.161	0

Notes:

t=metric ton; kt=000 tons; mt=million tons; bn=billion; met=metal

Processing requirements for exports from 2014: Ferronickel >16% metal content; Matte >70% met cont.

a. Indicative prices based on LME 3-month 2011($22,000/t), and Chinese import prices, matte 70% ($1500/t), and CRU International estimates.

b. Operating cost estimates are averages based on various processing methods from CRU International:

Laterite (limonite) HPAL = total processing costs of $8,600/t; Laterite (saprolite) FeNi = $11,250/t; NPI = $16,500/t.

Costs are additive across the row by stage of processing. In the HPAL method, for example: mining costs = $1,600/t, leaching $5,300/t, and refining $1,700/t for a total cost $8,600/t; in laterite (saprolite) ferronickel operations: mining cost = $1,500, milling $550/t, and smelting/refining costs = $9,200/t, for a total of $11,250/t.

c. Annual capital charges per ton can add another 30–40% to total operating costs of a typical ferronickel plant according to CRU International estimates.

Assumed at $0.05/Kwh. The average power price paid by industry in 2011 was $0.8-$0.9/Kwh

[d] *ITB/IMA Study*

Table 1-8 does not include the relatively recent emergence in China of nickel pig iron (NPI), a crude ferronickel product, which is generally 10 percent nickel, used in the production of the cheaper end of stainless steels. Due to regulatory changes in China, NPI production in that country has exploded over the past decade, which has greatly added to overall nickel processing capacity. This expansion has been mainly based on nickel ore imports from Indonesia, which expanded six-fold between 2005 and 2011 to about 300 kt of nickel.[9] The global excess capacity in nickel smelting of 20 percent shown in the table is probably greatly understated because it does not take into account the Chinese NPI evolution. China continues to invest heavily in NPI, adding to the excess capacity in nickel processing. This is surprising given that NPI production has high operating costs (because it is electricity intensive) and low gross margins, which are contingent on the LME nickel price. Today, for example, with the LME nickel price at approximately $18,000 per ton and Chinese NPI producers' costs at about $16,500 per ton, the gross margin is $1,500—only 9 percent. Taking into account the volatility in LME nickel prices, such thin margins can be short lived and turn negative quickly, as they did in mid-2012 when the LME nickel price dropped to $15,000 per ton.

Operating costs for other downstream nickel processing technologies vary by method, from $8,600 per ton for laterite (limonite) HPAL processing (not including by-products of cobalt and copper) to $11,250 per ton for laterite (saprolite) ferronickel operations. The principal cost in the HPAL process is leaching and smelting 81 percent (61 percent of total cost and 20 percent respectively), and in ferronickel operations the leading cost is smelting/refining, 82 percent. These costs suggest that margins are not awe-inspiring in most nickel processing activities, particularly when capital costs are included.[10] And if investments in new processing facilities require a power plant and other complementary infrastructure, financial feasibility looks even less likely. And although the variety and complexity of processing methods makes precise estimates difficult, at current LME nickel prices, matte and ferronickel downstream margins appear to be more favorable than those in downstream aluminum or copper processing.

Scale economies are less important in downstream nickel processing than in aluminum or copper processing, but the size of investment required for individual projects is not dissimilar because of the huge capital needs per unit of capacity. Table 1-8 records a planned greenfield ferronickel investment in Indonesia with a capacity of 27 kt, requiring $1.7 billion, or $63,000 per ton of capacity. Capital costs, such as interest and depreciation, could be a significant addition to operating costs in this facility. In addition, added costs would be incurred if a new power plant is needed. The cost picture suggests that this Indonesian operation will have a difficult time breaking even at current nickel prices, but this assessment does not rule out that other nickel processing projects with different cost configurations and alternative final product outputs could be economical. The MEMR lists this project as one launched by majority state-owned company Antam, with a feasibility study "currently under review and sampling pit tests being undertaken," with commercial

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[9] These figures are based on estimates provided by Vale. As noted earlier, MEMR provides data suggesting an eightfold increase in nickel ore exports between 2008 and 2011.

[10] A greenfield ferronickel smelter would have a positive net present value of $639 million, an internal rate of return of 20 percent, and a payback period of 8 years, while a HAPAL processing investment would have a net present value of $284 million, an internal rate of return of 15 percent, and a payback period of 12 years (ITB/IMA 2011). These have the best processing investment prospects of all the banned minerals.

production expected by 2014. Again, this starting date expectation is surely overly optimistic, considering the time it takes to get such a facility operational.

Almost 80 percent of Indonesia's nickel output is not processed beyond concentration and will thus be subject to the in-country processing restriction. The restricted proportion of output will fall only marginally, to 70 percent, if the Antam project becomes operational.

CONCLUSIONS

Our analysis of the financial feasibility of further downstream processing of minerals in Indonesia finds that investments in greenfield smelting and refining facilities, in the market circumstances likely to prevail until at least 2020, have poor commercial prospects. There are, however, differences among the minerals examined. Investments in greenfield copper smelting facilities would generate exceedingly poor returns. Copper smelting adds little value, and TC/RCs and margins for smelters are extremely low.

Aluminum smelting, however, adds much more value, although it is extremely expensive, especially in power and capital costs, which drives down profit margins substantially. Compared with bauxite mining, alumina and aluminum refining are low-return activities.

Nickel is somewhere in the middle. But even here, returns to greenfield smelting investments by themselves, without a mine attached, do not look remarkably profitable. What is more, all these downstream investments in mineral processing look much worse when considered in the light of the investment in complementary infrastructure—power plants, ports, roads, and so on—required for their success.

In summary, the following factors undermine the financial feasibility of new greenfield processing facilities in Indonesia:

- For all the minerals examined for this study there is substantial excess capacity in smelting/refining in world markets, and this capacity continues to expand, particularly in China, but also in areas with low-cost energy, such as the Middle East.
- Excess capacity makes competitive greenfield processing ventures difficult. Feasibility assessments for new greenfield capacity would have to consider the need to compete with low capital costs and low operating costs in Chinese facilities (and other parts of the world) and not end up being a high-cost producer vulnerable to the extraordinary volatility in world commodity prices.
- Capital investments required for smelters/refineries are extremely large and continue to grow, which translates into high capital costs per ton of output. The opportunity costs of such huge capital investments in Indonesia, when there are such pressing needs for capital investment in other areas, are extremely high.
- Operating costs of greenfield smelters/refineries, and particularly energy costs, are also high.
- Smelter TC/RCs are exceptionally low because of excess world processing capacity. The combination of high operating and capital costs and low TC/RCs has depressed gross smelting margins, and given world prices predicted until the end of the decade, they are not expected to rise much.
- Complementary investments in electricity and other infrastructure required for smelters/refineries are very large and will be a long time coming.

- Smelting/refining investment returns in Indonesia will be negatively affected, particularly in copper, by the lack of domestic demand for smelter by-products, which are an important part of smelter revenues. Most estimates indicate no excess domestic demand for smelter by-products today. Hence, the profitability of new smelter investments will be constrained by growth of domestic sales of by-products, which will be slow given Indonesia's relatively small industrial sector.
- Financing will be difficult. Because of the large investments required in smelter/refinery projects, significant debt financing—possibly 50–70 percent of the cost of the project—may be required. Raising $500 million to $700 million of long-term financing will be challenging. Commercial viability of the project will be a key factor for lenders, as will country risk, the regulatory regime, and environmental restrictions.

In addition to these reasons for low returns on greenfield investments in downstream processing, several additional comments are warranted. The first two go against the economic pessimism that we have expressed; the remaining three suggest that the outcomes could be even worse than the analysis indicates.

First, prevailing global excess capacity could disappear in the future, which would cause returns on processing to increase, but there is no sign of such development in the near term. Second, capital costs could be made significantly lower by expanding existing refining and smelting operations (brownfield), rather than constructing greenfield facilities from scratch, as assumed in tables 1-4, 1-6, and 1-8. Third, the investment expenditure and operating costs in greenfield ventures in Indonesia could be higher than the international benchmark reflected in our tables, and so make the economic outcomes even worse than demonstrated.

In the study team's interviews with industry representatives and government officials, two concerns emerged that heighten the probability of this outcome. Respondents emphasized that Indonesia has an unwieldy regulatory environment compared to those of many other nations with important mineral industries. Indonesia exhibits several layers of public administration, federal to regional to local, each with its own interests and agendas, and each often at odds with the others. To obtain necessary licenses, a mining or mineral processing firm has to satisfy the requirements of them all, which involves complex negotiations and compromises. Land rights and forest regulations are especially difficult issues. Several of our interviewees noted the need for costly side payments to smooth out regulatory hurdles. Speed in implementation after an investment decision has been made is crucial for the capital-heavy installations under review, and the long time needed to get all the permits cleared is probably even more important in raising investment expenditures.

Inadequate or absent infrastructure was the other cost-raising factor pointed out in interviews. Roads, harbors, and, in particular, power, were signaled as pertinent for keeping down the costs of greenfield mineral ventures. There is always the question of whether the government or the investor should provide infrastructure, especially in remote locations. Costs for smelter development in Indonesia will be higher than those in locations where the government plays a more active role in providing infrastructure. The advantageous cost levels for mineral processing investments in China were pointed out in this context. Overall, it appears that the costs of new mineral processing facilities in Indonesia work out above the international benchmark, further reducing potential investors' willingness to engage.

The time period needed for development of smelters is also an important consideration. The normal gestation period for investments in smelters and refineries for aluminum, copper, and nickel is seldom less than five years. Unless a plant is nearing completion late in 2012, as this report is being written, there is little chance for that plant becoming operational by 2014 when the ban is supposed to come into force. One has to be skeptical of the list of processing ventures under implementation issued by the MEMR in March 2012. It provides dates for entry into production for 16 projects, 11 of which are expected to be operational in 2014 or earlier. As pointed out in the discussion of aluminum and copper, completion of the investments will take much longer than envisaged, and few, if any, of the 11 projects will be completed by the indicated time. In all probability, the list has come into being on the basis of plans formulated by the miners, primarily to demonstrate that processing expansion is on the way, and so to induce the government to defer the introduction of the export ban.

2. Welfare Impact of the Export Ban on Unprocessed Minerals

Section 1 analyzed the financial feasibility of further downstream minerals processing in Indonesia and assessed the prospects of establishing required processing facilities by the start of export restrictions in 2014. Although this analysis is useful in gauging the effects of the coming export ban, it is part of a full evaluation of its impact. Judging the benefits and costs of such trade policies relies on an appraisal of welfare gains and losses for economic agents and net efficiency losses to the economy, to which we turn in this section.

We begin by developing an analytical framework to measure welfare impact and efficiency losses.[11] Second, we use this framework to estimate the magnitude of monetary transfers and costs of the export ban to the economy, given plausible assumptions about the structure of minerals markets and supply and demand elasticities of producers in these markets.

Finally, given the government's interest in using the export ban to encourage higher value-added exports, and export earnings, we examine the impact of the ban on total export revenues.

ANALYTICAL FRAMEWORK FOR MEASURING WELFARE EFFECTS OF THE EXPORT BAN

Export restrictions on intermediate inputs, such as unprocessed minerals, reduce the domestic cost of raw material inputs and increase the effective rate of protection to downstream processing. Sheltering the processing industry with lower cost inputs, however, generates side-effects in the form of economic distortions and efficiency losses and bestows benefits on owners of processing facilities at the expense of unprocessed mineral miners. Figures 2-1 and 2-2 illustrate this case and show the distribution of welfare gains and losses.

Figure 2-1 depicts the market for processed minerals (the final product) in the upper half of the figure and the market for unprocessed minerals (the intermediate input used in production of the processed final product) in the lower half. Both these markets are assumed to be competitive, and we begin the analysis assuming free trade: that is, no trade restrictions on exports of unprocessed minerals. Furthermore, we assume that the country is not a large enough exporter of processed or unprocessed minerals to influence world market prices of these exports.

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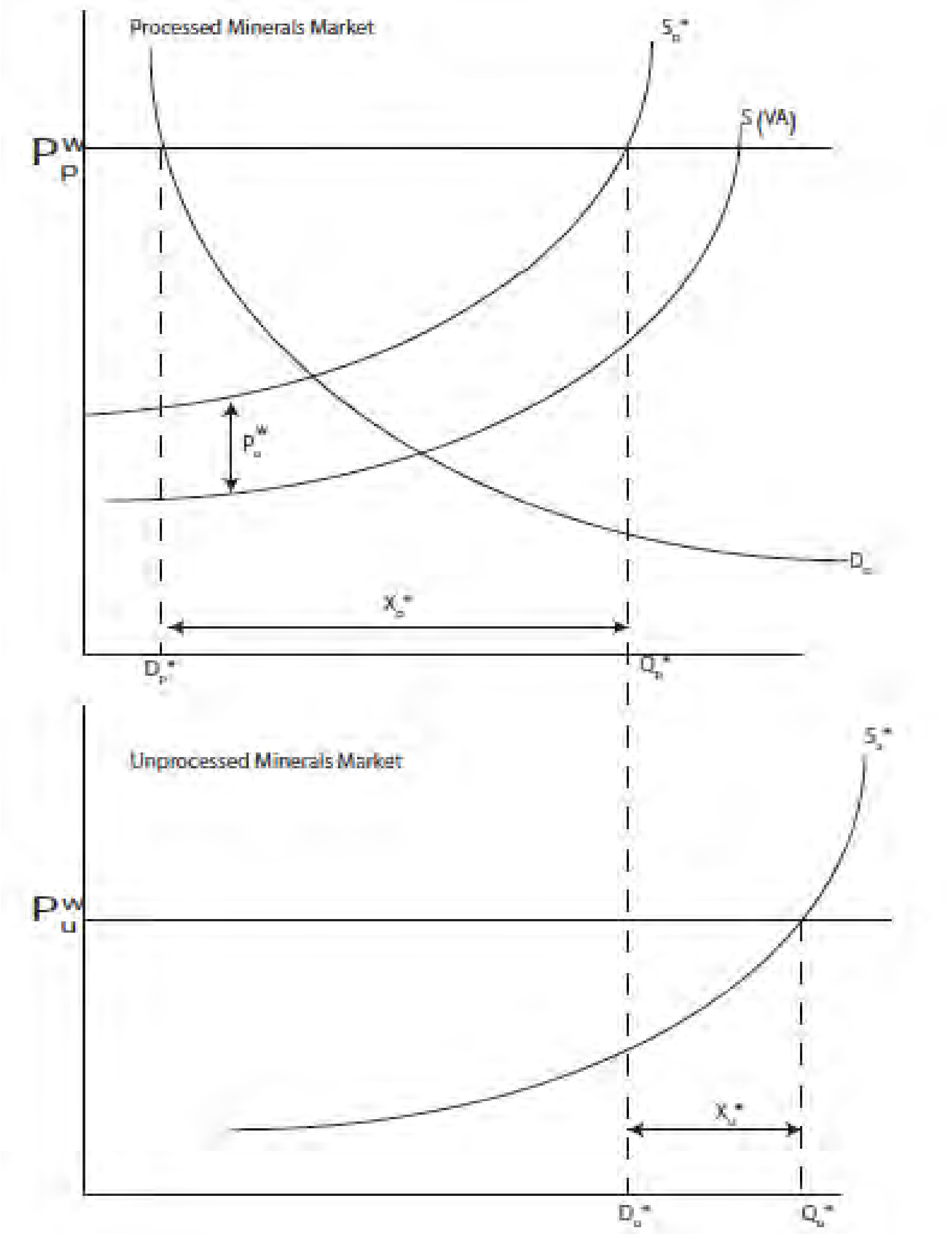
[11] The framework for analysis developed here benefited from previous studies: Bonarriva, Koscielski, and Wilson (2009); Takacs (1994), and Kishor, Mani and Constantino (2001).

Figure 2-1
Processed and Unprocessed Mineral Markets with No Trade Restriction



For simplicity of analysis, units of the input are defined so that one unit of input of the unprocessed mineral (U) is required to produce one unit of the processed mineral (P). In the unprocessed minerals market, miners will produce higher quantities of output depending on the price of unprocessed minerals, P_u, and they sell all of their output as intermediate inputs to the downstream processing industry. In the processing industry, smelters are ready to process more inputs into final outputs the higher the value added in processing per unit. Value added is simply defined as the price of the processed mineral minus the unprocessed mineral input, P_p - P_u. Given that figure 2-1 assumes no trade restrictions, the prices of processed and unprocessed minerals will equal world prices, P_p^w and P_U^W.

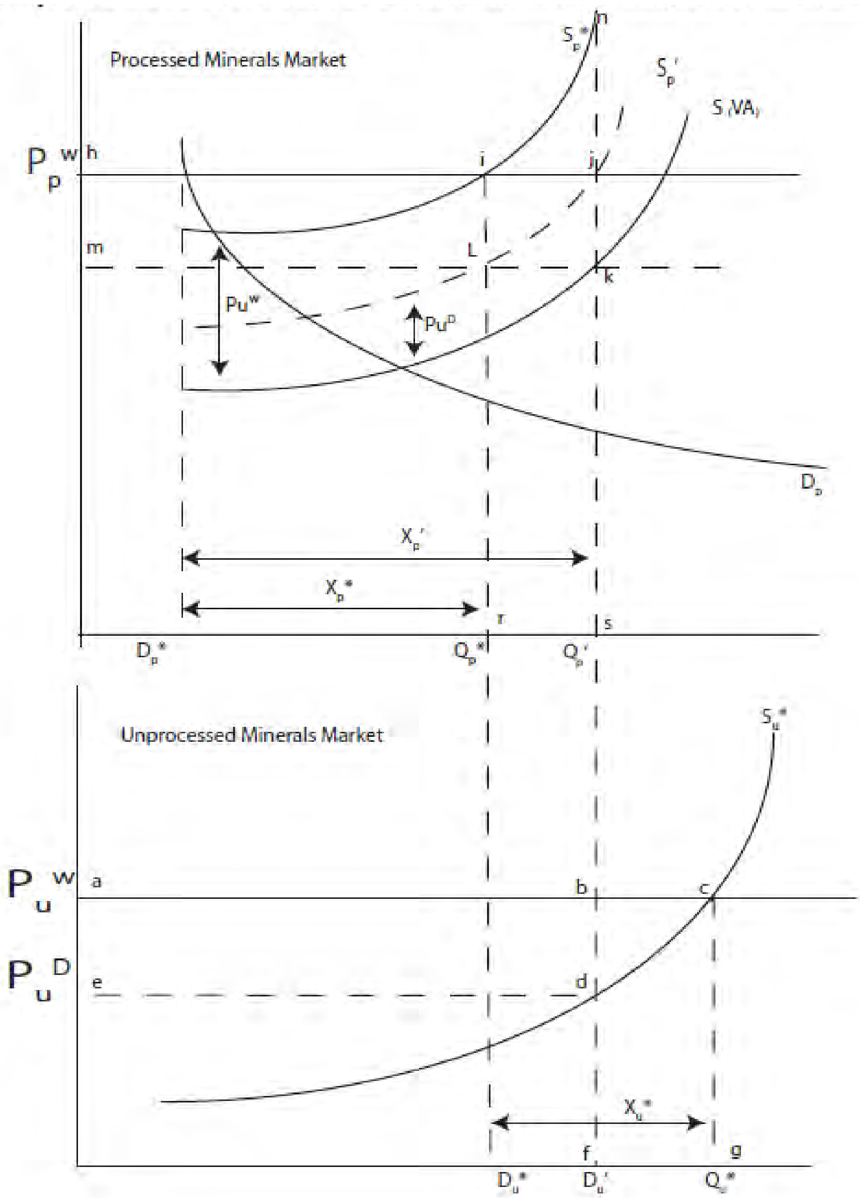
The supply curve of the processing industry, as a function of value added, is shown in the upper half of figure 2-1 as S(VA). The height of this curve is equal to the value added per unit of processed minerals produced. S_p^* is the supply curve for final processed mineral outputs under free trade. It lies above S(VA) by the cost of the unprocessed mineral input per unit of final output, P_u^w. Domestic demand for processed minerals is D_p. Given the world price of processed minerals, P_p^w, the quantity supplied by processors would be Q_p^*, the quantity demanded in the domestic market would be D_p^*, and exports would be X_p^*. In the unprocessed minerals market, domestic demand for unprocessed mineral inputs, D_u^*, is established by the processing industry's decision to produce, Q_p^*. The total quantity of unprocessed minerals supplied by miners is determined by the intersection of the mining industry's supply curve, S_U^*, and the world price of unprocessed minerals, P_u^w. At this world price, X_u^* of unprocessed minerals would be exported.

Now what if the government imposes an export ban and miners are no longer allowed to export unprocessed minerals? In figure 2-2, exports, X_u^* , in the unprocessed minerals market would equal zero. The ban on exports would create an excess supply of unprocessed minerals on the domestic market and the price of unprocessed minerals would decline, falling below the world price. The extent of decline (P_u^w to P_u^D in the bottom half of figure 2-2) would be determined jointly in both the processing and input supply markets: the quantity of unprocessed mineral inputs demanded depends on the output decisions of processors, and the position of the processing industry's supply curve depends on the price of unprocessed raw material, which is established by processor demand and the supply curve in the market for unprocessed minerals. As the price of unprocessed minerals falls with the ban, input costs of processors decline and the processing industry's supply curve shifts downward and to the right—S_p^* to $S_p^/$. At the constant world price for processed minerals of P_p^w, output of processors rises from Q_p^* to $Q_p^/$ (and, as a consequence, the quantity demanded of unprocessed mineral inputs) and exports expand from X_p^* to $X_p^/$. In the market for unprocessed minerals, domestic demand rises from D_u^* to $D_u^/$. Because unprocessed minerals cannot be exported, there is now an excess supply at the old world price, so price falls along the supply curve, S_u^*, from P_u^w to P_u^D, where the new domestic quantity demanded (determined by the processing industry) is equal to supply at point (4).

Figure 2-2 shows that the export ban on unprocessed minerals generates losses for miners and creates profits of processors. In the market for unprocessed minerals, miners' profits decline as prices fall. At the price of P_u^D, the net income of miners declines by area (acde), as revenues decrease by (acgfde), while costs fall only by (cdfg).[12] Part of the loss to unprocessed minerals miners (abde = hjkm) is a direct income transfer from miners to processors, as the processing industry enjoys higher profits because of lower input costs after the ban. A second part is an efficiency loss (bcd) to the economy. This efficiency loss arises because the unprocessed minerals that would have been exported under free trade, Q_u^*- $D_u^/$, earning P_u^w, would have cost only an amount equal to the height of the supply curve to produce. Under the ban, these exports will not be produced and sold on the world market for more than the cost of production. Area (bcd) thus represents a net efficiency loss (also called a deadweight loss) to the economy.

[12] This loss in mining profits can also be depicted as a loss in producers' surplus (defined as the extra amount that a producer earns above the marginal cost of production, represented by the height of the supply curve), which is equal to area (acde).

Figure 2-2
Mineral Markets with Ban on Exporting Unprocessed Minerals, Case A—Assuming Processing Capacity Can Expand



Turning to the processed minerals market, smelters gain (hjlm) in producers' surplus or profits as a result of the ban. Profits rise for two reasons: (1) an increment owing to a reduction in costs for each unit of output produced before the ban (hilm) and (2) an increment attributable to the difference between revenue and costs for the extra units produced after the ban (ijl). Additionally, the ban also causes an efficiency loss to the economy in the processed minerals market. The artificially low price of unprocessed minerals caused by the ban creates an incentive for processors to expand output beyond the point at which world price equals the true cost of producing minerals. This results in an efficiency loss equal to area (nji). In view of the fact that area (nji) = (jkl),[13] the direct income transfer from miners to processors, noted above (hjkm), is only partly a pure gain to the processing industry. Part of this direct income transfer, (jkl), is lost on account of the higher costs of processing the ban-induced extra units of output.

13 S_p^* is parallel to $S_p^/$ and lies below it by (P_u^W - P_u^D), therefore nji=jkl.

The losses to producers of raw materials and gains to processing can be calculated. Loss in producer's surplus,

$$\text{area(acde)} = \pi v_u + \frac{1}{2}\pi^2 e_u^s v_u$$

where $\pi = dp_u/p_u$

$V_u = P_u Q_u$

$e_u^s = \left(\frac{dQ_u}{dP_u}\right)\left(\frac{P_u}{Q_u}\right)$

$dP_u = (P_u^W - P_u^D)$

$dQ_u = (Q_u^* - Q_u')$

Efficiency loss, equal to area bcd $= \frac{1}{2}\pi^2 e_u^s V_u$

In the market for processed goods, processing industry gains:

$$\text{area hjlm} = \emptyset V_p \pi - \frac{1}{2} e_p^s V_p \pi^2 \frac{\emptyset^2}{1-\emptyset}$$

$where\ e_p^s = \left(\frac{dQ_p^s}{dv}\right)\left(\frac{v}{Q_p^s}\right)$

$dQ_p = (Q_p' - Q_p^*)$

$\emptyset = P_u/P_p$

$V_p = P_p Q_p$

Deadweight welfare loss, area jkl $= P_u Q_p d\frac{P_u}{P_u} - \frac{1}{2} e_p^s \frac{P_p Q_p}{V} \frac{P_u}{P_p} P_u \frac{dP_u}{P_u} \frac{dP_u}{P_u}$

If data on input-output tables are available, then the following equation can be used:

$$\text{jkl} = -\frac{1}{2} e_p^s V_p \pi^2 \frac{\emptyset^2}{1-\emptyset}$$

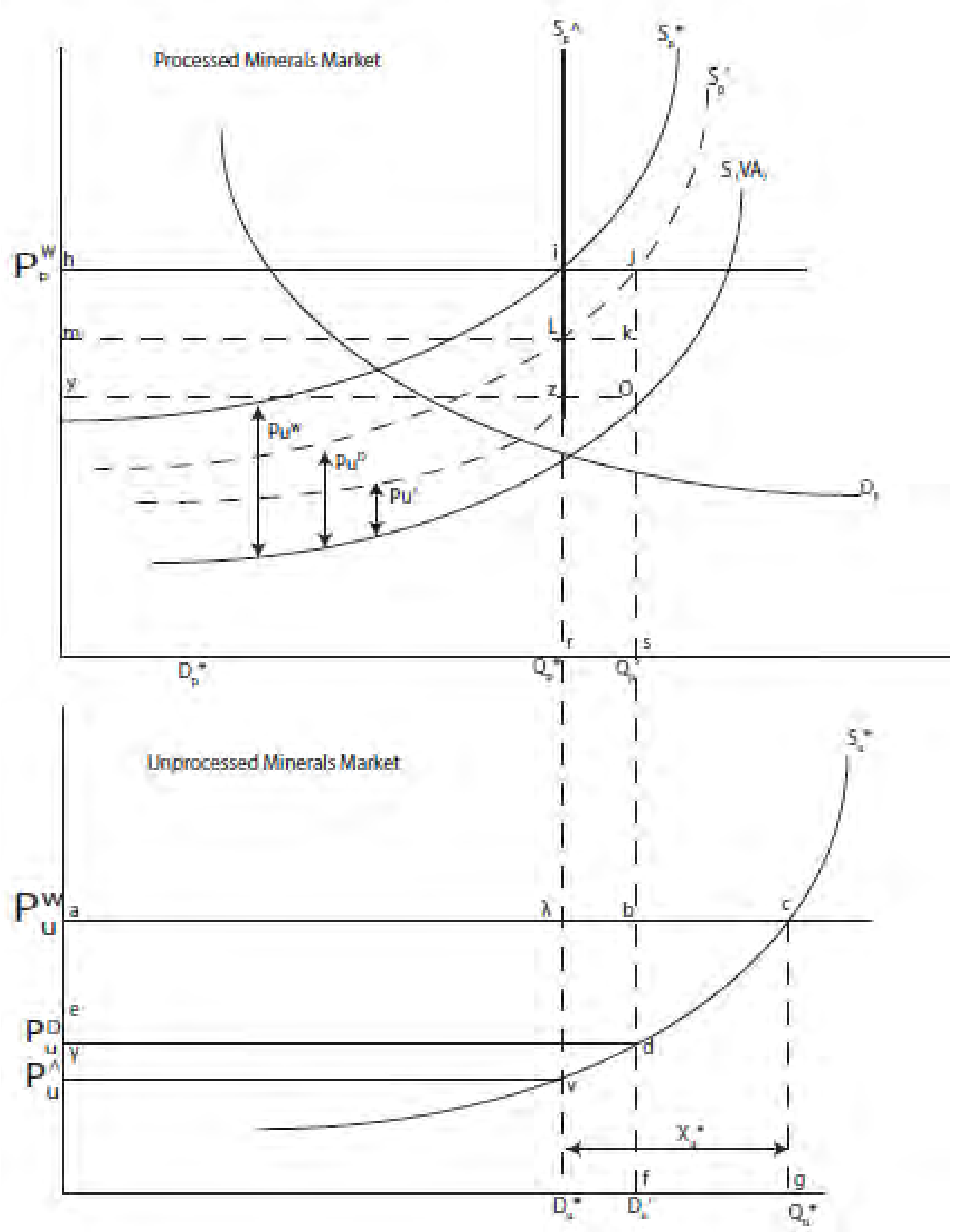
Impact of Processing Capacity Constraints

Section 1 of this study observed significant obstacles in the path of expanding processing capacity in Indonesia in time to meet the 2014 deadline for the ban on unprocessed mineral exports. In addition to problems with financial feasibility in some cases, difficulties of building new processing facilities on time, financial constraints, inadequate technological capability, infrastructure limitations, and impediments in the business environment all hinder processing capacity expansion. In view of these shortcomings, suppose now that, after the ban is imposed, smelting capacity does not increase to take advantage of lower unprocessed minerals prices. What happens then to the welfare impacts of the ban?

Figure 2-3 illustrates this case. Processed minerals output would be constrained by all the difficulties of making new investments in new smelters at Q_p^*. As a consequence, domestic demand for unprocessed minerals would be restricted to D_u^*. In this situation, the excess supply of unprocessed minerals would increase and the price would decline further along the supply curve S_u^* from P_u^D to $P_u^\wedge$ where domestic demand equals supply. This added fall in the price of unprocessed minerals causes a further shift in the processing industry's supply curve downward and to the right, except in this case processed mineral output would be fixed at Q_p^*. Hence, the new industry supply curve $S_p^\wedge$ would have a kink in it, becoming vertical at output Q_p^*, as shown in figure 2a.

Figure 2-3

Mineral Markets with Ban on Exporting Unprocessed Minerals, Case B—No Processing Capacity Response to Ban



In the unprocessed minerals market, miner's welfare losses increase because of a bigger loss in producer's surplus, equal to area (edvɣ), owing to the lack of processing capacity to absorb excess supplies of unprocessed minerals. This results in an even larger direct income transfer from miners to processors in the form of higher profits due to lower input costs. It also results in a larger net efficiency loss to the economy attributable to the ban, equal to area (λcv). The increased efficiency loss is due to the fact that the amount of preban unprocessed minerals that would have been exported, earning more than the cost of production, increases by $D_u^{/}$ - D_u^{*}.

In the processed minerals market, as figure 2-3 illustrates, processing profits rise to (hizy = aλvɣ) as a consequence of the added reduction in costs for each unit of previously produced output. Because there is no increase in processing capacity, there is no increment to profits generated by the difference between revenue and cost in producing extra units of processed minerals. Nor is there a net efficiency loss to the economy generated by producing ban-induced extra units of output beyond the point at which world price equals the true cost of producing minerals. There is simply an exceptionally large increase in profits of existing processors generated by a direct income transfer from miners.

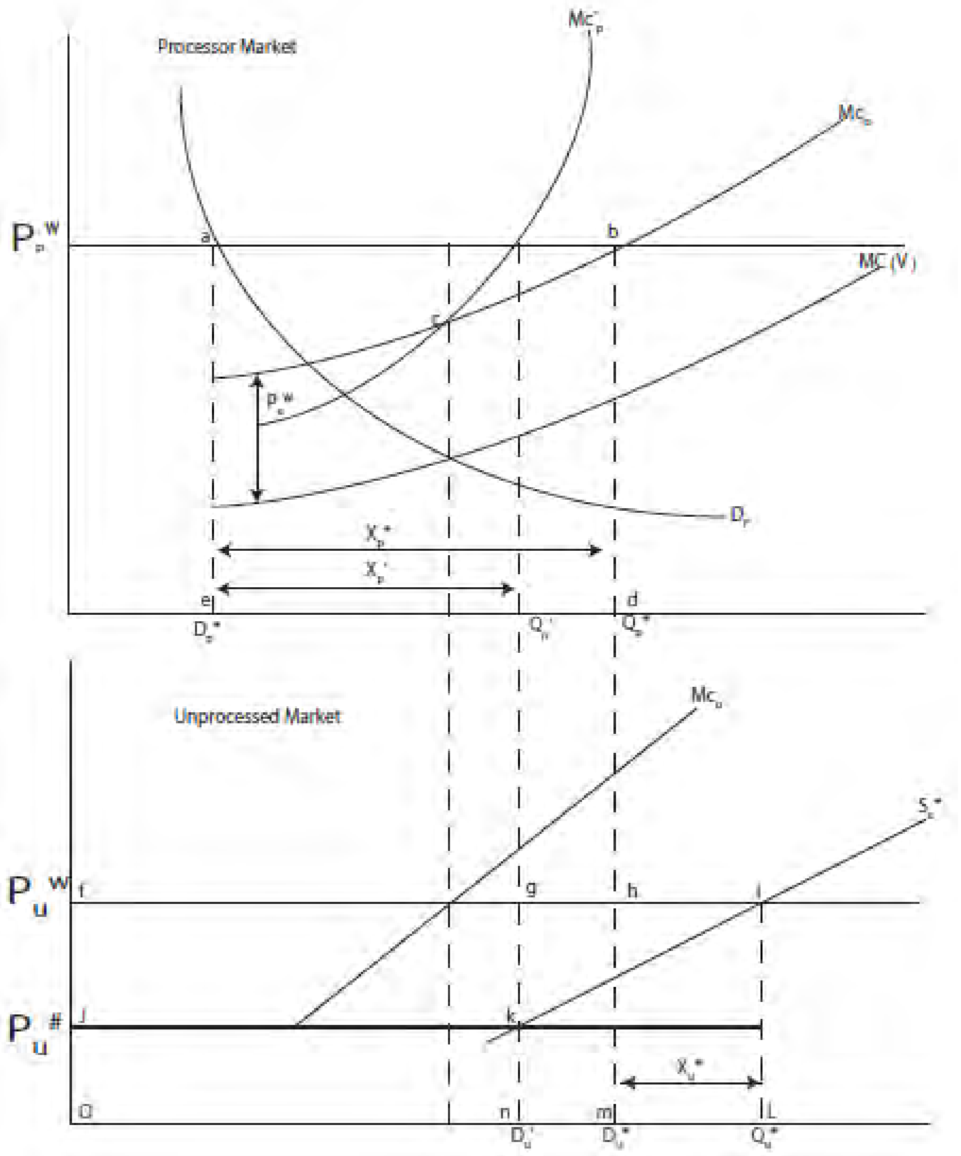
Impact of Market Structure on the Processing Industry

So far the analysis has assumed that the market for processed minerals is competitive: that is, it is presumed that many companies compete to buy unprocessed mineral inputs. But this assumption may not hold in Indonesia after the ban. Today only a few large smelters exist in most of the main minerals industries and even fewer with available capacity to smelt unprocessed minerals from independent mining companies.[14] Additionally, processing capacity for most minerals may be limited and not increase significantly by 2014, as observed in Section 1. This raises the possibility that only a few processors will exist in the market, creating a monopsonistic market structure in the processing industry, where processers can exercise buying power. If this situation occurs, the export ban will allow processors to control the price of unprocessed mineral inputs through their purchasing decisions, and the impact of the ban will be even more distortive.

Figure 2-4 shows what would happen to welfare impacts when there is monopsony power in the processing industry and an export ban on unprocessed minerals is introduced. In the market for processed minerals, processors confront an upward sloping supply curve for unprocessed mineral inputs S_u^*. D_p^* is the domestic demand curve for processed minerals. MC(V) is the marginal cost of production inputs to processors, not including the cost of unprocessed minerals. To obtain the marginal cost of production for processed minerals, the additional cost of an extra unit of unprocessed mineral inputs is added vertically to MC(V). Given free trade in the markets for processed and unprocessed minerals, even when the processing industry has monopsony power, processors must pay miners world price, P_u^w, for unprocessed mineral inputs, because miners always have the option to export. Therefore, before the export ban on unprocessed minerals takes effect, the marginal cost curve for processed minerals production is MC_p. And, since the world price for processed minerals is P_p^w, processors maximize profits at output Q_p^* and export X_p^*. Thus, when free trade in both markets prevails, export earnings in the processed minerals market would be equal to area (abde) in figure 2-4. In the market for unprocessed minerals under free trade, demand for unprocessed mineral inputs would be D_u^* and miners would supply Q_u^* at the world price of P_u^w, and X_u^* would be exported. Export earnings in the unprocessed minerals market would be equal to area (hilm).

[14] Tin and gold should not be included in this analysis because all unprocessed minerals in these sectors are already processed locally.

Figure 2-4
Monopsonistic Processor Market with a Ban on Unprocessed Materials



Introduction of an export ban on unprocessed minerals, when processors have buying power, puts smelters in a predicament. The more output they produce, and thus the more unprocessed mineral inputs they buy, the more prices of unprocessed minerals rise. The fact that processors' decisions now drive up prices for all unprocessed minerals used changes supply conditions in the unprocessed minerals market. The supply curve of miners now becomes MC_u, which shows the increasing marginal cost of additional units of unprocessed mineral inputs demanded by processors.[15] In the processed minerals market, MC_u is added to MC(V) to obtain the monopsony supply curve of the processing industry, $MC_p^{/}$. Monopsonistic smelters now sell their processed minerals at world price P_p^W and maximize profits at output $Q_p^{/}$. As figure 3 shows, output and exports, $X_p^{/}$, are lower when processors have buying power and exports of unprocessed minerals are banned. Processors reduce output and exports because it lowers demand for their unprocessed mineral inputs and lowers their costs of production.

15 MC_u is derived from S_u^*, the supply curve under free trade, and is steeper than S_u^* at every level of unprocessed minerals supplied.

Hence, a ban on unprocessed minerals when the downstream processing industry has monopsony power not only curtails unprocessed mineral exports, it also reduces exports of processed minerals. The net result is a decline in total export earnings.[16] The welfare implications of this outcome are straightforward. The export ban reduces profits of miners, even more than in the case depicted in figure 2-3 where the processing industry has no buying power, and increases profits of processors. In figure 2-4, the price of unprocessed minerals declines from P_u^w to $P_u^{\#}$ (which is < $P_u^{\wedge}$ in figure 2-3) and revenues of miners fall from (filo) under free trade to (jkno). Unprocessed export earnings fall by (giln). Part of this loss in unprocessed export revenues, (ikg), is a net efficiency loss to the economy, as it is equal to the difference between export earnings and the cost of producing these exports, which would have been sold on the international market if the ban had not been introduced.

A further issue that becomes apparent in this case is that market structure in the processing industry can influence conditions for new processing investment after the ban is imposed. Considering that both output and exports decline in figure 2-4, a need for consolidation develops in the processing industry after the ban, compared to the result in figure 2 where a need for further capacity expansion develops. The final outcome would depend on the degree of monopsony power of processors in different types of minerals and on the size of the processed and unprocessed minerals markets.

Quest for Higher Value-Added Exports and Higher Export Earnings

One of the primary stated reasons for the export restriction on unprocessed minerals under Mining Law No. 4/2009 and Regulation No. 7/2012 ("Per 7") is to foster higher value-added exports and increase export revenues. Given this avowed motive for the new trade policy intervention, a more direct focus on total export earnings would be instructive in assessing the impact of the ban.

Looking first at figure 2-2, export earnings of processed minerals rise by $P_p^w(Q_p^{/}$ - $Q_p^*)$, and foreign exchange revenues of unprocessed minerals fall from P_u^w X_u^* to zero. The net impact of the export ban on total export revenue in this case is indefinite. All that one can say in this base case is that the ban is more likely to increase export earnings: (1) the greater the value added in processing, (2) the greater the elasticity of supply in the processing industry (or put another way, the greater the ability to bring forth new smelter investments), (3) the smaller the elasticity of supply of unprocessed minerals, (4) the larger the processing industry relative to unprocessed minerals production, and (5) the more competitive the processing industry. We illustrated the impact of two of these conditions, in figure 2-3 and 2-4. In figure 2-3, where increases in processing capacity were constrained, it was shown that an export ban on unprocessed minerals is unlikely to increase net export revenues. Likewise, in figure 2-4, where buying power in the processing industry causes a decline in output and exports, it was shown that a clear net reduction in export earnings results from a ban.

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[16] There is some ambiguity in this result. Large exports of unprocessed minerals relative to domestic production of processed minerals increase the probability of an increase in output because $MC_p^{/}$ will cross MC_p at a higher output level. In this case, the value of the extra exports of processed minerals would have to be compared with the fall in exports of unprocessed minerals to determine whether total export earnings decrease or increase.

The net impact on export earnings can also be calculated. The total change in export earnings will be the net of the gain in export earnings from processed mineral exports minus the loss in earnings from unprocessed exports.

$$\text{Loss in Export earnings} = d[P_u^w x_u] = P_u^w[dQ_u^s - dQ_u^D]$$

$$\text{or } d[P_u^w x_u] = (1+\pi)e_u^s V_u \pi + e_p^s V_p \frac{\emptyset^2}{1-\emptyset}(1+\pi)\pi$$

The first term represents the decline in unprocessed exports due to the fall in production, while the second term represents the decline in exports due to diversification into domestic production.

$$\text{Gain in processed export earnings: } P_p^w dx_p = P_p^w Q_p e_p^s \frac{P_u}{V}\frac{dP_u}{P_u}$$

$$or\ P_p^w dx_p = V_p e_p^s \frac{\emptyset}{1-\emptyset}\pi$$

Therefore total export earnings will change by:

$$dv^x = V_p e_p^s \frac{\emptyset}{1-\emptyset}\pi - [(1-\pi)e_u^s V_u \pi + e_p^s V_p (\frac{\emptyset^2}{1-\emptyset})(1+\pi)\pi]$$

$$\text{or } dv^x = V_p e_p^s \frac{\emptyset}{1-\emptyset}\pi[1-(1-\pi)\emptyset] - \pi(1+\pi)e_u^s V_u$$

Summing up the welfare analysis of the export ban, figures 2-1, 2-2, and 2-3 make clear that an export ban on unprocessed minerals reduces the domestic price of these mineral inputs to domestic processors, which, in turn, provides an incentive for an expansion in minerals processing. This outcome will lower incomes of mining companies and cause economic distortions that result in net losses to the economy. Welfare outcomes for miners of unprocessed minerals under the ban are made worse if there are constraints on investment in new processing capacity or if market structure in the processing industry is monopsonistic.

Indonesia’s export restriction on unprocessed minerals was imposed to promote exports of higher value-added processed minerals and to raise export earnings. But the impact of the ban on total export revenues is ambiguous under the best of conditions, as the decline in unprocessed mineral exports may outweigh any increase in processed mineral exports. Moreover, under more down-to-earth conditions applicable to Indonesia, where there are constraints on expansion of downstream processing capacity, or where processors have buying power, the analysis has shown that total export revenues will decline after the ban takes effect.

EMPIRICAL ESTIMATES OF THE BENEFITS AND COSTS OF EXPORT RESTRAINTS ON UNPROCESSED MINERALS

Our analytical model can be used to generate estimates of the magnitude of welfare effects produced by the impending export ban. As described in our model, MEMR Regulation No. 7/2012 will cause the domestic price of unprocessed intermediate inputs to fall, increasing the effective rate of protection to downstream processing. Lowering the cost of inputs to processors in this way will create incentives for new investment in processing facilities. It will also produce side effects in the form of economic distortions and efficiency losses and will bestow benefits on owners of processing facilities at the expense of unprocessed mineral miners. In order to estimate the magnitude of these effects, one has to make some basic assumptions about the likely responses of miners and processors to the export restrictions. Most relevant will be the expected magnitudes of (1) the elasticity of processing capacity response and (2) the elasticity of price response in the market for unprocessed minerals after the ban takes place. That is to say, in the processing industry, will small changes in the price of unprocessed mineral inputs induce a large or small change in new processing capacity? In the mining industry, will small changes in domestic demand for unprocessed mineral inputs induce a large or small change in the price of these inputs? The size and distribution of welfare effects caused by the ban will be jointly determined by responses within and between these two markets. To keep the analysis tractable, we assume for the moment that ownership of mines and processing facilities is separated. We deal with the issue of joint ownership later.

The analysis examines three possible postban scenarios. The first, and we think most realistic scenario in the short run, assumes an inelastic supply response in the processing industry—with the exception of the few processing facilities currently under construction, it is assumed no other new processing investments will become operational by 2014 and for several years thereafter. Given that capacity in processing will be fixed at roughly today's levels, an enormous excess supply of ores and concentrates will be available for sale on the domestic market—excess supplies of concentrates in copper would amount to 62 percent of current output, 72 percent of current output in nickel, and 97 percent in bauxite. These excess supplies would lead to the closure of many mines, reduction in output, and significant downward pressure on prices of unprocessed minerals. As a consequence, domestic prices of unprocessed minerals would fall below the world price.[17] The extent of the price decline over time would be determined jointly by responses in both processing capacity and in the mining industry (see figure 2-2). It is difficult to determine precisely how far the domestic price of unprocessed minerals will fall, given our assumption of fixed processing capacity. In the current environment of high commodity prices, most mines have been operating at high profit margins (50–100 percent, depending on the mineral, and depending on the individual company's marginal cost curve). It is reasonable to assume that prices could drop to half their current levels—or even lower. We therefore consider two possibilities—a 25 percent decline and a 50 percent decline.[18] Using these assumptions, we estimate the welfare impact of the export ban on miners, processors, government, and the economy in each of the minerals examined in section 1—aluminum, copper, and nickel.

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[17] A good example of what happens to domestic prices of minerals after an export ban is the case of China's export bans and quotas on exports of rare earth and several other minerals. Prices of these minerals fell as much as 40 percent below the world price on China's domestic market after the export restrictions (Karapinar 2011).

[18] The ultimate extent of decline in price, as noted above, will depend on the marginal cost of mining. In this scenario, because processing demand is fixed, miners would compete for market shares of existing demand on the basis of their marginal costs of production, with the highest-marginal-cost mines closing as exports are cut because of the ban. Market equilibrium would be reached at a price where the supply of lowest-marginal-cost mines meets demand. In terms of Figure 2-2 in our analytical model of welfare effects, what we are assuming with our two cases (50 percent and 25 percent price declines), is the possibility of two different marginal cost curves of miners (i.e., two different mining supply curves) in the market for unprocessed minerals. If the mining supply curve in the unprocessed minerals market is steep, then after the ban is imposed, the fall in domestic price will be large—a 50 percent drop is not out of the question (in Figure 2-2 the supply curve would cross line **bf** below point **d**). If the marginal cost curve is flatter, the decline in domestic price will be smaller, perhaps 25 percent. Because we do not know the exact shape of the marginal cost curve of mining production, however, we cannot make an accurate estimate of the extent of decline in domestic price of unprocessed minerals.

Additionally, since export value added and export earnings are an explicit focus of Regulation 7/2012, we also consider the impact of the ban on net export revenues.

In the second scenario, we use MEMR's projected figures for planned new smelter/refinery investments, as of October 2012,[19] to make assumptions about how processors will respond to the ban (see Appendix B for list of MEMR's planned investments). We consider a scenario in which only some of MEMR's projected new capacity comes on stream three years after the ban takes place. In this scenario, we use the results of the financial feasibility study in section 1 to make assumptions about which investments are likely to occur. It is clear from the feasibility analysis that copper smelting is not likely to be commercially viable in Indonesia, while selected investments in nickel and alumina are possible, in some circumstances. Therefore, we assume for analytical purposes that, three years after the ban, one bauxite processing facility becomes operational (Harita Prima Abadi, processing 2 million tons of ore) and two new nickel smelters (Weda Bay phase 1, processing 2.5 million tons ore and PT Antam ferronickel processing 3 million tons of ore). Given this second scenario, we now have two snapshots of the welfare effects of the ban—one assuming fixed processing capacity and one assuming some increase in capacity—and we have a time dimension to the estimates, as capacity increases three years after the ban takes effect. Welfare impacts on the economy will thus accumulate over time, given our assumptions.

The third scenario considers a state of affairs where the capacity response in processing is much more elastic: that is, we assume all of MEMR's planned new processing investments become operational. Furthermore, we assume the new smelting projects will be operational by 2020 (given how long building some of these facilities takes, particularly a copper smelter, and the complementary infrastructure necessary to make them operational). Looking to MEMR's list of planned new investments, the third scenario anticipates that a second phase of Weda Bay is completed, processing approximately 3 million tons of nickel ores, three new copper smelters are built (Nusantara Smelting, Global Investindo, and Indosmelt) processing all the concentrates that were exported when the ban commenced in 2014, and one new smelter-grade alumina plant (SGA Antam) is brought on stream, processing 4 million tons of bauxite. These investments complete our speculation about the time line of processing capacity increases over the seven-year period, from no new processing capacity in 2014, to an increase of two new plants by 2017 and an increase of four new plants by 2020. Given these assumptions, we estimate the welfare impact of the ban for each scenario, as well as for the accumulated aggregate welfare effects over the time line of increases in processing capacity.

Scenario 1: No Additional Processing Capacity

Indonesia has no processing capacity in bauxite (Inalum, the aluminum smelter, imports all its alumina), two nickel smelters (PT Antam producing ferronickel and PT Inco producing nickel matte), and a copper smelter (P.T. Smelting-Gresik). Based on current construction activity, it is expected that one new bauxite refinery; a new chemical grade alumina refinery, CGA PT Antam, processing 1.1 million tons of bauxite; and one new ferronickel smelter, FeNi PT Antam, processing approximately 3 million tons of nickel ore will be operating in

[19] As of October 2012 MEMR had a list of existing smelters and planned investments in smelting of bauxite, nickel, and copper. We assume in scenario 3 that all planned smelters on the list become operational. The data sources are Geology Board (2010) and production data IDJMB (2011). MEMR's figures are also adjusted according to the latest information on planned projects provided on official company websites.

2014. All existing smelters operate at or near full capacity. According to MEMR, several other new smelters are planned and some are scheduled to begin operating by 2014 to 2016. As discussed in the financial feasibility analysis in section 1, however, it is highly unlikely that any of these prospective smelters will be operational anywhere near the start date of the impending ban.

Table 2-1 shows the magnitude of estimated welfare effects under the assumption that no new processing capacity is forthcoming. It presents the effects on miners, processors, and government, as well as efficiency losses to the wider economy due to the ban that would occur in 2014, when the export restriction takes effect. Columns 2, 3 and 4 show impacts in the mining market for unprocessed minerals—changes in miner's net revenues, direct income transfers from miners to processors, and efficiency losses sustained in the mining market. Columns 5, 6 and 7 show effects in the processing market—net revenue gains to processors (revenues minus costs of unprocessed mineral inputs), direct income transfers from miners to processors, and efficiency losses sustained in the processing market. Column 8 presents estimates of government revenue losses due to a decline in royalty payments because of a fall in mining production. Column 9 sums up total efficiency costs to the economy due to the ban relative to the free trade outcome. Lastly, column 10 shows the end result: the net welfare gains and losses of the export ban policy, totaling up the net effects on miners, processors, government, and the economy.

Assuming a price decline of 50 percent, miners of unprocessed minerals would suffer revenue losses of more than $7.44 billion per year, beginning in 2014, because of the inability to export.[20] Part of this revenue loss would come about because of a direct income transfer from miners to processors. A 50 percent domestic price decline of unprocessed minerals after the ban would compel miners to sell their excess supplies of concentrates and ores to smelters at one-half the world price. This would result in a $1.4 billion income transfer from miners to processors, as processors would enjoy higher profits because of lower input prices. A second part of the revenue loss to miners is an efficiency loss to the economy. This efficiency loss arises because the unprocessed minerals that would have been exported under free trade, earning the world price, would have cost only an amount equal to the marginal cost of production to produce. Under the export ban, these exports would not be produced and sold on the world market for more than it cost to produce them. This represents a net efficiency loss (or "deadweight" loss) to the economy, as explained in the discussion of the analytical model. Table 2-1 shows that this efficiency loss to the economy amounts to more than $1.5 billion.

[20] Net income of miners actually declines a bit less than this, because miners' production costs would also fall, but costs will decline much less than revenues.

Table 2-1

Welfare Impact in Scenario 1: No Increase in Processing Capacity (USD 000)

	Mining Market			Processing Market			Government	Economy	
Mineral	Total Revenue Loss to Miners	Transfer to Processors	Efficiency Loss	Net Revenue Gain to Processors	Transfers from Miners	Efficiency Loss	Loss in Mining Royalties	Total Efficiency Losses	Net Welfare Losses
IF PRICE DECLINES BY 50%									
Copper	(5,074,819)	(1,183,248)	(972,893)	1,183,248	1,183,248	NA	(202,993)	(972,893)	(4,094,564)
Nickel	(946,750)	(208,250)	(184,625)	208,250	208,250	NA	(42,604)	(184,625)	(781,104)
Bauxite	(1,420,200)	(19,800)	(350,100)	19,800	19,800	NA	(56,808)	(350,100)	(1,457,208)
Total	(7,441,769)	(1,411,298)	(1,507,618)	1,411,298	1,411,298	NA	(302,405)	(1,507,618)	(6,332,876)
IF PRICE DECLINES BY 25%									
Copper	(4,483,195)	(591,624)	(486,446)	591,624	591,624	NA	(179,328)	(486,446)	(4,070,899)
Nickel	(842,625)	(104,125)	(92,313)	104,125	104,125	NA	(37,918)	(92,313)	(776,418)
Bauxite	(1,410,300)	(9,900)	(175,050)	9,900	9,900	NA	(56,412)	(175,050)	(1,456,812)
Total	(6,736,120)	(705,649)	(753,809)	705,649	705,649	NA	(273,658)	(753,809)	(6,304,129)

If domestic prices of unprocessed minerals declined after the ban by only 25 percent, the total revenue loss to miners would be reduced, but it would still be considerable. As shown in table 2-1, a 25 percent price decline leads to a total revenue loss for miners of $6.7 billion per year. There are two reasons for this reduced welfare impact: (1) the income transfer from miners to processors is smaller ($706 million) because unprocessed minerals prices do not decline as much, and (2) the efficiency loss to the economy in the market for unprocessed minerals is smaller ($754 million). A smaller efficiency loss results because with a 25 percent price decline the supply curve in mining is flatter (which means marginal costs of production in mining are higher at point d in figure 2-2). Therefore, the unprocessed minerals that would have been exported under free trade would have cost more to produce than if there had been a 50 percent price drop. If the domestic cost of producing these lost exports is higher, then the difference between world price (what they could have sold for) and the cost of producing these exports is smaller, and thus the efficiency loss is smaller.

Welfare impacts for each of the individual minerals are also presented in table 2-1. More than 65 percent of the aggregate welfare loss caused by the ban occurs in copper mining, as copper concentrates are by far the largest mineral export by value, bauxite contributes 23 percent of the aggregate loss, and nickel 12 percent. Copper miners, under the assumption of a 50 percent decline in the domestic price of concentrates and no increase in processing capacity, would suffer revenue losses of $5.1 billion per year. Part of this loss is an efficiency loss to the economy of $973 million and part is a $1.2 billion income transfer from copper miners to copper smelters. Respective revenue losses in nickel mining would be $947 million and bauxite mining $1.4 billion. Because a higher percentage of copper concentrates and nickel ores are processed locally than in bauxite mining, income transfers from miners to processors are much smaller in bauxite. As a proportion of total revenue losses to miners, income transfers from miners to processors are 23 percent in copper, 22 percent in nickel, and only 1 percent in bauxite. Again, total revenue losses to miners and income transfers from miners to processors across the minerals are smaller, if the post-ban fall in domestic prices of unprocessed minerals is less than 50 percent—income transfers decline by 50 percent, as expected, but total revenue losses of miners fall by just 12 percent in copper, 11 percent in nickel, and 7 percent in bauxite.

Looking at the market for processed minerals in table 2-1, processors, in scenario one, only realize revenue gains via income transfers from miners. In the case of a 50 percent domestic price decline in unprocessed minerals, the revenue gain to processors from lower priced inputs would be $1.4 billion. To keep things simple, we neglect the fact that some processors, for example PT Smelting Gresik, will be compelled after the ban occurs to make investments in additional facilities to process smelting by-products, such as an anode slime processing plant. According to the financial feasibility study in section 1, such investments may be commercially unprofitable in Indonesia, substantially reducing any potential revenue gains from income transfers.

Another impact of the impending ban would be on government revenues. As exports and production of unprocessed minerals fall, government tax royalty revenues would fall. According to Price Waterhouse's 2012 mining taxation guide, the tax royalty on copper contract-based concession holders is 4 percent of total production; nickel IUP s pay 4-5 percent royalty, and bauxite IUP firms pay 4 percent. Assuming an average nickel royalty rate to be 4.5 percent, we calculate a rough estimate of Government of Indonesia losses from reduced mining exports and production following the export ban. Estimates for each of the minerals are presented in the next-to-last column of table 2-1. In the case where no additional processing capacity is forthcoming after the ban and unprocessed mineral prices fall by 50 percent, the magnitude of government revenue losses due to a decline in royalty taxes would be in the order of $300 million per year.

This estimate of royalty tax losses is just a small subset of the government revenue losses that would occur (1) because there are income taxes on company revenues of miners and processors, and (2) because there will be indirect tax effects: other companies in the industry will be affected by the decline in mining exports and any increases in processing capacity. Corporations in Indonesia are taxed at 25 percent of total profits. Profit margins vary widely among companies within an industry and among industries, making income tax losses difficult to estimate with any precision. It is clear, however, that tax losses would be substantial in copper, for example. For 2011, Freeport reported a 65 percent profit margin on total sales of $4.5 billion, resulting in total tax payments of $1.08 billion. If the export ban in copper results in revenue losses of $5 billion, it is conceivable that the Government could lose $1 billion in tax revenue from copper alone. Profit margins are lower in other minerals, and for the vertically integrated firms with mining and processing facilities. PT Antam, the largest producer of nickel ore and ferronickel, reported profit margins of 25 percent of total sales. A $1 billion loss in total revenue in nickel due to the export ban could lead to tax losses of about $75 million. Estimates for tax losses in bauxite are more difficult to calculate, given the large number of producers and their varying cost structures. But with total revenue losses of $1.7 billion due to the ban, even if a (low) 20 percent profit margin is assumed, corresponding tax losses could amount to $85 million. The government could lose between $1 billion and $1.2 billion per year from the ban in total income taxes.

If scenario 1 is the end result of the ban, no added processing capacity comes on line after the ban is imposed for as far as we can see into the future. Given this outcome, a cost-benefit analysis of the ban policy would find that the welfare costs of the policy far outstrip the benefits. Benefits of the export restriction, in the form of direct income transfers from miners to processors of $1.4 billion, are much smaller than the total costs incurred of more than $7.7 billion (losses to miners, government, and deadweight costs to the economy caused by the policy distortion). All told, Indonesia would suffer a net welfare loss due to the ban policy of about $6.3 billion per year.

On an individual company level, however, the welfare of some vertically integrated mining companies, which have mining operations and capacity to smelt/refine a portion of what they mine for export, would be sheltered to some extent from the welfare effects of the export ban. Any income transfers from miners to processors, for example, would simply be an accounting transfer within the company. The nickel industry has several companies in this category and so does copper. But, in Indonesia, all these vertically integrated operations, mine more ores than their locally-owned processing capacity can handle and, so, they are only partially protected from the ban. Freeport and Newmont, in copper, are good examples. Only about 30 percent of their concentrates are smelted by PT Smelting Gresik locally. Hence, after the ban takes effect, these integrated companies would have little choice but to reduce mining production if they are unable to export. Smaller miners of bauxite and nickel ore, without processing capacity, would, on the other hand, be hit very hard by the ban. Without the ability to export they would have to fully suspend all operations.

In view of the fact that one of the principal aims of the export ban is to increase the value added of exports and raise export earnings, we also look into what happens to export earnings in the case of scenario one . Table 2-2 shows the change in export earnings after the ban takes effect for the three minerals, assuming no increase in processing capacity. Export earnings decline across the board, with total export earnings falling by more than $500m per month, or in excess of $6 billion per year. On top of this decrease in export earnings, as table 2-1 showed, the ban causes large deadweight distortion costs to the economy totaling $1.5 billion. Clearly, if no additional processing capacity is forthcoming after export restrictions are imposed, a central policy goal of the ban will not be achieved.[21]

Table 2-2
Exports in Scenario 1: No Increase in Processing Capacity (USD 000)

	Bauxite	Copper	Nickel	Total
Initial export revenue: mining	1,400,400	3,891,571	738,500	6,030,471
Initial export revenue: processing	206,800	2,490,000	3,613,911	6,310,711
New export revenue: processing	206,800	2,490,000	3,613,911	6,310,711
Net increase (decrease) in export revenue	(1,400,400)	(3,891,571)	(738,500)	(6,030,471)

Scenario 2: Some New Processing Capacity

After the initial shock of the export ban in 2014, some new processing capacity may be forthcoming. Incentives for processors to invest in new capacity would be two-fold: (1) they would have access to large supplies of unprocessed domestic mineral inputs and (2) these inputs would be obtainable domestically at prices much lower than the world price. What would be processing capacity expansion in response to these incentives? Ultimately, the speed and trajectory of capacity increases will be conditioned by the financial feasibility of processing investments, as indicated in section 1, and by the degree to which the Government of Indonesia can address infrastructure and business environment problems that hamper the profitability of private investment in processing.

In the case of copper, for example, the financial feasibility analysis in section 1 shows that margins (and net present values of investments) for greenfield smelters in Indonesia would be negative. A significant drop in the domestic price of concentrates due to the ban would help make these greenfield projects more profitable, but it is unlikely to be sufficient to generate a substantial expansion in copper processing capacity. Considering the lack of value added in copper smelting, the high capital costs required to construct a copper smelter, the need for complementary investments in infrastructure (and in anode slime processing facilities), and the lack of adequate domestic markets for smelter by-products, greenfield copper processing facilities would continue to have limited commercial viability. The financial feasibility of processing facilities looks better in alumina, and better still in nickel; hence, the potential for entry and expansion of processing capacity in these minerals after the ban will probably be higher. Scenario 2 assumes that, three years after the ban, a bauxite refining facility becomes operational (Harita Prima Abadi) and two new nickel smelters (Weda Bay phase one and PT Antam).

[21] A microcosm of forthcoming losses was experienced during the short period between May and June 2012, when new export rules came into effect, with miners being required to produce the clean and clear certificates and pay a 20 percent export tax to continue exporting. Companies submitting processing plans were exempt from the export tax requirement. Smaller companies in bauxite and nickel mining, which could not produce processing plans, were hardest hit. Exports dropped by more than $194 million according to news accounts, and many small miners of bauxite and nickel exited.

Table 2-3 shows that, when the new processing capacity in bauxite and nickel comes on stream, the welfare effects of the ban do not change much. The total revenue loss to miners is $7.36 billion, only $79 million less than the losses to miners in scenario 1, when no processing capacity is forthcoming. This highlights that copper concentrates would be the central driver of the export ban's impact on the economy. Copper concentrates are 65 percent of preban export revenues of the minerals examined in this study and a major portion of total export volume. Moreover, concentrates make up 96 percent of value added in the copper value chain, as noted in section 1. Thus, when the ban cuts off copper concentrate exports, resulting in large revenue losses to miners, adding a bit more processing capacity in other minerals does not reduce total welfare losses much.

Policymakers must keep this fact in mind. If ways are not found to deal with the decline in copper concentrate exports, the magnitude of net welfare losses due to the ban will be substantial.[22] Revenue losses to miners in bauxite and nickel continue to be significant, because processing capacity increases absorb only a small fraction of the preban output of these minerals. Efficiency losses in mining due to the ban continue to be high—$1.46 billion if domestic prices drop by 50 percent and $733 million if prices drop by 25 percent.

In the processing market, adding processing capacity in nickel and bauxite has two effects on the net revenue gains of processors: (1) it increases the direct income transfer from miners to processors in these minerals, as more mineral inputs are sold to processors at lower prices, and (2) it results in more minerals being processed domestically for export. Total net revenue gains of processors increase to $2.5 billion, of which $1.4 billion comes from direct income transfers and the remainder from increases in valued added from processing more minerals. But the increase in domestic processing also entails an efficiency, or deadweight, loss to the economy of almost $40 million (assuming a 50 decline in prices of unprocessed minerals). The artificially low domestic price of unprocessed minerals caused by the ban creates an incentive for processors to expand output beyond the free-trade point at which world price equals the true cost of processing minerals. Thus, the direct income transfer from miners to processors is only partly a pure gain to the processing industry. Part of this direct income transfer is lost on account of the higher costs of processing the ban-induced extra units of output. The efficiency, or deadweight, loss to the economy in the market for unprocessed minerals, however, is reduced somewhat to $1.44 billion, as more unprocessed minerals are shifted from the category of banned exports (which could have been sold in the world market for more than the cost of producing them) into domestic inputs for export processing. Losses in Government royalty revenues due to the ban are also not as large when processing capacity increases. Mining production, which is depressed because of the ban, rises to meet the new domestic demand for inputs from processors. Because government royalty revenue depends on mining production, these tax revenue losses, totaling $293 million, are now smaller than they were in scenario 1.

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[22] Domestic processing of these concentrates for export is one way to improve the situation, but according to the financial feasibility study in section 1, this may be a costly way to solve the problem, because copper smelting looks to be very unprofitable in Indonesia.

Table 2-3
Welfare Impact of Scenario 2: Some Increase in Processing (USD 000)

	Mining Market			Processing Market			Government	Economy	
Mineral	Revenue Loss to Miners	Transfer to Processors	Efficiency Loss to Economy	Revenue Gain to Processors	Transfers from Miners	Efficiency Loss to Economy	Loss in Mining Royalties	Total Efficiency Losses	Net Welfare Losses
ASSUMING PRICE DECLINES BY 50%									
Copper	(5,074,819)	(1,183,248)	(972,893)	1,183,248	1,183,248	-	(202,993)	(972,893)	(4,094,564)
Nickel	(903,000)	(252,000)	(162,750)	933,848	252,000	(21,875)	(37,052)	(184,625)	(28,079)
Bauxite	(1,384,200)	(55,800)	(332,100)	359,800	55,800	(18,000)	(52,488)	(350,100)	(1,094,888)
Total	(7,362,019)	(1,491,048)	(1,467,743)	2,476,896	1,491,048	(39,875)	(292,533)	(1,507,618)	(5,217,531)
ASSUMING PRICE DECLINES BY 25%									
Copper	(4,483,195)	(591,624)	(486,446)	591,624	591,624	-	(179,328)	(486,446)	(4,070,899)
Nickel	(777,000)	(126,000)	(81,375)	807,848	126,000	(10,938)	(29,590)	(92,313)	(9,680)
Bauxite	(1,356,300)	(27,900)	(166,050)	331,900	27,900	(9,000)	(49,932)	(175,050)	(1,083,332)
Total	(6,616,495)	(745,524)	(733,871)	1,731,372	745,524	(19,938)	(258,850)	(753,809)	(5,163,911)

Overall, the increases in processing capacity in nickel and bauxite reduce net welfare losses caused by the ban. But the impact of the ban policy on the economy continues to be highly negative, with net welfare losses totaling $5.2 billion. The ban also continues to cause large annual losses in export revenues of $4.9 billion, despite an increase in export revenues from new processing investments in nickel and bauxite of $1.1 billion. The key reason for this continuing high export earning loss is the export revenue loss on copper concentrate of $3.9 billion, which offsets any revenue gain from new processing capacity. So in cost-benefit terms, the costs of the ban continue to outweigh the benefits, by a large margin, even as processing capacity is expanded.

Table 2-4

Exports in Scenario 2: Some Increase in Bauxite and Nickel Processing (USD 000)

	Copper	Nickel	Bauxite	Total
Initial export revenue: mining	3,891,571	738,500	1,400,400	6,030,471
Initial export revenue: processing	2,490,000	3,603,788	206,800	6,310,711
New export revenue: processing	2,490,000	4,373,136	582,800	7,445,936
Net increase (decrease) in export revenue	(3,891,571)	30,848	(1,024,400)	(4,885,123)

Scenario 3: All of MEMR's Planned New Processing Investments Become Operational in 2020

Scenario 3, shown in table 2-5, assumes that all of MEMR's planned processing capacity becomes operational by 2020: a second phase of Weda Bay is completed in nickel, three new copper smelters are built (Nusantara Smelting, Global Investindo, and Indosmelt), and one new smelter-grade alumina plant (SGA Antam) is brought on stream. These investments complete our speculations about the timing of processing capacity expansions after the ban takes effect. Scenario 3 also assumes that the domestic price of copper concentrate rises again after an initial decline to just 10 percent below the world price. This price rise occurs because, in 2020, with all the new processing investments, preban concentrate exports are now being processed domestically and four domestic processors are bidding for concentrate, which supports domestic concentrate prices at a level close or equal to the world price. We make the 50 percent and 25 percent assumptions about domestic nickel and bauxite prices, because substantial supplies of these unprocessed minerals are still available on the domestic market.

Table 2-5

Welfare Impact in Scenario 3: All MEMR Planned Processing Capacity Becomes Operational (USD 000)

	Minigg Market			Processing Market			Government	Total Efficiency Loss	
	Total Revenue Loss to Miners	Transfer to Processors	Efficiency Loss to Economy	Net Revenue Gain to Processors	Transfer from Miners	Efficiency Loss to Economy	Loss in Mining Royalties	Total Efficiency Losses	Net Welfare Losses/Gains
ASSUMING PRICE DECLINES BY 50% (10% FOR COPPER)									
Copper	-62,5806.72	(625,807)	-	763,056	625,807	(194,579)	(25,032)	(194,579)	(82,362)
Nickel	(823,375)	(331,625)	(122,938)	2,236,013	331,625	(61,688)	(55,368)	(184,626)	1,295,582
Bauxite	(1,312,200)	(127,800)	(296,100)	1,039,800	127,800	(54,000)	(54,252)	(350,100)	(380,652)
Total	(2,761,382)	(1,085,232)	(419,038)	4,038,868	1,085,232	(310,267)	(134,652)	(729,305)	832,567
ASSUMING PRICE DECLINES BY 25 % (10% FOR COPPER)									
Copper	-62,5806.72	-62,5806.72	-	76,3055.52	625,807	(194,579)	(25,032)	(194,579)	(82,362)
Nickel	(657,563)	(165,813)	(61,469)	2,070,200	165,813	(30,844)	(40,635)	(92,313)	1,341,158
Bauxite	(1,248,300)	(63,900)	(148,050)	975,900	63,900	(27,000)	(34,965)	(175,050)	(334,365)
Total	(2,531,670)	(855,520)	(209,519)	3,809,156	855,520	(252,423)	(100,632)	(461,942)	924,431

Table 2-5 presents figures showing that miners, even after all this new processing capacity becomes operational, continue to suffer total revenue losses of $2.8 billion. Revenue losses in the mining market continue because there is still not enough processing capacity to handle all available nickel and bauxite ores. Nickel and bauxite miners experience total revenue losses of $823 million and $1.3 billion per year respectively. The direct income transfer from miners to processors remains large at $1.1 billion, as domestic prices of nickel and bauxite are still 50 percent below the world price. Copper miners now transfer just $625 million to processors, given the rise in copper concentrate prices. An efficiency loss to the economy of $419 million remains in the mining market because of unrealized sales of banned unprocessed minerals.

In the processing market, all the new capacity raises net revenue gains to processors to $4.0 billion. The gain in processing net revenues is generated mostly by increased value added in processing nickel (55 percent) and in bauxite (26 percent). Given the high value-added in nickel processing, net revenue gains to processors ($2.2 billion) offset losses to nickel miners ($823 million). After deducting $184 million in efficiency losses in nickel, there is a net welfare gain to moving downstream into more nickel processing. In the case of bauxite, an increase in processing capacity in alumina increases net processor revenues. However, mining revenue losses in bauxite continue to outstrip these value added gains in processing, and, if we add the efficiency losses caused by the ban, bauxite continues to suffer a net welfare loss. In copper, net revenue gains to processors are small because of the higher cost of concentrates and because of the low value added in copper smelting (see section 1). Overall, there is a net welfare loss involved in increased copper processing of $82 million compared with the pre-ban free trade outcome.

In sum, when all of MEMR's planned processing capacity becomes operational, total net welfare gains are quite modest, totaling just $832 million per year. An additional letdown is the fact that large accumulated net welfare losses have been incurred over the years of the investment time-line of MEMR processing projects to finally arrive at this modest annual net welfare gain. 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 (see table 2-6). Gains to processors range between $15.7 billion and $11.1 billion, and 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. This is a hefty price to pay for a policy that generates such modest social benefits.

Table 2-6

Cumulative Impact on Welfare with Price Drops of 50% and 25% (USD 000)

	2014	2015	2016	2017	2018	2019	2020	TOTAL
IF PRICES DROP BY 50%								
MINERS								
Total Revenue Loss	(7,441,769)	(7,441,769)	(7,441,769)	(7,362,019)	(7,362,019)	(7,362,019)	(2,761,382)	(47,172,746)
Transfer to Processors	(1,411,298)	(1,411,298)	(1,411,298)	(1,491,048)	(1,491,048)	(1,491,048)	(1,085,232)	(9,792,270)
Efficiency Loss	(1,507,618)	(1,507,618)	(1,507,618)	(1,467,743)	(1,467,743)	(1,467,743)	(419,038)	(9,345,121)
PROCESSORS								
Net Revenue Gain to Processors	1,411,298	1,411,298	1,411,298	2,476,896	2,476,896	2,476,896	4,038,868	15,703,450
Transfers from Miners	1,411,298	1,411,298	1,411,298	1,491,048	1,491,048	1,491,048	1,085,232	9,792,270
Efficiency Loss	NA	NA	NA	(39,875)	(39,875)	(39,875)	(310,267)	(429,892)
GOVERNMENT								
Loss in Mining Royalties	(302,405)	(302,405)	(302,405)	(292,533)	(292,533)	(292,533)	(134,652)	(1,919,464)
ECONOMY								
Total Efficiency Losses	(1,507,618)	(1,507,618)	(1,507,618)	(1,507,618)	(1,507,618)	(1,507,618)	(729,305)	(9,775,013)
Net Welfare Losses	(6,332,876)	(6,332,876)	(6,332,876)	(5,217,531)	(5,217,531)	(5,217,531)	832,567	(33,818,651)
IF PRICE DROPS BY 25%								
MINERS								
Total Revenue Loss	(6,736,120)	(6,736,120)	(6,736,120)	(6,616,495)	(6,616,495)	(6,616,495)	(2,531,670)	(42,589,515)
Transfer to Processors	(705,649)	(705,649)	(705,649)	(745,524)	(745,524)	(745,524)	(855,520)	(5,209,039)
Efficiency Loss	(753,809)	(753,809)	(753,809)	(733,871)	(733,871)	(733,871)	(209,519)	(4,672,559)
PROCESSORS								
Net Revenue Gain	705,649	705,649	705,649	1,731,372	1,731,372	1,731,372	3,809,156	11,120,219
Transfer from Miners	705,649	705,649	705,649	745,524	745,524	745,524	855,520	5,209,039

	2014	2015	2016	2017	2018	2019	2020	TOTAL
Efficiency Loss	NA	NA	NA	(19,938)	(19,938)	(19,938)	(252,423)	(312,237)
GOVERNMENT								
Loss in Mining Royalties	(273,658)	(273,658)	(273,658)	(258,850)	(258,850)	(258,850)	(100,632)	(1,698,156)
ECONOMY								
Total Efficiency Losses	(753,809)	(753,809)	(753,809)	(753,809)	(753,809)	(753,809)	(461,942)	(4,984,796)
Net Welfare Losses	(6,304,129)	(6,304,129)	(6,304,129)	(5,163,911)	(5,163,911)	(5,163,911)	924,431	(33,479,690)

Export earnings, shown in Table 2-7, become positive in scenario 3 at $1.3 billion after many years of losses. But when we offset these export earnings with the total deadweight efficiency losses of $729 million caused by the ban policy, the result for 2020 does not look impressive. Considering all the public and private capital investment required to bring MEMR's planned processing investments into operation, and the years of welfare and export losses incurred to do so, a net reward of $548 million ($1.3 billion minus $729 million) is not large. Moreover, to attain the export gain from additional processing investments in 2020, accumulated export losses over the years equal to $31.5 billion have been incurred (Table 2-8).

Table 2-7

Exports in Scenario 3: All Planned MEMR Investments Operational (USD 000)

	Copper	Nickel	Bauxite	Total
Initial export revenue: mining	3,891,571	738,500	1,400,400	6,030,471
Initial export revenue: processing	2,490,000	3,603,788	206,800	6,310,711
New export revenue: processing	6,518,820	5,754,926	1,334,800	13,608,546
Net increase (decrease) in export revenue	137,249	1,412,638	(272,400)	1,277,486

Table 2-8

Cumulative Losses in Export Revenue, 2014–2020 (USD 000)

Year	Copper	Nickel	Bauxite	Total
2014	(3,891,571)	(738,500)	(1,400,400)	(6,030,471)
2015	(3,891,571)	(738,500)	(1,400,400)	(6,030,471)
2016	(3,891,571)	(738,500)	(1,400,400)	(6,030,471)
2017	(3,891,571)	30,848	(1,024,400)	(4,885,123)
2018	(3,891,571)	30,848	(1,024,400)	(4,885,123)
2019	(3,891,571)	30,848	(1,024,400)	(4,885,123)
2020	137,249	1,412,638	(272,400)	1,277,486
Total	(23,212,178)	(710,319)	(7,546,800)	(31,469,297)

3. Economic Effects of Mandating Pre-export Downstream Minerals Processing

MEMR's Regulation 7/2012 restricting exports of upstream unprocessed minerals is a strategic policy initiative with a lengthy tradition in developing countries. The idea behind the strategy is that it is a logical, natural progression for a country exporting raw materials to move into the processing of these materials, and therefore policies encouraging downstream processing can improve trade performance and accelerate structural transformation of the economy. This notion is based on the premise that vertical relationships in production chains, known as linkages, are central to the development process.

The concept of linkages was first popularized by Hirschman in his influential 1958 book, *The Strategy of Economic Development*. He argued that investing in industries with the greatest backward and forward linkages would have the most powerful total effect on economic growth and development, because it would induce a broad set of continuing responses: upstream supply responses would be stimulated by domestic investments in highly linked final goods industries (backward linkages), and downstream production responses would be stimulated by investments in highly linked upstream input industries (forward linkages).

The instinctive appeal of Hirschman's arguments led to two popular policy strategies based on linkages. Import-substituting industrialization was the first. It sought to induce investment, structural transformation, and growth through final demand linkages. Import substitution strategies targeted manufacturing of final consumer goods, previously imported, and then shifted to higher stages of manufacturing of intermediate goods and machinery, through backward linkage effects. Policies to foster these results imposed restrictions on imports of final consumer goods, which then, in turn, would stimulate domestic demand for inputs needed in their production.

The second popular policy strategy based on linkages was to promote downstream processing of natural resources previously exported as unprocessed raw materials. Policies to further this agenda aimed at forward linkages, restricting exports of unprocessed commodities in one part of the value chain to encourage development of downstream industries in another part of the chain.

For most of the 1960s and 1970s these ideas were trendy in policy circles in developing countries. By the 1980s, however, backward-linkage strategies, such as import substitution, had led to poor economic performance and macroeconomic crises in many countries, particularly in Latin America. This was brought home by the 1980s debt crises. Forward-linkage strategies, on the other hand, continued, and have seen an uptick in popularity recently, particularly in the past decade in resource-rich countries in the wake of the commodities boom. From Papua New Guinea to South Africa, ministries of trade have been eager to promote downstream processing of raw materials to diversify exports, create value-added products, and generate employment. In South Africa, for example, the National Industrial Policy Framework declared that "the promotion of greater value added of raw materials in downstream sectors is a logical progression to complete various value chains in the South African economy" (Department of Trade and Industry, July 2006; quoted in Hausmann el. al. 2007). To further this policy the country initiated export controls on many unprocessed minerals and financing programs to promote valued added in minerals industries. Several other African countries have pursued the same path, such as Botswana in diamonds, Zambia in copper, Ghana in oil, and Mozambique in natural gas and coal. In Latin America, Brazil, Peru, and Chile have initiated similar linkage-based policies during the decade. India recently instituted efforts to block exports of cotton to promote downstream processing. And developed countries, such as Australia, joined in with tax schemes to spur downstream processing. So Indonesia is not alone in attempting to foster a forward-linkage strategy for export development.

But do such forward linkage strategies make economic sense? What is the basis for using forward linkages as a guide to stimulating export value added and structural transformation of exports? While Hirschman justified forward linkages based on stimulating related industry, other advocates of forward linkages argue that physical proximity to raw materials provides downstream processors with economic advantages because of transportation costs. Why transport bauxite or copper concentrate from Indonesia all the way to China or Japan or Europe to be processed when it can be processed at home? Still others stress missing links in the value chain. Why import alumina when it can be refined from Indonesian bauxite at home? And some proponents highlight technological capability issues. Why export unprocessed minerals when we have the technical capability (or could develop the capability) to build smelters and other aspects of the supply chain domestically? Unfortunately, these arguments, and Hirschman's linkage analysis, make little economic sense in a world where (1) transport, information, and communication technology (ICT) costs have fallen dramatically and continue to decline, and (2) trade and globalization are accelerating because of supply chain fragmentation. Whatever merit forward-linkage strategies may have had in the past, their significance has been reduced substantially. Even if linkages might matter in autarky, as transport and ITC costs fall and trade is liberalized, they have to matter much less (Yi 2003; Baldwin 2012).

With increasing trade, high domestic linkage possibilities, a la Hirschman, do not automatically convey an advantage to developing resource-based production. Forward-linked industries, such as basic minerals, can be established in any country able to import the unprocessed resource. Only if home processing can supply the downstream product at lower cost (or reduce the risk of supply disruptions) can it be argued that it is advantageous to invest in developing the forward-linked industry at home. The cost factor in the calculation is determined by comparative advantage and technological differences. In terms of static comparative advantage, Indonesia's factor endowments (and technological capabilities in some cases) do not give it any cost advantages in highly capital intensive industries, which (1) require enormous capital investment (2) necessitate huge complementary investments in infrastructure, and (3) employ an exceedingly small portion of the country's large workforce.

Declining transport and ICT costs add another dimension to this calculation of establishing forward-linkage production. Since minerals processing reduces weight of the resource and raises the value, transport costs generally favor processing near the mine (The impact of transport costs, however, depends somewhat on the mineral's characteristics and on its stage of processing—for example, shipping rates for aluminum ingots are higher than for bulk cargoes such as alumina). But the decline in international transport costs over the decades has significantly reduced these incentives to process near mines. As shown in section 1 of this study, key determinants of the location of smelters/refineries for many minerals revolve around the need for complementary inputs like low-cost power, access to land, pollution and other regulatory requirements, access to low-cost finance, external economies, such as markets for by-products, and so on, rather than simply transport costs.

The ICT revolution has reduced trade costs further, encouraging additional geographical separation of links in the production chain and more fragmentation of production tasks. Email and specialized web-based coordination software have revolutionized the ability to manage multifaceted tasks and procedures across the world. This has lowered coordination costs dramatically and made it increasingly economical to geographically separate or "unbundle" many tasks in a vertical production or supply chain. This combined effect of falling transportation costs and the ICT revolution on fragmentation of the production chain has been called "globalization's second great unbundling" (Baldwin 2012).[23] Production stages previously carried out in close proximity have been dispersed to reduce production costs. This unbundling has not always been global. The most profound effects of the unbundling have been within regions, as distance still appears matter to some degree for the coordination costs of managing cross-border, vertical production links (Johnson and Noguera 2011).

TRANSFORMATION IN INTERNATIONAL TRADE

The important point here is that the second unbundling, driven by lower transport and coordination costs, has transformed international trade. It has made it much easier to separate links in the production chain and it has made it much easier to combine advanced-nation technology with developing country low-cost labor. In this transformed world of trade, goods are no longer "packages" of a single country's factor endowments, technology, social capital, governance capacity, and so on (Baldwin 2012). Goods are now "packages" of the factor endowments, technology, social capital, and governance capacity of many countries. Trade patterns and performance of most countries are now shaped by their position in an international production chain. In the supply chain for a particular product, designed can take place in one country, technology and management can come from another country, component parts can be produced in a third, and final assembly can take place in a fourth. This kind of trade involves continuous, back-and-forth flows of factors of production between countries that used to take place within countries, factories, and offices. Johnson and Noguera (2012) track this transformation in international trade from 1970-2009. They show that there was an acceleration in fragmentation of world trade over the period, with two-thirds of the change taking place in the last two decades. The largest increases in supply chain fragmentation occurred in fast growing countries undergoing structural

[23] According to Baldwin the "first great unbundling" took place in the early 20th century and was about the separation of production from consumption. Falling transportation costs because of the steam engine meant that goods made in factories in one nation could be sold cheaply to customers in another.

transformation. Furthermore, they find that policy and nonpolicy barriers to trade are significant determinants of a country's ability to benefit from this fragmentation process.

EASIER, FASTER INDUSTRIALIZATION

The transformation of trade has made the process of industrialization much simpler for developing countries. Prior to the ICT revolution of the second unbundling, it was not possible to develop a world-class industry unless a country had a well-developed industrial base, the technical capabilities of which took decades to build. A supply chain had to be constructed from scratch in highly competitive market conditions. Countries such as Japan, Korea, and Taiwan entered world markets with shoddy products and over time learned, with the assistance of state-directed industrial policy, to improve their technical capabilities and product quality. Many countries from other regions of the world tried to copy these hard-won, industrialization success stories, but failed. After the second unbundling, the requirement to build a whole domestic production chain from the ground up ended. Individual links in the chain can now be more easily in-sourced whole-cloth, with everything needed to export competitively—technology, management, quality control, and marketing. Obtaining such world-class technology can modernize segments of a developing country's industry almost overnight. Similarly, high cost links of the vertical production chain, which lack comparative advantage, can more easily be out-sourced and a country can concentrate its efforts on more competitive activities, raising aggregate industry productivity and growth. All of this fragmentation makes getting industrialization started and moving up the value chain easier. As long as a country has a workable import-export platform—a good business environment, reliable, low-cost workers, and basic infrastructure, it is able to do business. Multinational firms, searching the world for low-cost production sites, will help to do the rest. There is also an important neighborhood effect, as noted above. Being part of a fast-paced, industrializing region, such as Asia, with its highly-fragmented supply chains, is a big plus. Many more opportunities are available to acquire off-shored production links and to out-source others.

IMPORTANCE OF FORWARD LINKAGES FOR CROSS-COUNTRY TRADE

What does research say about the effect of the forward linkages paradigm on export performance? Advocates assert that forward linkages are a natural and logical progression that developed economies followed, and that they are the most commonsensical way to go, given the local availability of raw materials. But have countries actually found export success transitioning from production of raw materials to downstream processing of those materials? How much impact have forward linkages around the world had on sectors likely to emerge as export winners? Hausmann, Klinger, and Lawrence (2008) investigate these issues using trade data for the period 1975–2000 for all countries, as well as input-out data describing linkages for 241 products. They evaluate the role of forward linkages in determining international patterns of specialization and trade and how these patterns change over time, a process called structural transformation of exports.

The study made the following findings:

- Only a very small number of countries that export unprocessed commodities also export the processed version of these commodities. What's more, these countries do not evolve over time into increased processors of these unprocessed commodities.

- Patterns of production and trade, as well as changes in these patterns across countries in the 1975-2000 period, are explained primarily by typical determinants of comparative advantage, such as factor endowments and factor intensities, not forward linkages. Hence, policy initiatives that take for granted that further downstream processing is in accordance with the usual course of nature are not supported by cross-country experience.
- Focusing on those sectors that emerged as export winners across countries over the period, the study finds that forward linkages played an extremely small part in these export successes.
- Forward linkages have even less impact on production and the composition of trade in sectors where one might expect linkages to exert more influence, namely:
  - Goods with high transport costs—thus, claims that forward linkage strategies are necessary to save on the transport costs of unprocessed commodities are simply not founded on empirical evidence. As noted earlier, many other factors determine the location of processing capacity.
  - Primary product sectors—the impact of forward linkages on production and trade is weak overall and weaker than in manufacturing. This is significant because commodity sectors are where policies to promote downstream processing are generally aimed.
- Looking more closely at differences between the two country groups in the study, developed and developing countries, it might be expected that the importance of forward linkages for trade vary in these countries, possibly because colonial history in many developing countries inhibited transitions into downstream processing. Results of the study do not support this conjecture. Forward linkages have the same small impact in both developed and developing nations.

These results have important implications for policy. They suggest that policy interventions to encourage downstream processing to diversify exports and improve trade performance are ill-advised. Forward linkages are just not important in determining patterns of world trade and changes in these patterns. International experience also shows that new exports spring up more from lateral activities that are closely related in terms of technology, factor intensities, and capabilities, than they do from vertical activities connected in production chains. Forward linkages are shown to play an extremely small part in international export successes. Likewise, arguments claiming that proximity of natural resources and transport cost savings are reasons for promoting downstream processing do not correlate with cross-country evidence.

The bottom line is that there are opportunity costs to policy choices. Adopting a linkage-based strategy to promote export development means other policies that might be more productive in stimulating the emergence of new higher value exports will not be pursued. The results of Hausmann et. al. clearly show that this is a bad trade-off, as better opportunities are more often "lateral" than "downstream". As a rule, linkages appear to be a poor guide for formulating export development policy. Forward linkage-based policies are shown to go against international experience, and they do not make much sense in a world where trade costs have fallen substantially and supply chains make it much easier to in-source and out-source links in the production chain.

4. Policy Conclusions

This study shows that the Government of Indonesia's impending ban on exports of unprocessed minerals is a bad policy instrument for achieving the country's economic goals of increasing value added in exports and export earnings for the following reasons:

The ban is a blunt policy instrument that does not recognize significant differences among the important export minerals. The financial feasibility study in section 1 shows that there are substantial differences in the commercial viability of downstream processing investments. Greenfield copper smelting appears to lack any commercial feasibility—studies show smelters have negative margins and negative net present values—bauxite looks somewhat better, and nickel looks best. Copper smelting also adds very little value to exports. A wholesale export ban, which neglects these downstream differences in investment prospects, does not make a lot of policy sense if the goal is to increase export value added and export earnings.

Generally speaking, the financial feasibility of smelters does not look particularly good in Indonesia across all the minerals, given the complementary public infrastructure required to make these investments profitable, the need for supportive industries to sell output and by-products, the huge capital costs involved and the complexity of financing them, and current problems in the business environment. On top of these issues, world markets today have substantial excess capacity in downstream minerals processing and extremely low TCRCs, making it difficult to argue that new greenfield smelter investments in Indonesia can be competitive.

The export ban would inflict large net welfare losses on the mining industry and create deadweight efficiency distortions in the economy. Miners would experience large revenue losses from a decline in exports and from falling prices of unprocessed minerals on the domestic market. Overall net welfare losses would include substantial government revenue losses in royalty and income taxes. Net welfare losses would be especially large if no new downstream processing capacity comes on-stream. Our analysis shows that, as new processing investments become operational after the ban, net welfare losses decline. But the decline in losses depends heavily on increasing processing capacity in copper, which is, by far, the least feasible of all the processing investments and therefore the least likely to be forthcoming. Without additional new copper smelting capacity, the ban would continue to impose large welfare losses on the economy, despite increasing processing investments in other minerals. Ultimately, even after all of MEMR's planned new processing capacity becomes operational, welfare gains from the ban policy, compared with the pre-ban free trade counterfactual, are small. Overall, gains in export earnings due to the ban are also not very large, given all the capital investment required and time involved in moving downstream. Accumulated welfare costs over these years of getting processing investments up and running are huge compared with the final benefits of the ban policy.

Net welfare losses from the ban would be increased if processors have monopsony power, as shown in the analytical model developed in section 2. This would depend on the final market structure of the processing industry in any of the minerals examined in this study. With only a few processors and many miners in any mineral category, the chances for the exercise of monopsony increases.

The decline in domestic prices of unprocessed minerals that would come about after the ban would increase incentives for smuggling minerals out of the country, a problem the government would like to address. This would increase the necessity for more police involvement, not lessen it, as some have argued.

The ban distorts public and private investment decisions, causing substantial social opportunity costs. As noted above, the financially feasibility of smelters investment do not look particularly outstanding, particularly in the absence of complementary investments in infrastructure and supportive industries. The public investment part of the package has to be justified to taxpayers on the basis of a comparison with other public investments. Would investing in a power plant, road, or a port to support a copper smelter produce a bigger social or economic bang-for-the-buck than investing in a school, or a hospital, or even a power plant to support more investment in other economic areas, such as labor-intensive manufacturing? If not, then investment in the smelter is questionable. The findings in this study do not provide much evidence to support an affirmative answer to this question.

Even if the ban policy could achieve higher export value-added and earnings in the long run, but at what cost? Just because it may be technically possible to construct and operate smelters does not mean it should be done. The operating costs and competitiveness of these investments, the welfare costs and efficiency losses to the economy caused by the ban policy, and the opportunity costs of public investment that would be incurred must be part of the decision to go ahead with such as policy.

Alternatively, what would be a better approach than a wholesale export ban on unprocessed minerals? The argument against an export ban in this study is not an argument against all downstream minerals processing. There are substantial differences between the minerals we examined. Some, like nickel, have high value-added in the processing stage and, if processed cost-effectively, could be good prospects for development policies. The important point is to avoid blunt, across-the-board policies, to compel downstream investment in processing, in all minerals whether it is economic or not. If downstream processing is to be pursued as a policy it should be (1) selective and (2) based on "first-best" economic principles to avoid collateral damage. That is, if downstream processing in a particular mineral looks profitable and has promise in raising export earnings, then the "first-best" economic policy would be to target policy interventions on the problem of processing this mineral directly, rather than using indirect restrictions on all exports of unprocessed minerals to subsidize downstream processing of it via falling domestic prices of inputs.

More broadly, however, there is a question about whether one wants to direct policy towards subsidizing downstream minerals processing at all when other, "lateral" (rather than "vertical") competing activities may provide a greater impact in moving up in export quality, raising export earnings, and fostering employment? As this study argues, forward-linkage strategies are a poor guide for formulating export development policy. Forward linkage-based policies are shown to go against international experience, and they do not make much sense in a world where trade costs have fallen substantially and supply chains make it much easier to in-source and out-source links in the production chain.

In general, the best thing for policymakers to do to get more out of the country's natural resource endowments is to focus on fiscal policy rather than the production side of the minerals industry where distortions can be costly. Changes in the royalty and income tax regime would appear to be the most effective, least costly policy approach.

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Appendix A. Methodology

The welfare calculations are based on the following assumptions about mineral concentrations and related prices:

ALUMINUM

For the aluminum industry, we assume all downstream processing to be up to the alumina stage to meet the new export processing requirements. Data on ore production are taken from the MEMR report (2012). Potential alumina production levels are computed following the general rule followed by the U.S. Geological Survey, that 4 tons of dried bauxite is required to produce 2 tons of alumina, which in turn, provides 1 ton of primarily aluminum metal. Average prices for bauxite of $36.00 per ton and alumina of $364 per ton in 2011 are used for computing welfare effects of the export ban.

COPPER

In the copper industry, ore production levels are obtained from the MEMR report (2012), as well as individual company annual reports. Copper ores contain only about 0.49 percent of metallic copper, and because concentration is done at the mining stage, all data are converted to the amount of concentrates produced using the average copper concentration ratio of 33 percent LME copper. The average 2011 LME copper price of $8,300/t for copper cathodes is used. The average copper concentrate price is calculated on the basis of 33 percent copper content and takes into account the TC/RC paid to processors. The concentrate price of $2,629.52 is used to compute welfare effects.

NICKEL

Due to the vast differences in processing methods for Nickel, we simply use the LME Nickel price as the reference price for processed Nickel ($20026/t). Nickel ore prices are tied to LME prices by the following formula:

USD (LME nickel price) x (0.65 wet metric tonne for 35 percent moisture content) x (0.01for 1 percent ore grade)x (0.1 5*LME recovery factor)

Differences in nickel ore prices are due to differences in moisture content and the ore grade or the LME recovery factor, which depends on the ore grade, and ranges between 15 percent and 25 percent. Given the vast differences in the quality of nickel ore produced and exported, we use the 2011 average export price of $35 per ton. Conversion from ore to processed nickel assumes an average 1.5 percent grade ore. Since processed ferronickel (20-30 percent nickel) and nickel matte (60–70 percent nickel) differ so widely in nickel content, to compute welfare effects we simply convert the ore processing capacity figures, as reported by MEMR to LME nickel amounts.

Appendix B. Processing for 2012 Reported by Ministry of Mining

III. PRESENT CONDITION (CONTINUED)

III.2 *Material Balance*/Processing and Refinery Balance (Existing and Plan)

COMMODITIES	RESOURCES/RESERVES (tons of ores)	MINING PRODUCTION (tons of ores, 2011)	PROCESSING/REFINERY INDUSTRY	PROCESSING CAPACITY (tons of ores)
COPPER	**Resources** 4.900 million **Reserves** 4.200 million	**Cu** (tons of ores) 75 million	**Existing :** - Smelting Gresik **Plan :** - Nusantara Smelting (2014) - Global Investindo (2015) - Indosmelt (2014) **TOTAL CAPACITY** **BALANCE**	29 million 20 million 34 million 11 million 94 million **- 19 million**
BAUXITE	**Resources** 552 million **Reserves** 180 million	**Bauxite ores** (ton) 40 million	**Plan :** - SGA PT Antam (2014) - CGA PT Antam (2014) - Harita Prima Abadi (2014) **TOTAL CAPACITY** **BALANCE**	4 million 1,1 million 2 million **7,1 million** **32,6 million**
NICKEL	**Resources** 2.600 million **Reserves** 577 million	**Nickel Ores** (ton) 33 million	**Existing** - FeNi PT. Antam - Ni in Matte PT. INCO **Rencana** - Weda Bay nickel (2016) - NPI PT. Antam (2014) - FeNi PT Antam (2014) **TOTAL CAPACITY** **BALANCE**	2,95 million 6 million 6 million 0,9 million 2,95 million **18,9 million** **14,1 million**

Data Source : Geology Board (2010) and Production Data i DJMB (2011)