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GLOBAL COMMODITY CHAINS AND PRODUCTION NETWORKS
Understanding uneven development in the global economy

Schwerpunktredaktion: Leonhard Plank
Cornelia Staritz

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Lars Hildebrand

Brazil's integration into the global commodity chain of aluminium: an opportunity for economic development?[1]

1. Introduction

Today the majority of low- and middle-income countries (LIC/MICs) strives for world market integration, encouraged by major development actors (United Nations, World Bank) and facilitated by international trade and finance institutions (World Trade Organization, International Monetary Fund). At the same time, various LIC/MICs have started to focus again on expanding their activities in mineral mining and metal production since commodity prices started soaring in mid-2001 and predictions of rapidly rising global demand assure sustained high world market prices. This paper aims at analysing the development impacts associated with the expansion of the extractive and metal industries in LIC/MICs, using Brazil's export-oriented aluminium industry as an illustrative case. However, in contrast to most contemporary extractive industries research, the following analysis will not focus on the scale of the nation-state, but instead apply the transnational and network-based Global Commodity Chains (GCC) approach (Gereffi et al. 1994). Although originally developed for understanding the changing geographies of production in manufacturing (see Gereffi/Memedovic 2003 for the apparel industry; Humphrey/Memedovic 2003 for the automobile industry; Kaplinsky et al. 2003 for the furniture industry), the tools and concepts of the GCC approach also promise a new perspective on extractive and metal industries by placing spatial and temporal configurations of inter-firm networks as well as their implications for development at the centre of analysis. In fact, as Bridge has shown in his work on the oil industry, network-based research perspectives such as GCC, Global Value Chain (GVC) or Global Production Network (GPN) approaches "challenge

explanations of poor development outcomes based solely on state-failure" (Bridge 2008: 414).

The main purpose of the paper is to apply the analytical toolkit of the GCC approach to the global aluminium industry, focussing on development issues in the export-oriented aluminium industry in Brazil. Therefore, in the first part the basic structure of the global aluminium industry will be introduced, outlining the main processes of production and geographic shifts as well as characteristic features of the GCC, e.g. type of governance and distribution of value along the chain. The second part will focus on Brazil as an illustrative case and briefly analyse the outcome of Brazil's expansion in the aluminium sector, especially in relation to the characteristic features of the GCC. In the final section the findings will be used to reflect on the main factors that condition the (limited) opportunities of transnational extractive and metal industries for providing sustainable development benefits.

2. The global commodity chain of aluminium

2.1 Processes, production shifts and lead firms of the global aluminium industry

The production of primary aluminium[2] can be divided into three basic processes (see also Figure 1): (1) The mining of bauxite involves the relatively simple mechanic extraction of the ore as well as crushing and washing processes. (2) For refining, bauxite is dissolved in caustic soda before it can be chemically decomposed. The generated aluminium hydroxide condenses and is then transformed into aluminium oxide (alumina). (3) The smelting (also called reduction) requires the dissolving of aluminium oxide in molten cryolith, after which the raw aluminium is obtained by electrolysis. Subsequent processing includes the metallurgical production of alloys (by blending with elements such as copper or silicon) and the fabrication of semi-finished and end-products (by a variety of casting, rolling and extrusion methods).

Historically, mining, refining and smelting were concentrated in the industrial centres of North America and Europe. However, today a major part of the production processes take place in various countries of Latin America, the Caribbean, Asia and Africa (see Table 1 and 2). In recent

years, the emerging markets of China, Brazil and Russia in particular have accounted for high growth rates in production volume as well as in market share in all three production segments of the commodity chain. Within a few years they became global leaders in the world market of aluminium. Another characteristic development is the relocation of smelting activities in countries with energy abundance, especially in the Persian Gulf Region. Construction of new reduction plants as well as the upscaling of existing ones in the United Arab Emirates, Bahrain, Oman, Saudi Arabia und Qatar will increase the global production share of the Gulf Cooperation Council from 4% to 10% by the year 2010 (Bundesagentur für Aussenwirtschaft 2006). This is motivated by the fact that costs for electric energy account for almost one third of the total production costs of primary aluminium. In summary, the commodity chain of aluminium has disintegrated geographically over the past decades and has spread out globally. The main focus of production has moved from the high-income countries (HICs) (e.g. Canada, USA, Japan) – which at the same time represent the biggest consumers – to various LIC/MICs (see Hildebrand 2007).

Table 1: The largest bauxite, alumina and primary aluminium producing countries worldwide

Bauxite (2007)		**Alumina (2007)**		**Primary aluminium (2006)**	
Country	*Volume (Thousand metric tons)*	*Country*	*Volume (Thousand metric tons)*	*Country*	*Volume (Thousand metric tons)*
Australia	62,428	China	19,500	China	9,349
China	30,000	Australia	18,844	Russia	3,718
Brazil	22,100	Brazil	6,890	Canada	3,051
Guinea	18,000	Jamaica	3,941	USA	2,284

Source: USGS (2008)

Table 2: Production share of High-Income Countries (HICs), Low and Middle-Income Countries (LIC/MICs) and Eastern Europe Countries (EEC)

Year	Bauxite			Alumina			Primary Aluminium		
	HIC	LIC/MIC	EEC	HIC	LIC/MIC	EEC	HIC	LIC/MIC	EEC
1985	41%	49%	10%	60%	24%	15%	58%	19%	23%
1995	38%	58%	4%	56%	34%	10%	53%	31%	16%
2005	37%	59%	4%	46%	45%	9%	40%	46%	13%

Source: Hildebrand (2007)

These global shifts in production coincided with further internationalisation of the companies involved in the chain. Major actors in the GCC of aluminium are privately owned transnational corporations (TNCs). The degree of concentration in the industry has increased significantly since 1995 following a series of cross-border mergers and acquisitions. Today, the three biggest producers of primary aluminium have a market share of more than 35%. These are Rio Tinto-Alcan (Australia), United Rusal (Russia) and Alcoa (USA). Alcoa and Rio Tinto-Alcan are at the same time the TNCs with the highest revenues from aluminium related activities, accounting for more than US$20 billion in 2007. Both companies are among the largest commercial enterprises in the world, generating total revenues of over US$30 billion annually. It is a common strategy in the aluminium industry to cooperate as investors in collectively controlled joint ventures. The participating companies do so in order to reduce exposure to extremely high financial (and sometimes geological) risks involved in large-scale investment projects. These risks are largely associated with variations in resource quality as well as volatile world market prices – risks which are characteristic for the extractive industries. At the same time, the cooperation with equity partners increases their market power in relation to suppliers and their bargaining power towards host governments. The Brazilian Mineração Rio do Norte (MRN) for instance – one of the largest bauxite producers worldwide – is a joint venture of Vale (formerly Companhia Vale do Rio Doce (CVRD), Brazil), Alcoa (USA), BHP Billiton (Australia), CBA (Brazil), Hydro (Norway), Rio Tinto-Alcan (Canada) and Alumina Company Limited (Australia). Since

the 1970s TNCs have also included state owned companies as equity partners in their operations in LIC/MICs, mainly in order to secure their access to resource deposits and to reduce the risk of nationalisation in times of state-induced industrialisation policies. In the 1990s however, most of these companies were privatised so that the participation of state owned companies in the aluminium industry is very limited today. Nevertheless, in countries like India, Venezuela and Ghana national governments remain owners or shareholders of various production facilities. In general, the majority of the lead firms in the aluminium industry are still headquartered in HICs; however, the importance of companies from the emerging markets of Russia, China and Brazil has increased significantly in recent years.[3]

2.2 Features of the GCC of primary aluminium

The GCC of the aluminium industry is a classic producer-driven chain (for the concept of GCC see Gereffi et al. 1994), characterised by capital- and technology-intensive processes, high production capacities and a high degree of control exercised by the key production units of the chain: the TNCs. Traditionally, metal producers (meaning the operators of the reduction plants) constitute the lead firms of the commodity chain. They coordinate the economic activity in upstream (mining, refining) as well as in downstream processes (processing). Despite a tendency to focus on core activities while relying more on specialised providers, these lead firms continue to be characterised by an extremely high degree of vertical integration[4], which enables them to minimise the transfer costs of raw materials and maximise their value added. It also allows them to focus their investments in the chain segment with the highest returns, depending on the current raw material, labour and energy prices.[5] The fast-growing mining companies, which in recent years entered the GCC from the upstream end of the chain, are no exception to that strategy; they have started to integrate downstream processing into their activities as well (e.g. BHP Billiton).

Considering the distribution of value added (as a conventional indicator of income shares), two structural aspects of the GCC of aluminium are of particular importance: firstly, compared to other metals the share of value added in the production step of ore extraction is only around 10%. In the production of lead and copper this share is 77%; tin even generates 83% of total value added in the mining process (UNCTAD 2007). Secondly, in

contrast to steel production, for instance, the share of processing in total value added is relatively low, depending on the end-products. The major share of total value added – and therefore the major share of total income – accrues at the smelting process. Therefore, the powerful position of lead firms in the aluminium industry stems from their market power as well as from their positioning in a chain segment with a large share of total returns (see Kaplinsky/Morris 2001). An indicator of the importance of the smelting process for the generation of income is the fact that it is highly protected against competitors by a variety of patents. In fact, virtually all parts of reduction technology, ranging from process control engineering to production components like point-feeders and sometimes including complete factory layouts, are protected by patents today. Some of them are so fundamental for the production processes that their owner can directly control the entrance of new producers into the commodity chain of aluminium. The AP (Aluminium Pechiney) technology, for instance, accounts for more than 80% of new smelting capacity installed since 1990 in the Western World (Alcan 2005). Pechiney's patents for this leading-edge smelting technology has given the company a powerful position in the construction of reduction plants and significantly influenced Pechiney's takeover by Alcan in 2003. Today only a very limited number of lead firms possess the ability to construct new smelters for the global aluminium industry, among them the global leaders Rio Tinto Alcan and Hydro.

Although not yet incorporated into the GCC approach, another aspect of the control exercised by key production units seems to be particularly relevant in the production systems of extractive and metal industries: the externalisation of ecological and social costs. Following Gereffi, governance means the authority to influence the creation and allocation of value within a chain (Gereffi 1994: 97). Building on Gereffi's notion, this article argues that, particularly in the extractive industries, governance might also include the ability to free oneself from environmental and social costs or to influence the activities of governments, workers, and local populations confronted with these costs. As in most resource extraction projects, the environmental and social impacts of aluminium production are influenced by various factors, such as the technology in use, the scale of the extraction activities and the location of the projects (e.g. the proximity to other economic activities, such as agriculture and fishing). Despite this complexity some parts of

the production chain of aluminium can be identified as being particularly problematic. One is undoubtedly the refining process, because it generates large quantities of red mud, a residue of the chemical breakdown of bauxite ore. Red mud contains caustic soda as well as heavy metals and must be disposed of in sealed storage sites. In the past, inadequate storage of red mud residue led to massive environmental pollution; in Jamaica for instance, about 200 million m^3 of groundwater were contaminated between 1960 and 1990 (Fernandez 1991). Today, storage methods have progressed significantly. However, storing red mud residues continues to be associated with environmental risks, especially in high-precipitation areas of the tropics[6]. Negative impacts of the mining process have been significantly reduced in the past by technical progress in restoring mine sites following their closure. Still, mining in rainforest areas remains problematic, as the original biodiversity of the primary rainforest cannot be restored. Most affected by this environmental change are indigenous groups, whose traditional forms of subsistence often depend on the rainforest ecosystems. Emissions of smelting could be reduced by the modernisation of process engineering and filtering systems. More important are the impacts of electricity generation linked to the energy-intensive smelting of aluminium, as more than half of the energy consumed in the electrolytic reduction process is produced by hydroelectric power plants (International Aluminium Institute 2008). The social and ecological effects of dam projects are severe. Estimates by the World Commission on Dams (WCD 2000) suggest that some 40 to 80 million people have been displaced by dams worldwide. Large dams have also led to the loss of forests, wildlife habitats and the aquatic biodiversity of upstream and downstream fisheries. Many of the dam projects of the last 50 years were directly connected to aluminium production, e.g. Guri (Venezuela), Grand Coulee (USA), Assuan (Egypt) and Akosombo (Ghana).

3. Brazil's integration into the global commodity chain of aluminium

3.1 The aluminium sector in Brazil

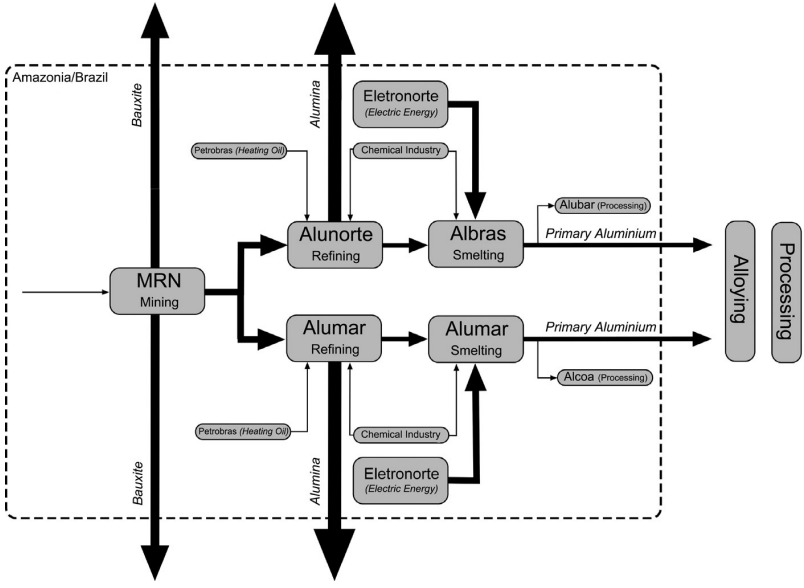
With more than 22 million tonnes annually, Brazil (meaning the companies producing in Brazil as a whole) is the second largest bauxite producer,

with more than 6 million tonnes, the third largest alumina producer, and with 1.5 million tonnes the sixth largest aluminium producer in the world. A significant share of total production volumes is exported, especially alumina (50%) and primary aluminium (52%). The share of bauxite exports is only 23%. Brazilian aluminium consumption is growing but still relatively low, on average 4.6 kg per year and person[7] (ABAL 2008).

Since the 1940s various privately owned companies have operated smaller production plants in Brazil, mainly aiming at the domestic market, e.g. the Brazilian Companhia Brasileira do Alumínio in São Paulo, Alcan (Canada) in Ouro Preto and Alcoa (USA) in Poços de Caldas. However, these enterprises have never been able to meet domestic demand, and today their share in Brazil's total production volume is only around 30% for bauxite, 20% for alumina and 45% for primary aluminium (ABAL 2008). Instead, Brazil's strong position in the world market today is connected to the establishment of large export-oriented production complexes in Amazonia. These production complexes were the result of the ambitious industrial development projects put into place under the Brazilian military governments in the 1970s and 1980s[8]. Under the import substitution industrialization policies (ISI) of that time, the expansion of mining and production capacities – spearheaded by the state-owned company Companhia Vale do Rio Doce (CVRD) – aimed at enhancing exports and generating foreign currency. Since the military governments relied on foreign investment for this large-scale industrialisation project, they negotiated agreements with several large TNCs from the global aluminium industry to establish a complete aluminium production line in Amazonia. As a result of this, three export-oriented industrial complexes were erected between 1979 and 1985: Mineração Rio do Norte (MRN) (bauxite) in Porto Trombetas, Alumar (alumina, primary aluminium) in São Luís, the Alunorte-Albras (alumina, primary aluminium) in Barcarena, and the hydropower plant Tucuruí (see Figure 1). All of the production facilities were joint ventures of differing compositions; among the foreign stakeholders were Alcan, Alcoa, BHP Billiton and the Japanese consortium Nippon Steel. The debt crisis, the return to democracy, falling aluminium prices and a growing environmental movement resulted in a temporary policy change in the late 1980s, stressing concepts such as participation, environmental conservation, and sustainability[9]. However, since the late 1990s, world market integration

has become the main objective in Brazil's economic policy, and the recent boost in metal prices turned the aluminium industry into a key sector of this development strategy once again. Even the former union leader and currently acting president Luiz Inácio Lula da Silva supports the expansion of the aluminium production, although his *Partido dos Trabalhadores* (PT) once strongly opposed various energy projects of the industry (e.g. the damming of the Rio Madeira and Belo Monte) during the late 1980s. Today Lula's economic and tax package *Programa de Aceleração do Crescimento* (PAC), amounting to 500 billion Reais (US$200 billion) and introduced after his re-election in November 2006, focuses mainly on public investments in infrastructure projects and official credit lines. It also includes a number of tax cuts designed to stimulate investment in some key sectors (e.g. the civil construction industry). Major beneficiaries of the PAC are the export-oriented companies of the agro- and mineral industries in Amazonia. Motivated by this growing political support as well as by increasing world demand the major aluminium companies operating in Brazil project investments of more than US$7 billion by the year 2010, mainly in the production segments of mining, refining, and smelting (Filleti 2006).

Figure 1: The production chain of the export-oriented aluminium industry in Amazonia/Brazil



Source: own elaboration

3.2 Economic impacts of Brazil's integration into the GCC of aluminium

Brazil's longstanding experience with the aluminium industry as a main driver for economic development, whether under policies of import substitution or market liberalisation, provides important insights into the potential and problems of integrating into global commodity chains in the extractive/metal industries, especially regarding enhancements of exports, linkages, employment impacts, and generation of government revenues.

The military governments of the 1970s and 80s succeeded in establishing a complete aluminium production line. Even if the environmental and social costs of these industrialization policies were significant, it must be conceded that in one aspect the ISI strategy was successful: the rapid expan-

sion of production capacities in mining, refining as well as smelting enabled forward linkages along the GCC of aluminium and allowed the companies operating in Brazil to capture a relatively large share of total value added. This rapid growth helped to balance Brazil's negative foreign trade balance and increased foreign exchange reserves – even though the economic impact of the last aspect depends on metal prices and therefore proved to be extremely volatile. Attempts to upgrade into downstream segments (production of alloys, processing) were, however, rather unsuccessful: up to today only 5% of the primary aluminium from the Albras reduction plant, for instance, ends up in Brazilian manufacturing and most of that is processed into electric cables with low value added. The bulk of primary aluminium of the Albras and Alumar smelters is exported to North America, Europe and Japan, mostly as unalloyed aluminium ingots. As a result of the liberalisation policies of the 1990s and soaring metal prices since 2001, Brazil's export-oriented aluminium industry has started to focus on chain segments rather than on strengthening linkage effects: rapid growth took place in the upstream segments of mining and refining, while the smelting capacities stagnated. Today Brazil is already the biggest exporter of bauxite worldwide and ranked number three in alumina exports. The future investment of leading TNCs in the upstream segments will add to this tendency – this applies for Alcoa as well as the Brazilian global player Vale. This massive expansion in upstream segments does not, however, result in a massive growth in revenue. More likely, it demonstrates the shift of Brazil's position in the GCC of aluminium to upstream segments with significantly lower value added. However, despite the fact that export volumes of bauxite and alumina production have rapidly increased between 2000 and 2005, together they still only add up to half of the export value of primary aluminium (about US$1.4 billion) (UN Comtrade 2008). The main cause for this shift in the GCC is the strategic orientation of the participating TNCs, which focus on the strong demand for bauxite and alumina on the world market (especially from China) as well as the competitive advantages of the host country.

In contrast to significant backward linkages, the Brazilian production line does not have significant ties to other industries. Bauxite mining primarily requires drilling equipment, load haul dumps, trucks and crushers, which are provided by specialized suppliers headquartered mostly

in the United States or Scandinavian countries (e.g. Caterpillar/USA, Atlas Copco/Sweden). For refining the most important input is caustic soda, which is a waste product of large-scale industrial chlorine production and therefore does not have major economic impacts. Aluminium smelting is closely connected to the energy sector, but the beneficial implications are questionable, as the low electricity rates do not even cover production costs. After renegotiations in 2004 Albras and Alumar pay between US$17 and 21 per MWh to the state-owned energy provider Eletronorte – market prices were at around US$27, while production costs are estimated at around US$70 (ABRACEEL 2004).

Extractive industries generally make only a limited contribution to employment at the macro level. This applies especially to projects where TNCs are involved, as they tend to use more capital-intensive technologies than domestic companies in developing countries (UNCTAD 2007). The Brazilian aluminium production is no exception to that. In general the technology-intensive, export oriented production complexes in Amazonia are important regional centres of commerce, attracting a variety of different suppliers and services; still, the number of directly employed persons is rather low. Brazil's export-oriented joint ventures of major TNCs – MRN (mining), Alunorte (refining), Alumar (refining), Albras (smelting) and Alumar (smelting) – together add up to only 5,350 direct employees. In comparison, the domestic aluminium company CBA alone – producing mainly for the national market – has 5,700 direct employees.

As in many extractive industries, capturing a significant share of the mineral rents through direct ownership (be it through wholly state-owned companies or joint ventures) or through taxes and royalties is particularly important for the Brazilian state in order to achieve economic benefits from the aluminium production. In fact, since the 1980s the taxes and royalties paid by the entire Brazilian aluminium industry have increased. At the same time, it is rarely disclosed that the export-oriented companies in Amazonia still receive significant tax cuts. Since 2000 Alunorte, for instance, has been granted a complete remission of income tax for production volumes up to 800,000 t/a and a tax benefit of 75% for production volumes exceeding that number (Alunorte 2006). Similar agreements exist with the remaining joint ventures in Amazonia (see Hildebrand 2007).

The bulk of the aluminium production chain in Amazonia has always been owned by TNCs headquartered in the US, Canada, Australia, Norway and Japan; therefore, it can be concluded that a large proportion of the income has always gone to them rather than to the host economy. However, Brazilian government revenues, through direct ownership, were still substantial as long as the mining company Vale (a major stakeholder in the projects Alunorte, Albras and MRN) was a state-owned company. The process of deregulation and privatisation which started in the 1990s led, however, to the controversial disposition of Vale in 1997, resulting in the loss of these important government revenues. Today a large part of Vale's profits is transferred abroad as dividends to international shareholders.

Both aspects – favourable tax regulations as well as the questionable disposition of major state owned assets – show how the Brazilian government, against the backdrop of large external debts, adopted agreements that were extremely generous to foreign investors, especially to powerful consortiums of TNCs promising large scale industrial development and modernisation.

3.3 Environmental and social impacts

The aluminium production line in Amazonia has caused various environmental problems and social conflicts. Some of them occurred primarily during the 1970s and 80s, when the facilities and the infrastructure were erected, while some of them still persist today. For instance, the mining company MRN has learned to considerably improve the reutilisation of abandoned mining areas, thereby avoiding the severe and long-lasting environmental degradation of earlier times. However, since the mining activities still take place in areas of primary rainforest, the extraction inevitably leads to the loss of the original biodiversity, making it impossible for the local indigenous population to maintain their traditional forms of subsistence. In addition, hunting, fishing and cultivation are forbidden everywhere in the concession area of MRN (Müller-Plantenberg 2006). The experiences with MRN have also demonstrated the reluctance of companies to clean up contaminations from the past: the local people, the Quilombos, for instance, still await the purification of Lake Batata, contaminated with residues from bauxite washing during the 1980s (Schäfer/Studte 2005). In the refining stage technical progress has led to advanced production proc-

esses and lower environmental risks as well. Despite this, accidents periodically occur and caustic soda ends up in rivers or groundwater systems, contaminating drinking water and killing fish stock. In 2003 and 2005 for instance, caustic soda from Alunorte contaminated the Rio Murucupi and the Rio Pará. The storage of red mud in large open pits remains a severe environmental risk, especially in Brazil's tropical rainforest areas. The reduction plants of Albras and Alumar have reduced the emissions with modern process- and filter-facilities. A major environmental problem, however, is the energy generation associated with the smelter. The construction of the Tucuruí dam involved the displacement of 25,000 to 35,000 people between 1975 and 1985, and 40,000 people were affected by water shortage, reduced fish stock and health problems (La Rovere/Mendes 2000). In the late 1980s this led to a broad protest movement, consisting of environmentalists, local groups, and the Landless Workers' Movement (MST), among others. This protest movement has gained momentum again recently, since various dam projects are back on the agenda (Estreito by Alcoa and Vale, Belo Monte by Alcoa). Demonstrations, occupation of bridges, and lawsuits against dam projects illustrate the growing resistance against new projects of the aluminium industry.

Conflicts around health and safety issues as well as workers rights are apparent all along the production chain. Brazilian union associations such as the STIEMBO (*Sindicato dos Trabalhadores nas Industrias Extrativas em Minerais Não Ferrosas de Oriximiná*, PA) criticise the harsh working conditions at MRN as well as the absence of state control in the large company town of Porto Trombetas (Switkes 2005; Girndt 2007). According to the Central Unionists Association CUT (*Central Única dos Trabalhadores*), at Alunorte and Albras intimidation and buying of votes took place during union elections in 2007. These activities aimed at putting pressure on local union groups in order to keep critical voices out of the media (CUT 2007). Employees of Alumar in Sao Luís complain about insufficient occupational safety as well as repressive measures by the management. The company has still not permitted a workers' council. In 2003, the management of Alumar made use of the military police in order to end a demonstration of workers on the factory ground. The metal union CNM (*Confederação Nacional dos Metalúrgicos*) characterised Alumar as the worst company of 2005 (CNM 2006).

4. Policy challenges for broader economic development

The depicted economic, ecological, and social impacts of the Brazilian aluminium production reveal two significant aspects of the integration of LIC/MIC into the GCC in the extractive and metal industries: firstly, there is a conflict of interests between the two main actors, namely the participating TNCs and the Brazilian government. The latter promotes a massive expansion of the production capacities in the aluminium sector in order to stimulate economic development, or more precisely to increase private income through the generation of employment as well as to increase government income through tax revenues and foreign exchange proceeds. Therefore, the integration of the technology-intensive smelting process, as well as the participation of domestic companies, is of great importance for the development objectives of the Brazilian governments. In the 1970s and 80s a major concern was the establishment of downstream linkages towards processing industries, as they play a key role in employment creation and other positive externalities such as technology transfer (Prebisch 1981). These longer term development objectives do not always coincide with the short-term profit maximisation motives of TNCs, which do not focus on labour-intensive downstream processing, but on capital-intensive upstream production in order to meet rapidly growing demand on the world market, especially from China. However, upstream production in the aluminium industry does not create significant value added, which seems to be generally symptomatic of Brazil's recent integration into the world market, as it is particularly characterised by rapidly growing exports of agrarian products and mineral resources. Based on research on the fast-growing development economies of Brazil, Russia, India and China (the so-called BRICs) conducted by the former investment bank Goldman Sachs (Wilson/Purushothaman 2003; Goldman Sachs 2007), this development has commonly been put into a polemical but revealing formula: Brazil will become the raw materials warehouse of the world economy in the next 20 years – along with India as service provider, China as factory, and Russia as gas station (FAZ 2006).

Secondly, the Brazilian case study demonstrates that in the capital-intensive aluminium production industry the distribution of income between TNCs and the Brazilian state largely was – and still is – a result of

negotiations over the terms and conditions of TNC participation. Since the industry is highly concentrated, vertically integrated, and characterised by joint venture investments, a small number of global TNCs possess strong bargaining power over host countries. Under the Brazilian military regime of the 1970s and 80s this fact led to agreements extremely generous to investors, including, for example, the complete public funding of the Tucuruí dam and power plant (US$6.6 billion), an industrial village and a harbour – all financed by external debt – as well as extremely low electricity rates with terms of 20 years (approved by the state-owned Eletronorte). On the other hand, the Japanese consortium NAAC, one of Brazil's contract partners in these negotiations, managed to withdraw from the agreement to establish a manufacturing industry (De Sa 1994). Interestingly enough, comparable agreements were made during the liberalisation period of the 1990s, when once again efforts were undertaken to attract foreign investment in order to boost exports and earn foreign currency, even though this time they were undertaken by a democratic government aiming at world market integration. A prominent example is the controversial privatisation of Vale (then CVRD) in 1997 that led to a massive protest movement and violent encounters in front of the stock market of Rio de Janeiro. In the end the company was sold at an extremely low price of 3.3 billion Reais – between 1998 and 2000 CVRD's profits alone accrued to 4.5 billion Reais, while in 2006 they reached 13.4 billion. Brazil has tried to respond to experiences like that by, for example, publicly auctioning the power generated at Tucuruí after the expiration of the contracts with the industry in 1994. Yet, in the end, the market power of the aluminium companies remained significant: state-owned Eletronorte negotiated electricity prices higher than in 1984, but still substantially below market-prices and still not cost-covering. Altogether, the bargaining power of the lead firms in relation to host countries corresponds with their powerful position inside the commodity chain, which also gives them the ability to enforce operating measures against the opposition of workers or local populations. In view of the history of the aluminium industry, the power of the lead firms is unlikely to decline in the future; on the contrary, the trend of ongoing market concentration suggests it is more likely to increase substantially.

In conclusion, the analysis of Brazil's involvement in the GCC of aluminium demonstrates that net outcomes of market integration in the

extractive and metal industry depend mainly on two factors. Firstly, the structure of the particular chain; in the case of aluminium production this is characterised by relatively high value added in smelting in contrast to manufacturing and upstream production. Employment effects are low in upstream activities but substantial in manufacturing. Social and ecological problems are most severe in refining and in power generation. At the same time, the aluminium industry is characterised by a high degree of internationalisation as well as concentration and is driven by a small number of powerful TNCs. They control most chain operations and capture a major share of the total income; as a result, their bargaining power vis a vis host countries is high. Secondly, the interests and policies of host countries: capturing the maximum value created in aluminium production is closely connected to issues of direct state-ownership or participation (for revenues through profits) as well as stringent fiscal frameworks (for revenues through taxes and royalties) in upstream operations. Generating employment and learning opportunities, on the other hand, depends largely on the establishment of processing industries downstream and requires the active participation of domestic enterprises rather than TNCs exclusively. To minimise the ecological and social costs along the chain, the introduction and enforcement of environmental legislation as well as regulatory frameworks for the participation of grassroots actors such as workers, local communities and indigenous minorities, is indispensable.

1) I would like to thank the editors for their invitation to contribute to this special issue of the JEP. I also thank Christof Parnreiter for his support and the constructive comments on an earlier draft. This paper draws on research undertaken for my first degree master's thesis on the Global Commodity Chain of the Aluminium Industry at the University of Hamburg. I am solely responsible for any errors of fact or interpretation.

2) This paper only deals with primary aluminium (made from bauxite ore), because in the discussion of strategies for economic development in LIC/MICs secondary aluminium (processed from aluminium scrap) has not played an important role yet.

3) In October 2006, the Brazilian CVRD took over the Canadian Inco at the price of US$17 billion. It was one of the biggest acquisitions in the extractive industries and made CVRD the second largest mining corporation in the world.

4) Vertical integration describes a management style where one firm also owns upstream suppliers and/or downstream buyers.

5) The distribution of value along the chain is significantly affected by changes in the

price of primary aluminium. Swings in world market prices cause value to move back and forth from one end of the chain to the other: a rise will distribute value away from downstream processing towards upstream production, while a fall reverses this process.

6) Incidents in various modern refineries illustrate this, e.g. chemical spills at Alcoa's Wagerup refinery in Australia in 2005 or at Alcan's refinery in Jonquiere/Canada in 2007.
7) Average annual consumption in the US is around 37 kg/person, in Japan 31 kg, and in Western Europe 19 kg.
8) The largest and most controversial industrial development project of that time was the Programa Grande Carajás (PGC). The PGC aimed at establishing an industrial corridor from São Luís into Amazonia, focusing on extraction and processing of iron ore. It was accompanied by broad environmental degradation, for which reason the PGC encountered massive resistance.
9) The Pilot Program to Conserve the Brazilian Rain Forest (Programa Piloto Internacional para Conservação das Florestas Tropicais Brasileiras, PPG7) represents an alternative approach of this period of policy changes. Launched in 1992, it was a multilateral initiative and aimed at finding ways of protecting Brazil's rain forests and using them in a sustainable fashion.

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Abstracts

Driven by soaring commodity prices, various low- and middle-income countries (LIC/MICs) once again press for world market integration in the extractive and metal industries. This strategy may assist, as well as hamper, the achievement of certain development objectives. Using the network-based Global Commodity Chains (GCC) approach, the analysis of the export oriented aluminium industry in Brazil demonstrates that net outcomes of world market integration in the extractive and metal industry depend mainly on two factors: firstly, on the structure of the particular commodity chain, especially the type of governance and the distribution

of income, and secondly, on the ability of LIC/MICs governments to establish political and institutional frameworks that maximise the capture of value created (through ownership or tax revenues) while minimising social inequality and environmental degradation.

Vor dem Hintergrund des Rohstoffbooms der letzten Jahre setzen eine Reihe von Ländern mit niedrigem und mittlerem Einkommen wieder verstärkt auf eine Weltmarktintegration im Rohstoff- und Metallsektor. Diese Strategie kann das Erreichen bestimmter Entwicklungsziele sowohl fördern als auch erschweren. Die Analyse der exportorientierten Aluminiumindustrie Brasiliens mithilfe des Globalen Güterkettenansatzes zeigt, dass das Ergebnis einer Weltmarktintegration im Rohstoff- und Metallsektor vor allem von zwei Faktoren abhängt. Es ist erstens abhängig von der Struktur der jeweiligen Güterkette, insbesondere der Steuerungsform (Governance) und der Einkommensverteilung. Der zweite maßgebliche Einflussfaktor ist die Fähigkeit der betreffenden Regierungen, politische und institutionelle Rahmenbedingungen zu schaffen, die durch Eigentümerschaft oder Steuereinnahmen eine Aneignung substantieller Anteile des erwirtschafteten Mehrwertes ermöglichen und gleichzeitig soziale Ungleichheit und ökologische Schäden gering halten.

Lars Hildebrand
Max-Brauer-Allee 90
22765 Hamburg
l.hildebrand@gmx.de