The Global Aluminium Industry
40 years from 1972

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February 2013

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Foreword

In 2012, the International Aluminium Institute (IAI)—a global forum for aluminium producers worldwide—celebrated its 40th year, having been incorporated on 28 April 1972 as the International Primary Aluminium Institute (IPAI). The term "Primary" was deleted in 2000, the change reflecting a broader, inclusive agenda and commitment to sustainability along the whole industry value chain.

At the 1972 incorporation, there were 44 member companies; global primary aluminium production was less than 12 million tonnes (Mt). A smelter capacity of over 150,000 tonnes was considered to be large; today 500,000 tonne capacities are commonplace and a number of facilities are at or approaching one million tonnes annual capacity. Currently, the IAI has 26 member companies, responsible for around 70% (about 28 Mt) of world primary aluminium production.

The IAI invited Dr Carmine Nappi, Consultant and Industry Analyst, to reflect upon the global changes and developments within the aluminium industry over the period of the existence of the IAI. The contents of this paper reflect the views of Dr Nappi, not the IAI.

Dr Carmine Nappi has almost four decades of experience in the metals and mineral economics industry. Carmine joined Alcan *in May 1999 as Director of Industry Analysis and was promoted to the position of Vice President of Industry Analysis at* Rio Tinto Alcan *in November 2007, where he was responsible for price forecasting and analysis of aluminium industry trends. Carmine retired from* Rio Tinto Alcan *in 2011 and is now consulting in the field of industrial organization.*

1. Introduction

Today, the global aluminium industry has only a bare resemblance to what it was in the early 1970s. The most important structural changes are the geographical relocation of bauxite, alumina and aluminium production centres; shifts in the degree of concentration and integration; the emergence of new consuming regions, the development of new end-use markets and the threat of substitutes, including recycled metal; the historical decline in real prices of the metal and the recent upward shift in the industry cost curve; the market adjustment mechanisms and, more recently, the rising popularity of commodities as an asset class.

The main objective of this paper is to highlight and analyze these changes over the last four decades. Commencing with an identification of the main characteristics of the aluminium industry in the early 1970s, the paper then examines the main forces or drivers that have deeply modified the structure of the global aluminium industry, factors such as energy crises, arrival of new players, variations in exchange rates, shifting trends in aluminium cost curves, and the role of emerging economies. The main characteristics of current global aluminium industry are then presented, with a view on future demand and production.

2. The Global Aluminium Industry in the Early 1970s

The year 1972 saw bauxite production dominated by four countries — Australia, Jamaica, Suriname and USSR — which together held a 60% global market share. Today, only Australia is on a list of the top six producers. Even greater changes have occurred in the location of alumina-producing countries. In 1972, more than 45% of global alumina production was concentrated in five industrialized countries, poorly-endowed with bauxite reserves: United States, Japan, Canada, France and Germany. The other major producers were then Australia (13%), USSR (12%), Jamaica (9%) and Suriname (6%). Today, among the countries mentioned above, only Australia is still a significant producer, with alumina production having generally shifted from industrialized or aluminium producing countries to bauxite producing regions.

Major shifts have also occurred in the geographic location of aluminium production centres. The combined share of United States, USSR and Japan reached almost 60% of global primary production in 1972. Today, their corresponding share barely exceeds 10%. Norway, Germany and France have also been replaced on the list of top aluminium producers. This relocation of bauxite, alumina and aluminium production centres has been accompanied over the last 40 years by other significant structural and behavioural changes that need to be analyzed.

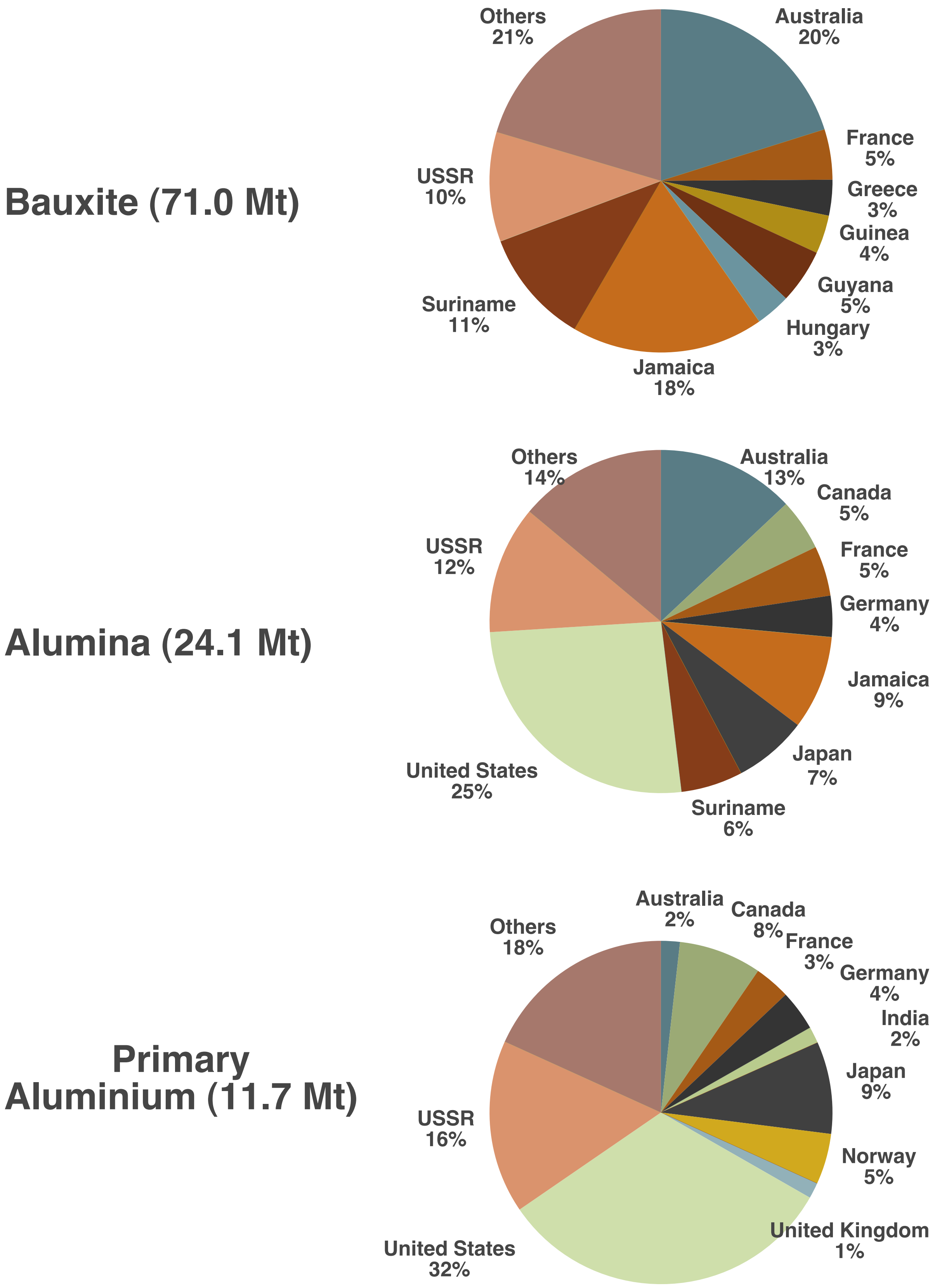

Figure 1: World Production of Bauxite, Alumina and Aluminium (1972)
Source: Derived from *World Bureau of Metal Statistics (WBMS)*, various years

Degree of concentration and integration

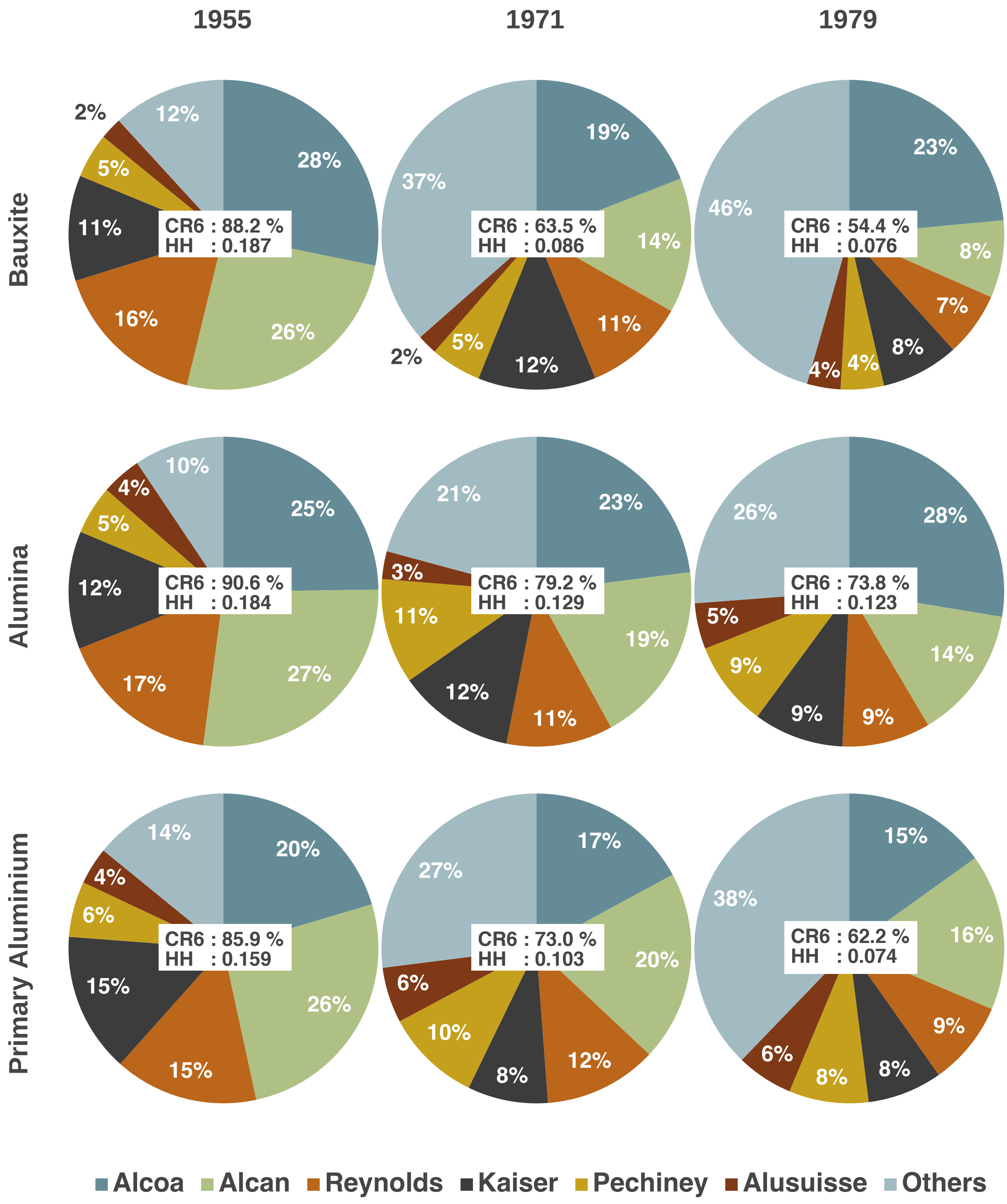

Figure 2: Market Shares and Degree of Concentration[1] in Global Bauxite, Alumina, & Primary Capacities: 1955, 1971, 1979
Source: Derived from John A Stuckey, *Joint Ventures and Vertical Integration in the Aluminium Industry*, Harvard University, Cambridge, 1983, p.84

[1] Measured by share of the six most important companies (CR6) and HH index (sum of squared market shares)

The international aluminium industry was dominated in the early 1970s by the “Six Majors” – Alcoa, Alcan, Reynolds, Kaiser, Pechiney and Alusuisse – with a combined share then exceeding 60% for bauxite, approaching 80% for alumina and hovering around 73% for primary aluminium. Despite this robust degree of concentration, Figure 2 indicates that it was even higher in the mid-1950s (between 85 and 90% at each step of the production process), while towards the end of the 1970s the combined market share of the Six Majors was still significant. An alternative way to measure the degree of concentration is to sum the square of each producer market share (the HH index) in order to give more weight to large players in an industry and thus better assess the existence of market power. This index is presented in Figure 2. In addition to a high degree of concentration, Figure 2 also suggests that the aluminium industry of the early 1970s was highly integrated, since the companies with smelters were operating alumina plants to supply alumina to the smelters and bauxite mines to supply bauxite to alumina refineries.

Vertical integration also extended beyond the integration of mining, refining and smelting: the operations of the largest aluminium companies of that period also embraced the production of downstream fabricated aluminium products such as sheet & plate, extruded products, wire, cable & tubes and foil.

Consumption growth by region and end-use market

Given the product characteristics (light weight, strength, moderate melting point, ductility, conductivity, corrosion resistance and barrier properties), aluminium consumption experienced a compounded annual growth rate (CAGR) of almost 10% over the 1945-1972 period – thus exceeding GDP growth, a clear sign of increasing intensity of use of aluminium per product – gaining ground in building applications, electric cables, basic foils and the aircraft industry. In the early 1970s, an additional boost resulted from the development of aluminium beverage cans.

Forty-years ago, 62% of global consumption of primary aluminium was concentrated in six industrialized Western countries, the United States leading the pack with a market share of 36.3%, and Japan second at 10.3%. China’s share was below 2.5% in 1972, while about 12% of global demand was then concentrated in the USSR.

For total aluminium consumption by end-use, the pattern was quite different by region. Slightly more than 20% of German aluminium was used by the transportation sector, followed by engineering (18%) and building & construction (16%). Only 9% of aluminium shipments were directed to the packaging sector. The picture was quite different in Japan where aluminium demand was dominated by building & construction (31%), followed by transportation and engineering; the Japanese packaging sector was absorbing in the early 1970s less than 2% of total demand. While similar to Japan with building and construction consumption at 26%, the US packaging consumption share was much higher at 15.2%.

In each end-use sector, aluminium was in the early 1970s displacing substitutes, including cast iron, rolled and galvanized steel, tinplate, cast zinc, copper wire and tube, timber, glass, cardboard and metallised paper. The rivalry between substitutes would become harsher in the following decades as consumers continuously assessed not only the functional characteristics of competing materials but also their relative prices.

Within the aluminium sector, the substitution of primary metal by recycled aluminium metal has been a significant change, with a shift in environmental and social attitudes over the period bringing the industry to a new paradigm in terms of sustainability and product life cycles.

The aluminium beverage can takes centre stage during the early part of the period under review and further reinforces the development of the aluminium recycling industry. According to WBMS data, aluminium recovered from scrap in Western countries represented in 1972 about 21% of Western World total (primary and secondary) consumption of aluminium. The latter share remained below 24% until the end of the 1970s.

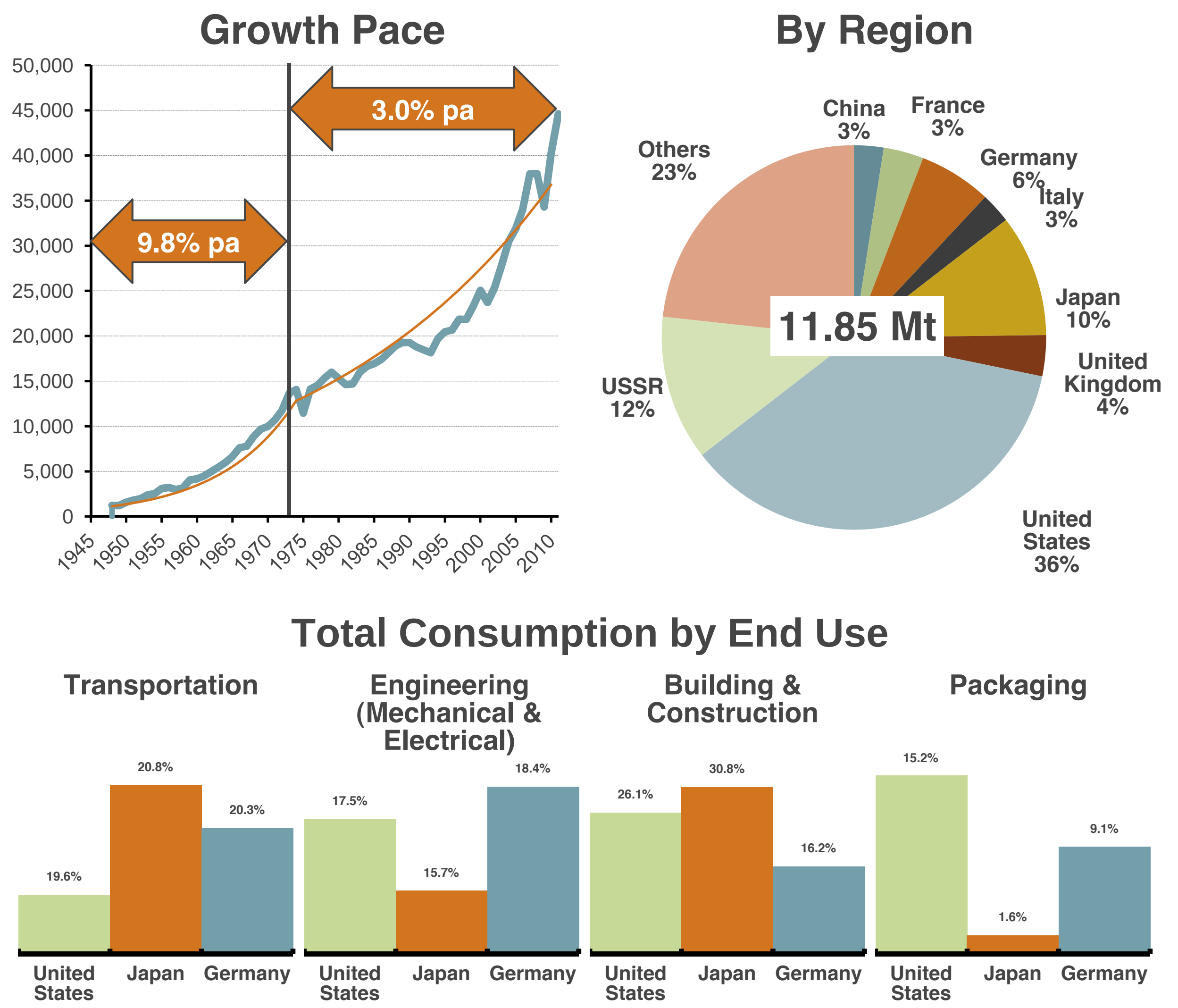

Figure 3: Primary Aluminium Consumption, 1972

Source: Derived from *World Bureau of Metal Statistics (WBMS)*, various years

Market adjustment mechanism

Forty years ago, the peaks and troughs of aluminium demand were managed by changes in capacity rates of utilization or inventory accumulation but as little as possible by changes in price. This was the period dominated by producers' list prices which were typically rigid despite considerable instability in market conditions.

Such insensitivity or "stickiness" of producers' prices is possible as long as:

1. the metal demand facing a dominant group of producers is in the short run insensitive to price variations (because of a lack of substitutes);
2. the average total cost curve is flexible (because variable costs are important in the cost structure since there are very few take-or-pay contracts); and
3. the management's is able to coordinate cutbacks of production (because of a soaring concentration ratio).

If the above conditions prevail, then the producing firms or dominant strategic group of firms will use their market power to stabilize prices against developing excess capacity. Market prices cannot survive in such market conditions since prices are then too sticky.

As suggested above, these conditions were to a large extent present in the global aluminium industry between the mid-1940s and the early 1970s. Consequently, aluminium nominal prices hovered around their average of US$ 453 per tonne during the 1946-1972 period (see Figure 4) with a degree of instability of only 0.16, measured as the standard deviation over the average price for the period. However, during that same period, utilization rates below 80% were not uncommon. In October 1978, in spite of strong producer opposition, the first aluminium contract was introduced on the LME, a clear sign that the major Western producers had started to lose control of price setting in their industry.

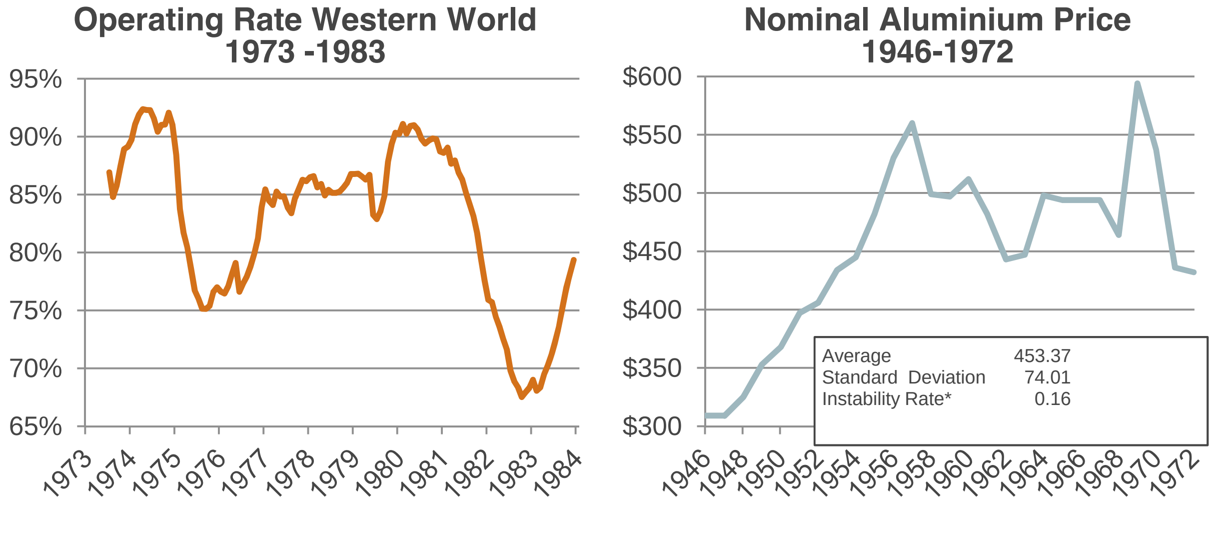

Figure 4: Utilization Rates and Nominal Aluminium Prices

Source: Derived from *International Aluminium Institute (IAI)* production & capacity data, and from *Reuters*

Historical decline in real prices of metals

Finally, the global aluminium industry was characterized, until the mid-1970s, by declining real prices. There may be disagreement about identifying the appropriate price deflator, selecting a relevant time period or estimating a trend that periodically changes in some unknown way, but the fact remains that real prices of primary aluminium were sliding down.

As suggested by Figure 5, the rate of decline has been estimated at about 2% per year during the1945-1972 period. Technological change and economies of scale tend to push down extraction and processing costs over time, whereas the need to exploit lower-grade poorer-quality deposits or the use of fast increasing input costs (such as energy or chemical products) tends to drive production costs up. Thus, for a long period of time, the beneficial effects of technological change have offset the adverse effects of higher production costs, allowing the real price to decline.

This favourable trend cannot continue indefinitely as rising costs of bauxite and, above all, energy will eventually offset the decline in production costs. Other drivers such as exchange rates, greenhouse gas regulation and the shape of the industry cost curve must also be taken into account.

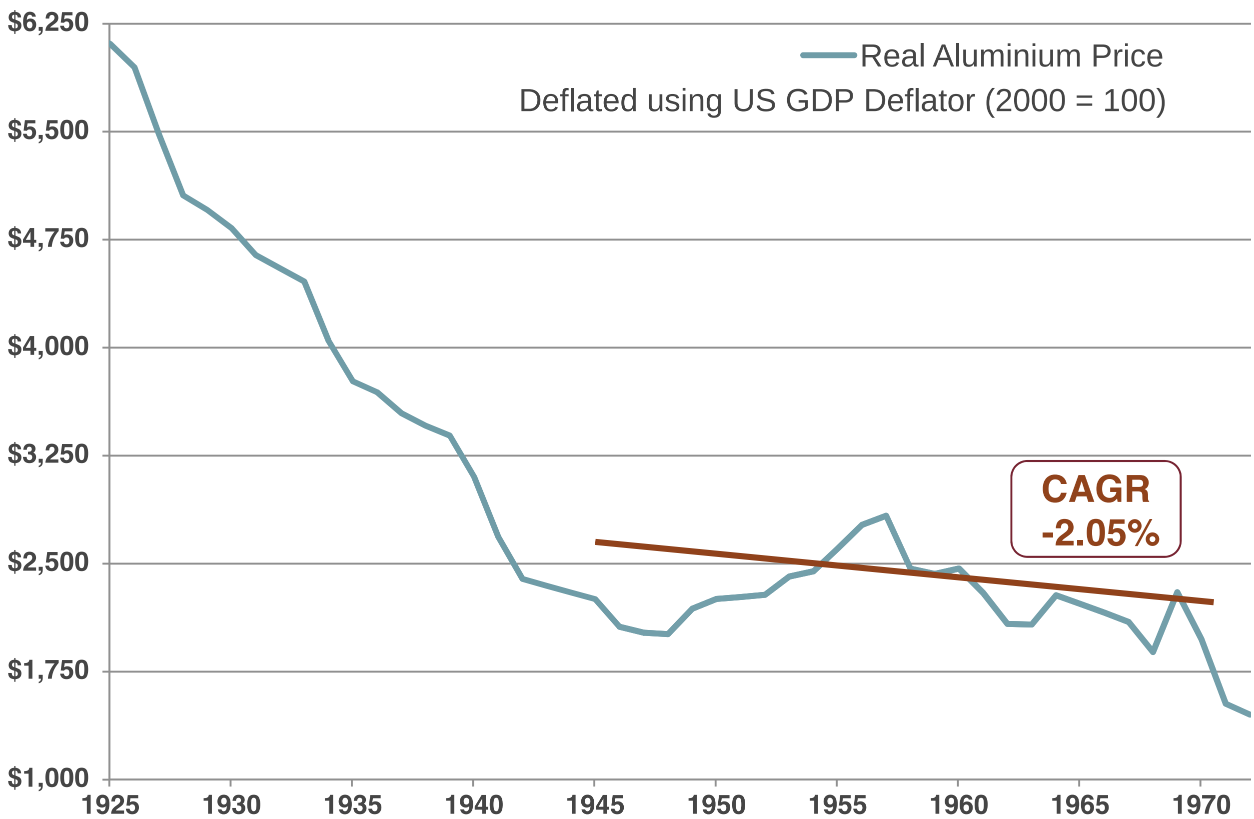

Figure 5: Real Aluminium Price: 1925 -1972

Source: Derived from *WBMS*, various years

3. Main Drivers of Change Since 1972

In a nutshell, the global primary aluminium industry of the early 1970s was highly concentrated and vertically integrated. A large share of the alumina and aluminium production was taking place in industrialized countries and not in regions endowed with abundant bauxite or energy resources. Primary consumption was then increasing at a faster pace than GDP, a clear sign of increasing intensity of use of aluminium relative to most of its substitutes.

Prices were quite stable since market imbalances between demand and supply were corrected by volume variations. Finally, real prices were declining by about 2% per year due mainly to improved economies of scale. Why are the structural characteristics of the global aluminium industry so different today? What have been the main drivers of change since 1972?

Higher energy prices

Energy shocks of 1973 and 1979, and the surge of energy demand in China, India, Brazil and other fast growing emerging economies in the early years of the new millennium have pushed up prices not only of oil but also of all other forms of energy (Figure 6). Even if discoveries of new energy supply or financial crises have kept prices at bay, the general trend has definitely been upward, thus increasing the price of electricity generation. The latter jump in electricity prices has dramatically altered the international competitiveness and hence location of industries such as aluminium whose production process uses large amounts of electricity. Energy shocks and the soaring energy demand in many emerging economies did not push up the price of electricity equally in all countries. Some nations are endowed with ample supplies of hydropower or low cost coal preventing electricity costs from rising as sharply as in nations more dependent on imported oil-generated power.

The interregional differences in electricity prices and hence in countries' primary aluminium production costs were exacerbated by the factors mentioned above, accelerating the shift of primary aluminium production centres that began in the 1970s from high cost locations such as Japan, United States and Western Europe to lower cost regions such as Australia, Canada, Middle East, Russia and China.

In the last 10-15 years, the shift has accelerated, with the Middle East strengthening its position as a leading aluminium production centre; within China, the move is from the high cost areas of the south and south-east to the west and north-west regions.

However, differences in electricity prices do not fully explain the shift in primary aluminium production centres. The impact of public policy — electricity rates below the long-run marginal opportunity cost of production, taxes, exchange rates, trade tariffs, or industry subsidies — also needs to be taken into account. The clear objective of these policy-induced changes to competitiveness was to promote growth of the aluminium industry in the low-cost power countries or maintain its existing size in high-cost ones.

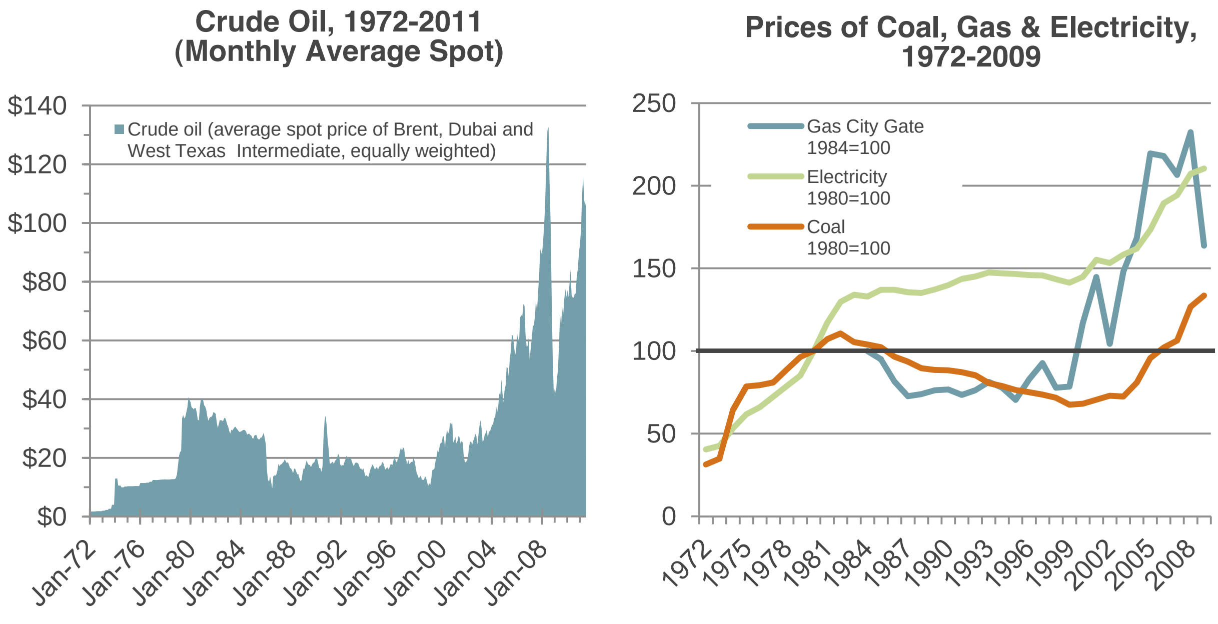

Figure 6: Energy Prices

Source: Derived from *The World Bank* and *US Energy Information Administration (EIA)*, various years

Arrival of new players

Starting in the late 1960s, the Six Majors' share of primary aluminium production started to decline, reflecting the entry of new private producers, conglomerates and of partly or wholly state-owned enterprises. While the main objective of the private new entrants was profit-maximization through diversification, brought about by horizontal integration, economies of scale or better control of raw materials/markets for final products, the motivations or goals of state-owned enterprises (SOEs) are less clearly specified.

Among the main SOEs objectives, one should note:

- addressing uncompetitive market structures due to the presence of economies of scale, established marketing and distribution systems, patents or ownership of rich mineral resources;
- compensating for insufficient investment resulting from excessive risk aversion and short-sightedness of private entrepreneurs;
- improving national employment, income distribution and regional equality; or,
- the pursuit of political goals such as the national sovereignty of natural resources.

Government influence on mining, refining and smelting activities may take a variety of forms, including not only various degrees of equity ownership but also interventionist policies on the exploration/exploitation of mineral and energy resources, changes in royalties and other forms of taxation, the movement of foreign exchange, policies on local purchase requirements and employment restrictions (such as targets for substituting nationals for foreign personnel in management positions).

According to the OECD *(Aluminium Industry: Energy Aspects of Structural Change, 1983, p.99)*, 46% of primary aluminium capacity in the world was under direct government influence in the early 1980s, either through state ownership or equity participation. With centrally planned economies excluded, government involvement remained significant since 31% (including Pechiney which was nationalized in 1981) of the global capacity were then under direct government influence.

In addition to the Six Majors of the early 1970s, a long list of private or government-influenced producers has joined the fray over the last four decades. Among the most significant are UC Rusal, Chinalco/Chalco, BHP Billiton, Rio Tinto Alcan (combination of Alcan, Alusuisse, Pechiney and Comalco), Hydro Aluminium (combination of VAW and CVRD/Vale aluminium assets), Century Aluminium, Ormet, Glencore, CVG of Venezuela, China Power Investment Corporation (CPI), Dubai Aluminium Company, Aluminium Bahrain, Mubadala, Hindalco, Nalco, Vedanta Resources, Aluar, CBA, and various Chinese State governments or private investors (including Guangxi Investment Group, Zengshi Group, Wanfang Group, Zhongmai Group, Yankuang Group and Xinfa Group). The list of merged or acquired producers over the same period is also significant and includes among them Alcan, Reynolds, Alumax, Alusuisse, Corus, Pechiney, Gencor, RTZ-Comalco, Hoogovens, VAW, Howmet, Hanna Mining, Camargo Correa, Ardal Sunndal Verk (ASV), Alumix, Noranda, Granges AB, Commonwealth, Martin Marietta Aluminium, SUAL, Northwest Aluminium and others.

The Six Majors of the early 1970s have shared their presence with newcomers not only in the production of primary aluminium but also in bauxite and alumina. Among them, Alumina Limited, Chinalco/Chalco, BHP Billiton, Rio Tinto Alcan, Nalco, Hydro/Vale, UC Rusal, Chiping Xinfa, Weiqiao, East Hope Group, CVG-Bauxilum, Glencore, Aluminium of Kazakhstan, Kaiman Sanmenxia, Hindalco, CBA Vedanta, Luneng Jinbei, Dadco, Minmetals, Bosai Minerals Group, Guinean State, Government of Ghana, Vimetco, PT Antam, Xinfa Group, Government of Guyana, Jamaican State, CVG, and Mytilineos Holdings are worth mentioning.

Exchange Rates

Aluminium is a US-dollar based commodity, listed on the *London Metal Exchange* (LME). However, most production and consumption takes place outside the US. Thus, if the US-dollar price of aluminium starts moving up, this may be explained by reasons which have nothing to do with the industry fundamentals. Metal prices may be strengthening only because the US-dollar has been losing ground against a basket of major currencies.

Conversely, the US-dollar based price of aluminium may be losing ground not because of softer industry fundamentals but simply because the US dollar has been appreciating against other currencies. Variations in exchange rates also affect producers' competitiveness when all costs are expressed in US dollars. For example, a weaker US dollar relative to other currencies is good for American producers not only because of higher aluminium prices expressed in US dollars but also because it reduces their domestic costs relative to other producers. Their competitiveness is enhanced unless a large share of their inputs is imported. Here, the Australian, Canadian or European producers are disadvantaged because the appreciation of their currency has made their domestic inputs more expensive when expressed in US dollars.

The result is quite different when the US dollar strengthens relative to the Euro or the Chinese Yuan: in this case the competitiveness of US aluminium producers starts shrinking, unless a very large share of their inputs is imported, because of higher relative costs, while the opposite becomes true for the European or Chinese producers.

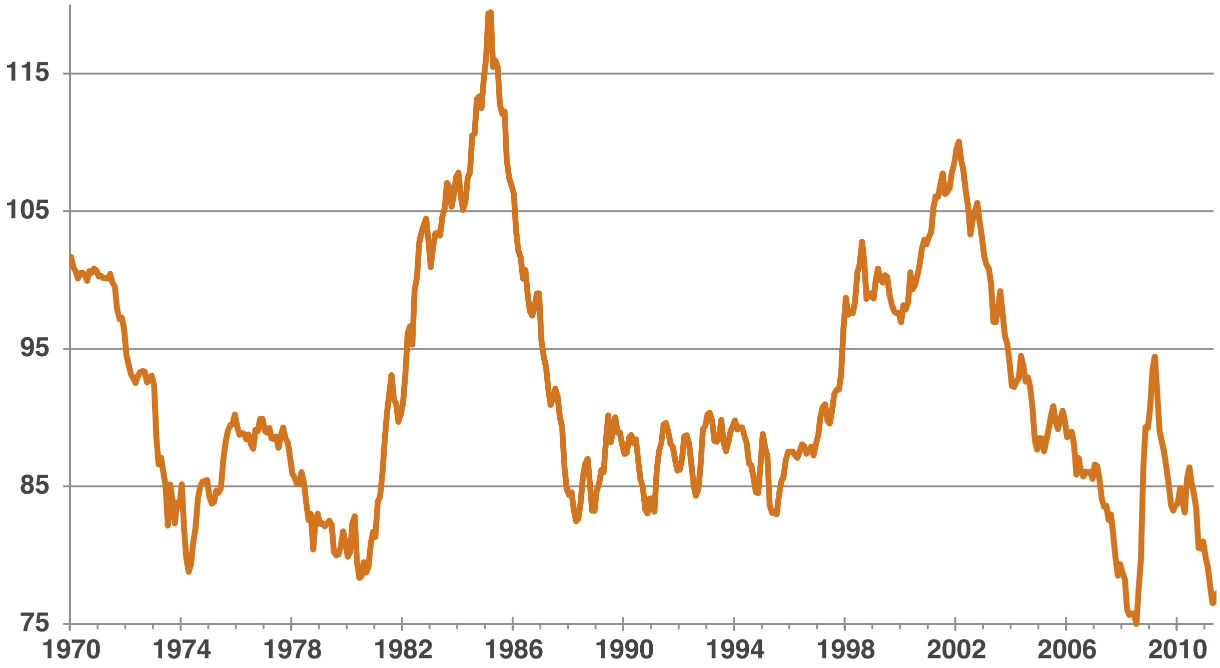

Figure 7: US$ Trade Weighted Exchange Rate (1970 = 100)
Source: Derived from *Global Insight*, various years

Figure 7 illustrates the high degree of volatility of the US dollar relative to the currencies of its main trading partners over the last 40 years. It clearly suggests that the lower aluminium prices over the years 1995-2002 were due not only to weaker industry fundamentals — excess supply during the 1990s due to the dumping of Russian metal on Western markets and lack of demand in the early 2000s because of the “dotcom recession” — but also to the stronger US dollar over the whole period.

Conversely, if there seemed to be no limit to the higher aluminium prices over the years 2002-2008, this was not only the consequence of soaring demand due to easy credit conditions or inadequate supply related to the low prices of the previous decade, but also to the weakening of the US dollar over that period. Thus, the role of exchange rates must be taken into account when comparing the global aluminium industry at two points in time given that their variations affect not only aluminium prices — the latter tend to vary in opposite directions when expressed in various currencies — but also the producers’ degree of competitiveness.

Shifting trend in aluminium cost curves

Operating cost curves — which reflect raw materials, energy, labour, maintenance and overhead costs for each smelter arranged in ascending order — remain one of the most useful tools of industry analysis. Operating cost curves for the primary aluminium industry became popular in the late 1970s as various producers and consulting firms developed quite detailed cost models reflecting the current and expected operating costs of each smelter. Some also include capital costs of each plant, based on estimates of actual costs incurred at the various stages of the project from inception to present capacity.

Operating cost curves generate useful information such as:

- the weighted average operating costs for all the smelters in a given year;
- identification of the smelters in each quartile of the curve and thus guidance on the point at which proportions of the industry will find current prices below their short run operating costs;
- benchmarking facilitation, by providing targets to be reached in order to improve energy or alumina efficiency and thus reduce costs;
- proportion of the industry not viable on a commercial basis relative to alternative investments, if depreciation and interest on short-term loans for working capital and long term debt are added to operating costs.

The evolution of operating cost curves since 1980 for the global primary aluminium industry clearly identifies two distinct trends. First, the shape of the industry cost curve has been flattening over the last few decades, implying a much lower gap between the low (in first and second quartile) and high (in third and fourth quartile) cost producers. Flatter cost curves may be seen as a consequence of globalisation: lower tariff barriers and disappearing captive markets have forced the closure of high cost capacities, while new investments have taken place at the low end of the cost curve.

Second, operating costs curves have continuously declined between 1980 and 2003, driven down by factors such as:

- **technology** (the closure of less energy efficient and more polluting Søderberg systems which involve the use of a continuous self-baking carbon anode and their replacement by the prebaked carbon anode technology; the widespread use of point feeding system of the raw materials alumina, cryolite or fluoride; lower costs through improved cell design and increased current density as the industry moved from 50kA cells to 400-500 kA cells);
- **lower energy prices** (as suggested by Figure 6, energy prices have come down from the time of the second energy crisis in 1980 to the early 2000s; this was particularly true for coal, crude oil and gas);
- **appreciation of the US dollar** (see Figure 7) (with the exception of the 1986-1988 period, the US dollar has strongly appreciated between 1980 and the beginning of 2002, pushing down not only metal prices but also the cost of inputs varying with the price of the output);

- **stable/weaker alumina prices** (Figure 8 suggests that with the exception of the late 1980s — when aluminium and thus alumina prices reached new highs — and of 1999, when the Gramercy alumina refinery exploded, nominal spot alumina prices have generally remained below $200/tonne over the 1980-2003 period; thus, real prices of alumina were definitely down during that period).

However, after moving down between 1980 and 2002-2003, the global primary aluminium industry cost curve trend shifted in the following years on **soaring energy prices** (due to significant increase in resources demand by China and other BRIC countries), **a weaker US dollar** (resulting in higher input costs as the price of alumina, energy or carbon products in many contracts is linked to the price of aluminium) or a **stronger Chinese Yuan** (as a large share of Chinese smelters are located in the third or fourth quartile of the cost curve, this factor increased the steepness and the level of the cost curve), and, **higher alumina and carbon products prices** (driven up by higher demand in China as this country accounts for over 80% of the increase in global production between 2002 and 2011).

Environmental regulation also played a certain role in driving up the cost curve. The only exception to this upward trend were the years 2009-2010 when output and input prices were negatively impacted by the worst recession since the end of World War 2. Improvements in alumina and aluminium technology continued to keep costs at bay; however, the impact on operating costs was more than offset by the drivers highlighted above.

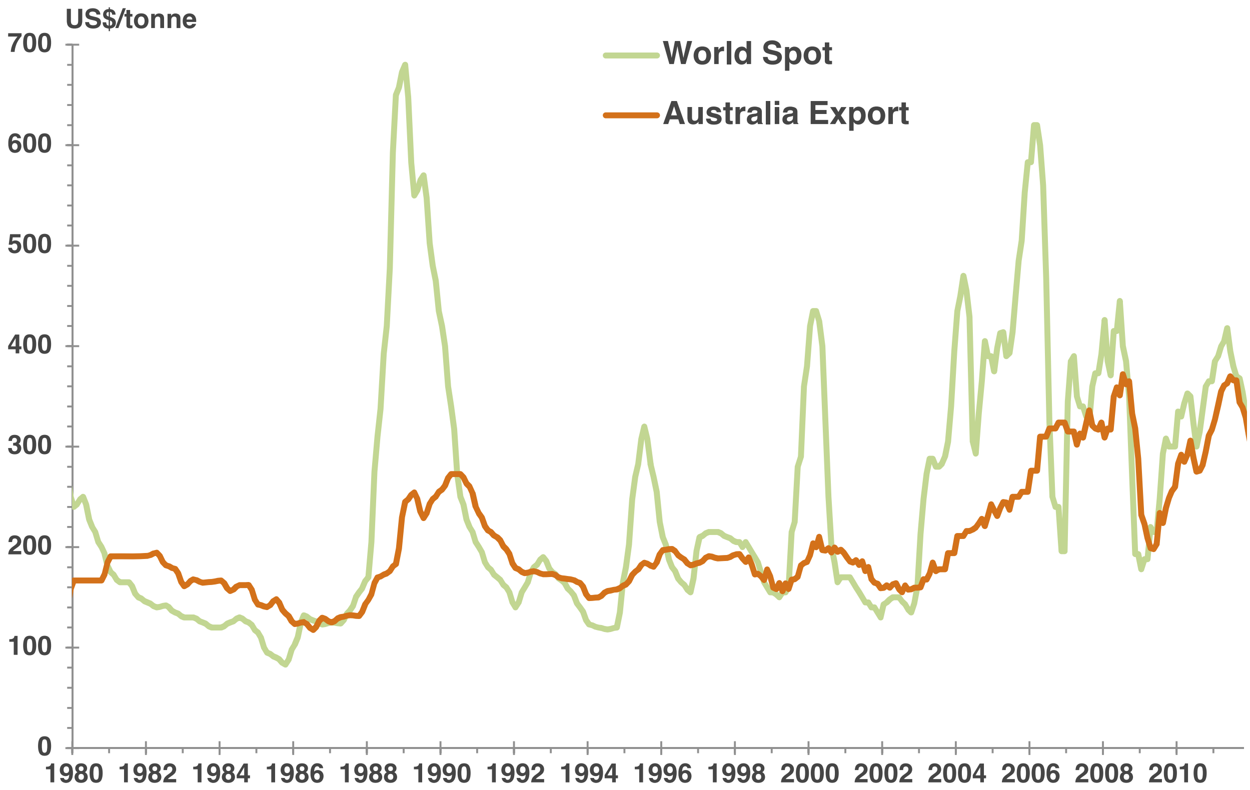

Figure 8: Alumina Prices – Spot and Australian Export, 1980-2011

WORLD ALUMINIUM

Emerging economies

No matter which measure is used, the emergence of the developing economies in general and of BRIC — Brazil, Russia, India and China — countries in particular represents one of the most significant structural changes of the last 40 years. Starting with the global economy, the combined output of the developing economies (the world excluding the original members of the OECD but including Turkey) accounted in the year 2000 for slightly more than 20% of global GDP measured at market exchange rates. This share has almost doubled to reach 38% in 2010. If GDP is measured at purchasing-power parity (PPP), which takes into account the higher real spending power provided by lower prices in poorer countries, emerging economies overtook the developed world in 2008 and accounted for 75% of global real GDP growth over the last decade.

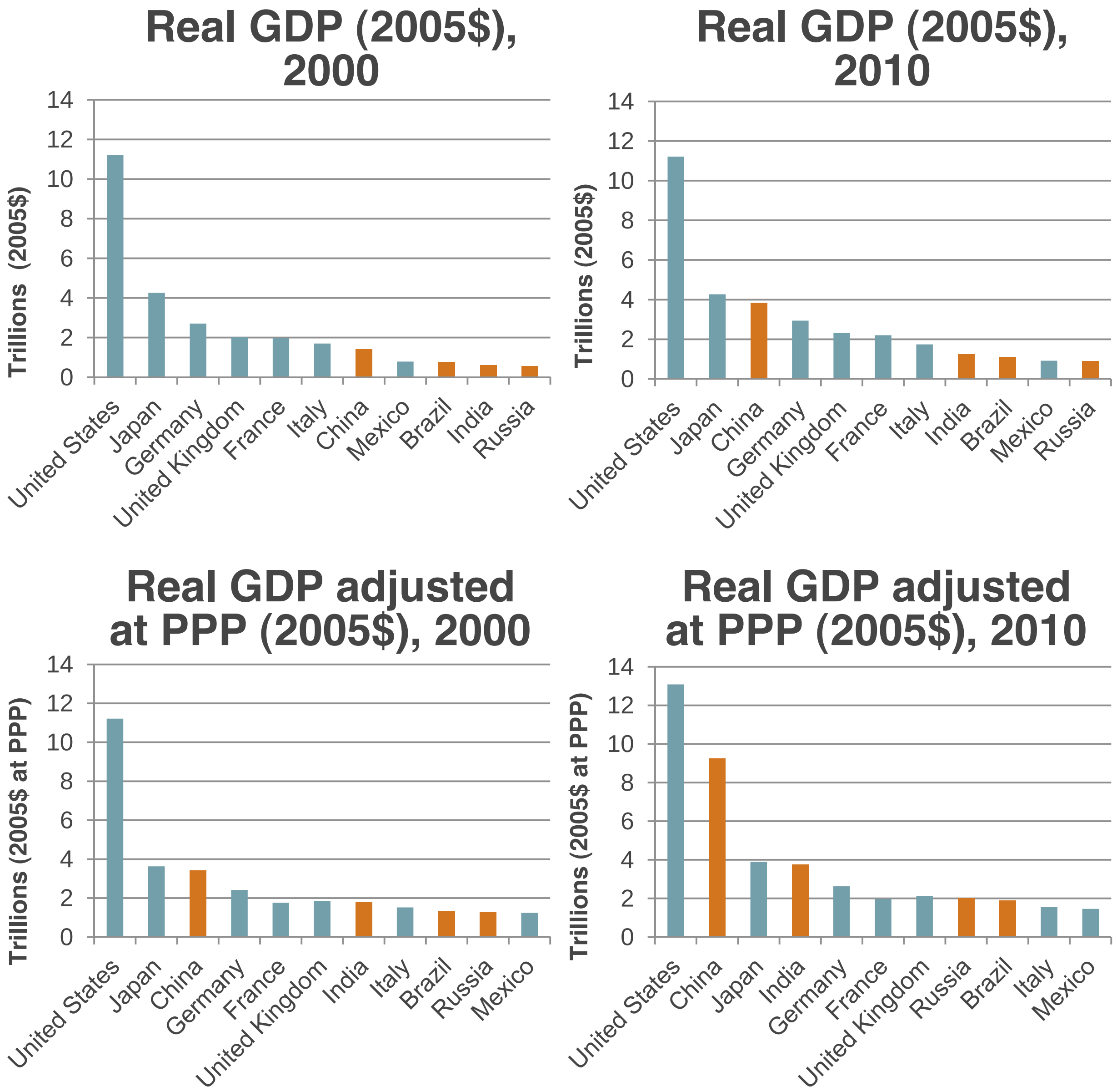

Figure 9: BRIC's Share of World Real GDP Measured at Market Exchange Rates and at PPP (2000-2010)

Source: Derived from *Global Insight*, various years

Other economic indicators such as inflows of direct foreign investment, capital spending, foreign exchange reserves, mobile-phone subscriptions, motor-vehicle sales or commodity consumption (using 60% of world's energy, 65% of all copper and 75% of all steel) also support the conclusion of a structural shift in world economic power during the last few years.

If only the four BRIC countries are considered, their real GDP valued at market exchange rates relative to the world equivalent almost doubled from 6.5% in 2000 to 11.7% a decade later (see Figure 9). Using GDP measured at PPP, the BRIC share exceeded 24% in 2010 as compared to 15.9% ten years earlier. Improvement has been particularly impressive for countries such as China (second largest share of global GDP measured at PPP) and India (fourth on the same scale). The impact of the BRIC economies on the global primary aluminium industry has been even more significant, not only in terms of surging demand but also on the supply side of the market (Figure 10).

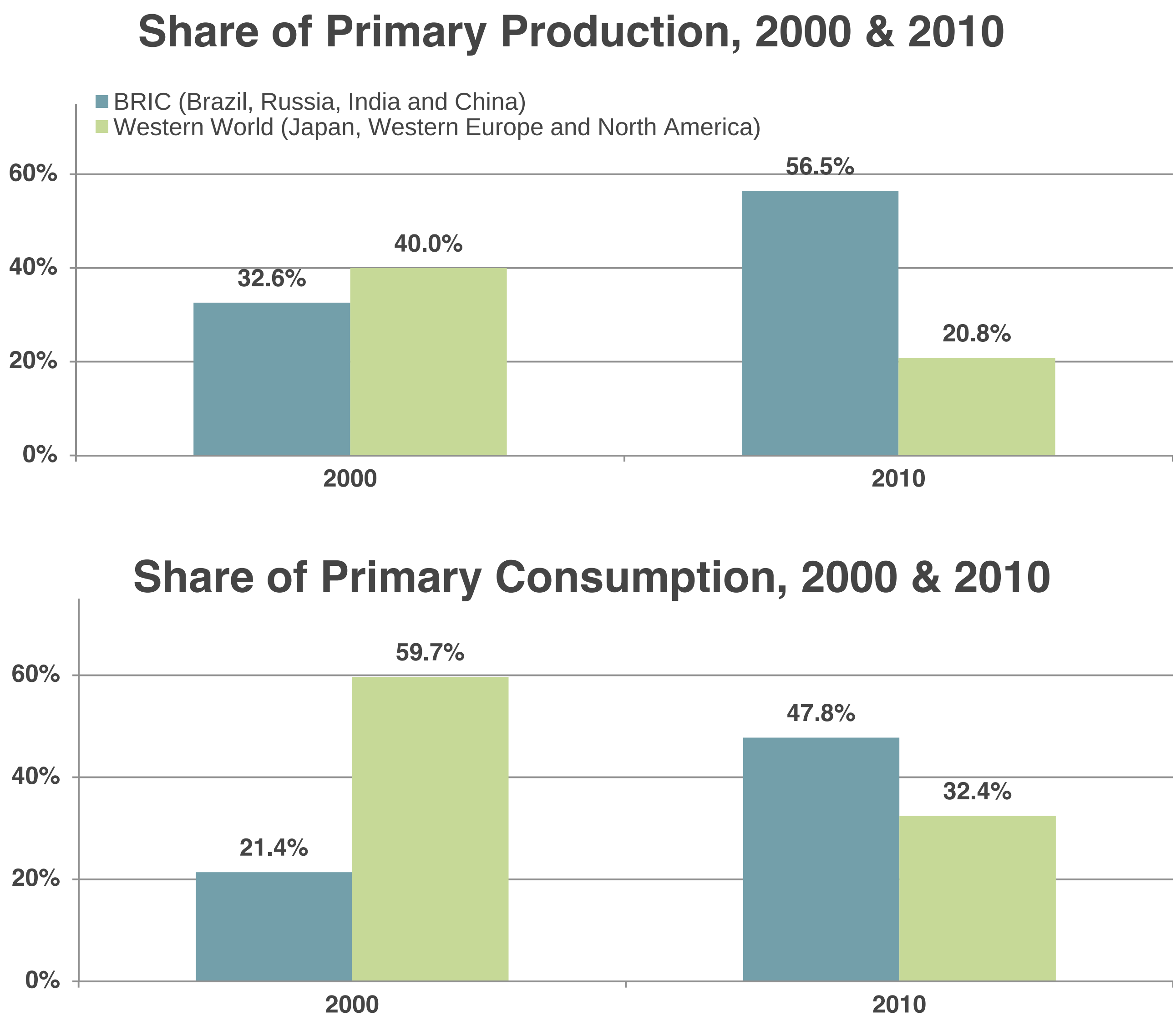

Figure 10: Share of Developed & BRIC Economies in Global Primary Aluminium Production & Consumption (2000 & 2010)

Source: Derived from *WBMS*, various years

Figure 10 indicates that the BRIC countries were producing almost 8Mt of primary aluminium in the year 2000 or a third of global production, with Russia accounting for 13.3% of the global total. Ten years later the BRIC contribution had surged to over 23 Mt (56.5%) of global primary production, with China being by far the largest producer. During the same period, the cumulative share of Japan, Western Europe and North America was sliced by half from 40% (or slightly below 10Mt) to less than 21% (or slightly above 8.5Mt). As for primary consumption, the BRIC share surged from about 21% in 2000 to 48% ten years later, while the share of major industrialized consuming countries went in the opposite direction from about 60% to below 33% over the same period.

To sum up, the global primary aluminium industry has been profoundly modified by drivers such as the rise in energy prices, the arrival of numerous new players, the US dollar depreciation over the last decade, the shifting trend in aluminium cost curves and the emergence of the BRIC economies. The impact of these drivers on the main characteristics of the current global primary aluminium industry will now be analyzed in greater detail.

4. Current Picture of the Primary Aluminium Industry

The geographic distribution of bauxite, alumina and aluminium production has shifted significantly since 1972. Starting with **bauxite**, while Australia increased its share of global output from 20% to 32% over the last 40 years, Jamaica, Suriname and Russia are no longer on the list of the major producers, having been replaced by Brazil (15%), China (14%) and Indonesia (11%). The combined market share of the four largest producers is now over 70%.

A complete relocation of producing centres has also been taking place in the global **alumina** industry. The production shares of Japan, Russia, Jamaica and Suriname have drastically shrunk since 1972 – and today four countries (China, 35%; Australia, 23%; Brazil, 11%; India, 4%) have a combined share of 73% of global alumina output. While the BRIC countries now account for almost 40% of global bauxite output, this share jumps to 53% for alumina. In the latter case, production has definitely shifted towards countries with access to an abundant and inexpensive source of bauxite. In addition to being the most important cost element, the bauxite cost is the most important source of variation of alumina production cost. China has become the largest alumina producer, but continues to import a large share of its bauxite needs, mainly from Indonesia.

If bauxite cost remains the most significant driver of the current location of alumina production, shifts in the geographic location of **aluminium** production is determined to a large extent by variations in energy prices. Even if capital, alumina and energy costs account for about equal shares of total aluminium production costs, energy costs vary much more between countries than the two other cost elements; consequently, energy costs remain the most important determinant of international differences in aluminium production costs (about 70% of the variability in aluminium's total cost is linked to energy cost). Unsurprisingly, US share of global primary output has moved down from 32% in 1972 to only 4% in 2010. The same applies to Japan (its share dropping from 9% to nil during the same period) and most European producer countries of the early 1970s, with the exception of Iceland and Norway.

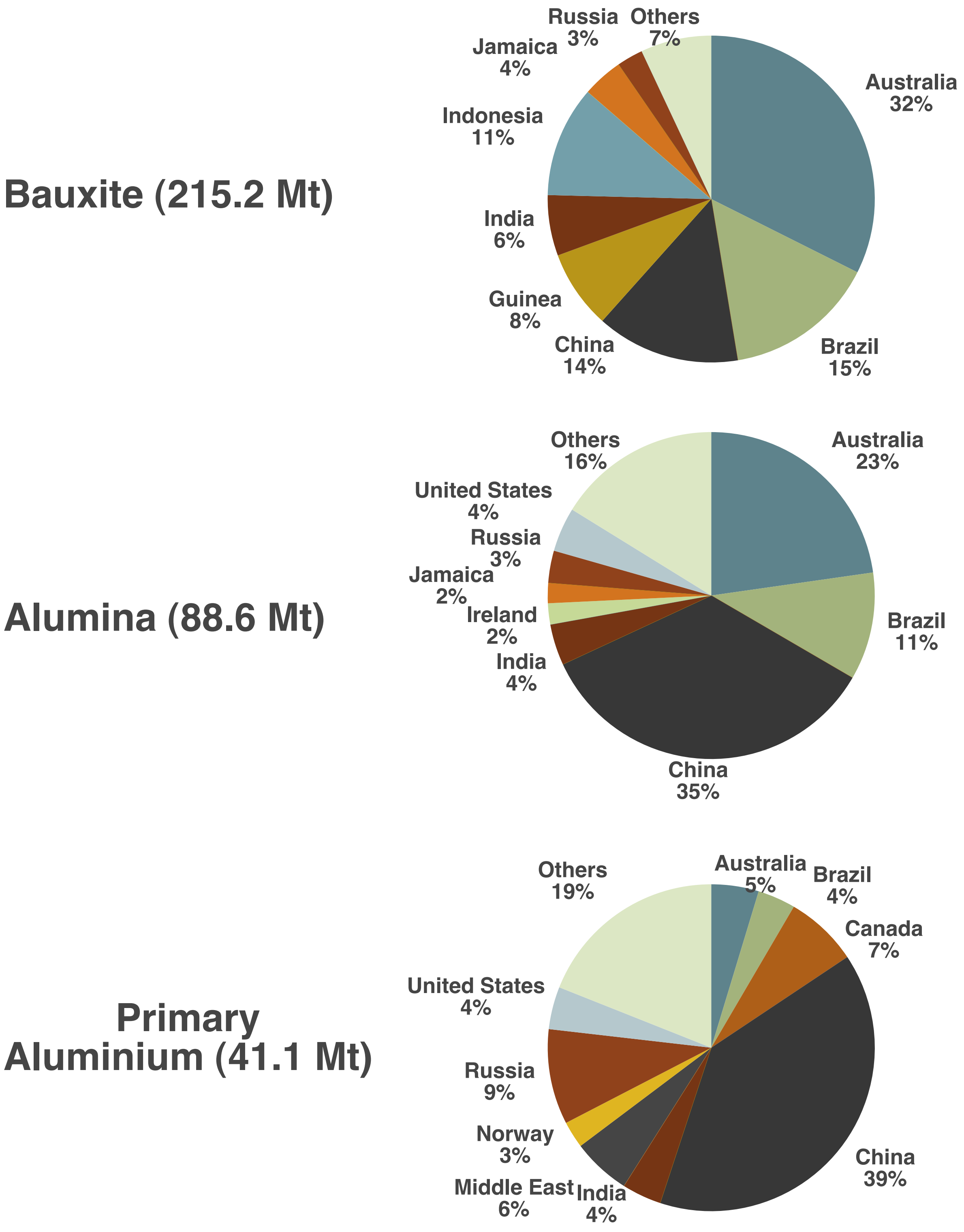

Figure 11: Geographic Distribution of World Production of Bauxite, Alumina and Aluminium (2010)

Source: Derived from *WBMS* and *CRU*, various years

Primary output has been moving to China (with around 40% market share) not only because of its natural sources of comparative advantage (energy is abundant and relatively cheap in its western and north-western regions) but also because of policy-induced sources of competitiveness related to provincial subsidies, exchange rates and trade policies. Other major producers include energy-rich regions such as Russia (9% in 2010), Canada (7%), the Middle-East (6%), Australia (5%), Brazil and India with 4% each. The Middle-East region share is continuing to grow with the commissioning of the EMAL and Qatalum smelters in 2011 and Ma'aden smelter in 2013. Despite being endowed with vast energy resources, Russian output has been moving up during the last 20 years at a slower pace than global production, bringing down its market share.

What are the other new characteristics of the global aluminium industry?

Lower degree of concentration and integration, and more "strategic groups"

The arrival of new private or state-owned enterprises has also completely modified the degree of competition within the industry. Starting with **bauxite**, not only the share of the six major producers has dropped to about 50% in 2010 (the HH index also lost ground to reach 0.058 during the same period), but even the players have changed: Alcoa (10.6%) is still present through a 60% ownership of AWAC and Alcan was acquired by Rio Tinto providing Rio Tinto Alcan (RTA) with a market share of 13.1%; the others have been replaced by Alumina Ltd (7% through its 40% ownership of AWAC), Hydro (a pro-forma share of 6.1% in 2010 since Hydro acquired Vale's aluminium business on February 28, 2011), BHP Billiton (6%), UC Rusal (5.5%) and Chinalco/Chalco (4.6%).

The story is similar in the global **alumina** market. The share of the six most important producers (CR6) has come down from almost 80% to slightly more than 53% over the last four decades. If the degree of concentration is measured using the HH index, the drop is even more important from 0.129 to 0.048. Once again, while Alcoa (10.4%) and RTA (9%) are still present, the other players are newcomers: Chinalco/Chalco (11.9%), UC Rusal (9.8%), Alumina Ltd (6.5%), Hydro (6%) and Chiping Xinfa (5.8%). Figure 12 highlights the significant presence of Chinese alumina producers – the cumulative share of Chinalco/Chalco, Chiping Xinfa, East Hope Group and Weiqiao was around 24% in 2010.

As expected, the arrival of new players has also reduced the degree of concentration in the global primary **aluminium** industry. The share of the original Six Majors back in 1972 has dropped from 73% to 38% four decades later. Given the disappearance of very large players, the HH index suggests a much more drastic drop from 0.103 to 0.027. No single company in 2010 had a degree of ownership of the global primary capacity exceeding 9%, while three Chinese producers (Chinalco/Chalco, 6%; China Power Investment, 2.3%; and Xinfa Group, 2.1%) had a combined share of 10.4%.

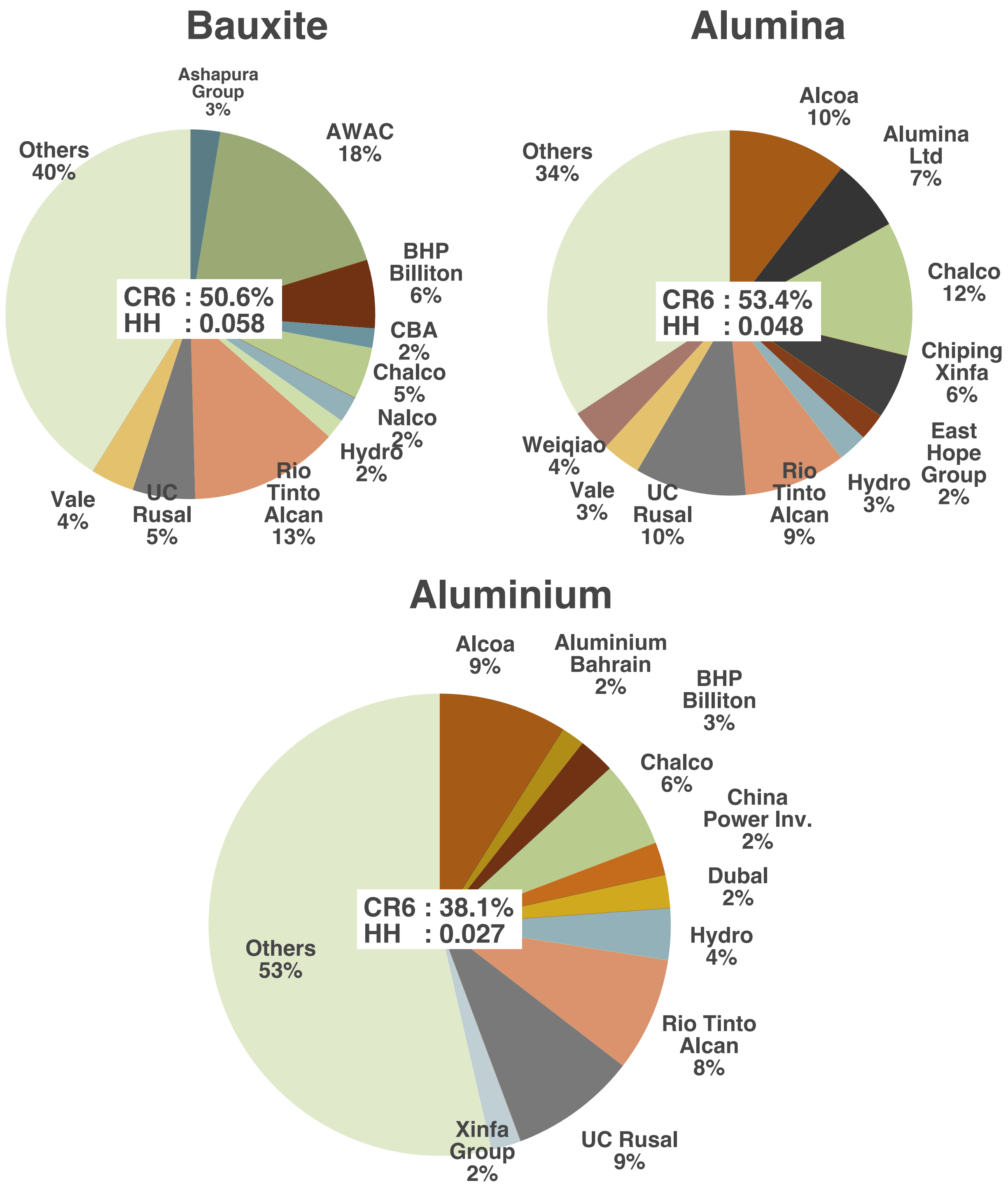

Figure 12: Market Shares and Degree of Concentration[2] in Global Bauxite, Alumina & Primary Aluminium Capacities (2010)

Source: *CRU Bauxite & Alumina Market Outlook*, July 2011 and *Aluminium Quarterly Industry & Market Outlook*, July 2011

However, the most distinctive feature of the current global aluminium industry is the fact that many producers are not fully integrated with upstream and downstream assets. For example, RTA and BHP represent large conglomerates with no downstream facilities but with large upstream interests. On the other hand, Alcoa and Hydro (since the 2010 acquisition of Vale's

[2] Measured by share of the six most important companies (CR6) and HH index (sum of squared market shares)

aluminium assets) are fully integrated, while UC Rusal, Chinalco/Chalco and some Chinese producers are stronger upstream than downstream. Finally, some large producers such as Alba and Dubal are focused on the smelting stage of the production value chain.

The various types of producers reflect not only a lower degree of integration over time but also the presence of many “strategic groups”, defined as clusters of firms following the same strategy, making the same type of choices with respect to some key variables such as resource commitments, and thus having the same interests. An increase in the price of aluminium is certainly positive for “upstream-only integrated producers”, while being detrimental to those with downstream operations fighting for a higher market share relative to substitutes. The degree of competition within an industry is positively correlated with the number of strategic groups, suggesting that competition within the aluminium industry may be even larger than what is indicated by the current degrees of concentration.

Shifts in consumption patterns by region and by end-use market: China and transportation dominate

Global primary aluminium consumption has been increasing at a compounded annual growth rate (CAGR) of about 5% over the last decade, despite two recessions and continuous market threats of substitutes. During this period, demand growth rate has been much faster in countries such as China (CAGR of almost 17%) and India (10.4%) than in the rest of the world (0.8%), reflecting the growth and growing importance of the BRIC countries. This is better illustrated by Figure 13 which presents use of primary aluminium by region in 2010.

In 1972, more than 60% of global consumption of primary aluminium was taking place in six industrialized countries, with the United States leading the pack at 36%, followed by Japan (10%), Germany, France, Italy and the United Kingdom. In 2010, the combined share of these same industrialized countries was barely exceeding 25%. The same is true for Russia: its market share dropped from 12% in 1972 (for USSR) to less than 2% in 2010.

The leading role in global consumption is now played by China whose market share has swelled from 2% in 1972 to 40% today. As for India and Brazil, they have more than doubled their market share. Thus, almost half of global primary consumption is today accounted by BRIC economies.

What about the total aluminium consumption by end-use market? Transportation has become the most significant end-use market, accounting for almost 43% of the metal used in Japan and 35% of North American and West European aluminium shipments. This contrasts with the situation 40 years ago when this end-use market was responsible for about 20% of total consumption in the United States, Japan or Germany.

According to Ducker Worldwide (see *Aluminium International Today*, September 2011), a well-known research firm in this field, automakers are accelerating their shift to aluminium away from other materials for new car and light truck construction in order to safely and cost-effectively lower the weight of their vehicles. Ducker's survey of North American auto producers indicates that since lighter vehicles get better fuel economy with fewer emissions, aluminium is already the leading material in the engine and wheel markets and is gaining market share in hoods, trunks (boots) and doors. Aluminium usage has increased every year for nearly 40 years to reach 148kg in 2009 and should hover around 156kg in 2012. Stricter fuel economy regulations should accelerate the use of aluminium in bumpers, heat shields, brake calipers, ABS and driveline components, cylinder heads or bed plates.

However, the market challenge from alternatives remains present: the steel industry continues to invest millions of dollars to demonstrate that high strength steels can be engineered to provide the same weight savings as aluminium; composites (like carbon fibre) also represent a serious competitor in the automotive and aerospace sectors. Although composites have a cost and repair disadvantages, their price is coming down while offering improved corrosion properties and good aesthetics.

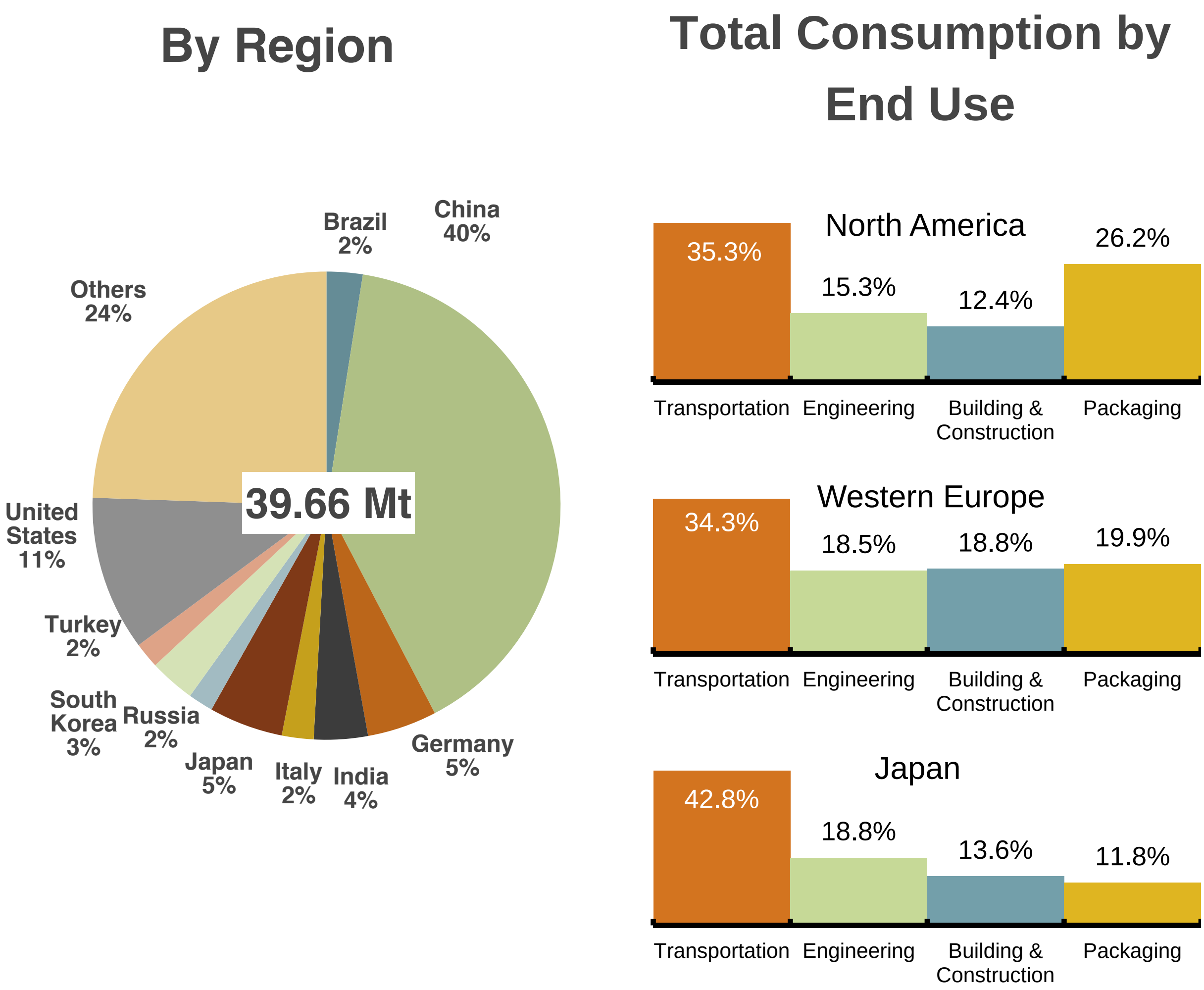

Figure 13: Primary Aluminium Consumption (2010)
Source: *WBMS*, various years and *Brook Hunt Long Term Outlook*, July 2011

As for the other end-use markets (also see *Brook Hunt Metals Market Service Insight*, August 2011), a number of circumstances favour aluminium:

- the copper to aluminium substitution (as the price differential reached record highs) in overhead cables, heat sinks for electronics, utility buss bars, battery cables, wire harnesses and aluminium wiring in air conditioners and white goods;
- the wider use of aluminium in consumer electronics for backing plates for flat screen TVs (a lightweight alternative to steel), tablet computers, mobile phones, laptops or as a laminated film used in exterior packaging for batteries;
- the use of aluminium in green applications such as solar panelling (used in the frame) and wind farms (in submarine cables for off-shore wind farm projects);

However, substitution can work both ways – and aluminium remains under challenge in the buildings sector where plastics have become increasingly popular, in the aerospace sector with inroads by composites and in the US packaging industry where aluminium has lost market share in the individual drinks market to plastic bottles.

Investor demand and market fundamentals as price drivers

As for most commodities, the global aluminium industry is characterized by a strong relationship between the real price of the metal and the gap between demand and supply of the metal as captured by the variations in total stocks (including both visible and unreported inventories) expressed in weeks of shipments. Prices tend to explode for very low levels of inventories, while being quite stable despite high level of inventories as prices cannot drop below their average operating costs for a long period of time. As mentioned earlier exchange rates also play a role given that aluminium prices are generally expressed in US dollars—thus a weaker dollar drives up the US-dollar price of aluminium.

However, since the middle of the past decade, another aluminium price determinant has been identified with the rise in popularity of commodities as an asset class, with investors using a variety of instruments and strategies to gain exposure to commodity prices. The most important investment vehicles used include:

- various **Commodity Index Funds** (CIFs), where investments are made through the purchase of commodity futures, which are then rolled forward by being sold at or prior to maturity and replaced with a new futures purchase with a more distant maturity date as long as they provide positive returns from rising spot commodity prices;
- **Commodity Trading Advisors** (CTAs) or momentum investors where decisions to buy or sell are based on trends or technical factors (mainly past patterns of price behaviour);
- **hedge funds** where investment decisions are based on their view of the economy outlook or of the metals' fundamentals;
- **proprietary trading desks** of major investment banks or trading firms that invest in commodities on their own account (note that some of these major banks and commodity traders have their own warehouses and provide incentives to metal holders to guarantee that enough metal would sit in their warehouse at full rent to cover the cost of the incentives

paid; these stocks are referred to as “stealth or unreported” stocks since their importance may only be estimated).

What is the impact of this investor demand on spot aluminium prices?

The answer is not straightforward, even if the rise in popularity of commodities’ investment coincided with a surge in many commodity prices. In general, spot prices (for immediate delivery) are lower than future prices (in the case of aluminium, official contracts exist for 3-, 15-, 27-, 63- and 123-months), and the difference or “contango” between the two prices is high enough to at least cover finance and warehousing costs.

The presence of such contango induces investors to buy spot and sell futures, raising the spot and reducing the futures prices until the gain from the contango covers no more than the costs mentioned above. Obviously, near-zero interest rates and subsidized warehousing costs increase the contango and thus the expected return from such deals.

The same applies if the futures price moves up because of higher investor demand: the contango becomes wider, inducing more investors to buy spot and sell forward, which raises the spot price. In all other market circumstances (insufficiently high contango or spot prices higher than the futures price), the mechanism linking spot and the futures price is less clear as other variables such as expectations about the futures price or the cost-benefit ratio of holding inventories must also be taken into account.

Nevertheless, even if investor demand may in some cases influence spot prices, this new driver has made the traditional relationship between supply, demand, stocks and prices more murky not only because this influence is not straightforward but also because of the increased presence of unreported stocks. The latter are currently estimated in the 3.0-4.5Mt range, which makes price forecasting and apparent consumption calculations more challenging.

5. <u>Outlook</u>

The primary aluminium industry of today has little resemblance to what it was 40 years ago. BRIC economies now account for more than 40% of bauxite production, while alumina output has shifted towards bauxite-rich countries and away from industrialized economies. Reacting to the continuous increase in energy prices and in some cases to government industrial policies, primary production has moved from regions such as the United States, Japan and most West European countries towards China, Russia, Canada, Brazil, Australia, the Middle-East, and now India and some parts of South East Asia. The degree of competition has surged, driven not only by lower concentration and integration, but also by the presence of different strategic groups with different economic interests.

Significant structural changes have also taken place on the demand side of the industry equation where the 60% combined share of global consumption held by six industrialized countries in 1972 has shrank to 25%, replaced by China (40% in 2010), India and Brazil.

As for end-use markets, transportation now dominates, accounting for 35-40% of Japanese, North American and West European total shipments.

Aluminium spot prices are also more volatile than 40 years ago: during the 1973-2011 period, the degree of volatility (standard deviation over average prices) reached 0.335, more than doubling the corresponding value for the 1946-1972 period. Investor demand has “financialized” base metals markets. This new driver may explain some of the increase in metal prices when futures prices exceed spot prices by a margin high enough to more than offset financial and warehousing costs. Other variables need to be taken into account under alternative market hypotheses.

Looking forward, even if primary aluminium consumption has been growing at a pace of about 3% per year (see Figure 3) over the last 40 years, a higher CAGR of around 4.0% can be expected over the next two decades as urbanization, industrialization and economic development in BRIC and other emerging countries continue to positively impact the use of aluminium.

Even if the consumption per capita of mature economies such as Germany, South Korea, Japan and the United States has stabilized at around 20kg in 2010 and may come down slightly during the years ahead, this is not the case for countries such as India (only 2kg per head), Brazil and Thailand (about 5kg), Turkey (8kg) or Malaysia and China (slightly above 10kg per capita). If these countries follow more or less the same pattern of growth as the current mature economies, primary aluminium consumption should double in the next 20 years. Drivers such as stricter environmental policies, energy efficiency, downsizing, globalization or the continuous development of new applications may drive up the use of aluminium at a faster rate than expected. On the downside, the negative substitution in favour of plastics or new materials, policies favouring growth instead of sustainable development or the challenge of developing new applications in an industry as fragmented as aluminium may result in less demand than forecasted.

This growth projection implies the “equivalent” of about 40-50 new smelters (with a capacity of 500-kty each) will be needed to satisfy 2030 forecasted demand. The required additional capacity will in fact be even higher as some smelters will be dismantled or idled during the same period. These expansions (brownfield) and/or new investments (greenfield) will raise new challenges in terms of commissioning additional capacity of bauxite, alumina and carbon products, and developing new sources of energy. Given that electricity will remain the most important driver of competitiveness, the new smelters will be found in the Middle East region, Russia, the western and north-western provinces of China, Malaysia, Africa (including Algeria, Angola and the Congo), India and other regions where stranded energy can be available. Policy-induced sources of competitiveness (subsidies, legislation, undervalued exchange rates) will remain present, influencing not only the level of total supply but also its distribution among the regions mentioned above.

The future of the global aluminium industry will be influenced by its ability to minimize environmental impacts and to be considered as a solution to some of the problems generated by CO_2 emissions. For example, according to a recent study by *The Aluminum Association* (September 2011), North American 2009 “light-weighting” of vehicles with aluminium offset 90% of the energy consumption and 96% of cumulative greenhouse gas emissions associated with primary aluminium production. Even more, 75% of all the aluminium ever manufactured – dating back 125 years and over multiple generations – is still in use today as the metal is recycled after each use phase, further compounding the metal’s sustainability dividends.

Just like the rise in energy prices in the mid-1970s, legislation on CO_2 emissions may impact both sides of the market simultaneously. Supply growth may to some extent be hindered by higher production costs related to emissions and higher raw material and power prices. However, CO_2 caps may also favour the use of aluminium by encouraging energy efficiency and light-weighting, with potential beneficiaries in the transportation, power distribution & transmission, air conditioning & refrigeration, renewable energies, green buildings and other end-use sectors.

Aluminium product characteristics such as lightweight, strength, moderate melting point, ductility, conductivity and corrosion resistance will continue to be in demand well into the future.