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The aluminium industry and export revenue volatility

Aluminium production in Iceland will increase several times over in the next few years if pending projects are realised. Increased aluminium production has been regarded as a way to level out cyclical fluctuations in the Icelandic economy. The following article points out that export revenues will become more volatile with an increased weight of aluminium. It also discusses the relation of aluminium prices to global economic swings and global interest rates.

Iceland has long been dependent on fisheries, which was the main national export industry in the 20th century. However, undiversified exports have been regarded as a cause of economic instability, since export revenues have mostly relied on this single industry. GDP growth in recent decades has to a large extent been driven by fisheries, where growth potential is nonetheless restricted since fish stocks are a limited resource. Over this period, the government has therefore been seeking ways to diversify exports with the aim of boosting growth when the fisheries sector exhausts its growth potential and reducing cyclical swings in the Icelandic economy. The metals industry has been under particular consideration, with the chief focus on aluminium production.

Despite decades of discussion about diversifying exports by increasing the share of metals production, relatively little research has been conducted into the macroeconomic impact of the metals industry. In an article in issue no. 2 of *Fjármálatíðindi* 1998, Páll Hardarson (1998) attempted to evaluate the macroeconomic impact of the metals industry in Iceland over a period of more than 30 years. Other studies have been made by Jón Vilhjálmsson (1983), on the impact of the power agreement between Landsvirkjun (the National Power Company) and ISAL (now Alcan Iceland) on electricity prices to the ordinary market (public utilities), and the findings of a Ministry of Industry committee on the macroeconomic importance of the metals industry for Iceland. From a historical perspective, Páll Hardarson (1998) estimated that 60% of the benefit derived from the construction phase and 40% from increased long-term output capacity in the economy. Construction of industrial and hydropower facilities can act as a stabiliser for the economy as a whole if it is scheduled for a time when there would otherwise have been slack. This impact will not be examined in this article. The first section aims to highlight the effect of the metals industry on export revenues, in order to reveal whether increased aluminium production will act as a cyclical stabiliser. It briefly considers two related questions which have been under discussion in connection with the impact of increased investment in the aluminium industry in Iceland. The first issues involves how fisheries and aluminium production correspond to the global economic cycle, and the second is the correlation between aluminium prices and global interest rates.

Export shares by sector and the proposed increase in aluminium production

Exports are divided into goods and services. In 2002, services accounted for one-third of Iceland's exports by value, and goods two-thirds. Table 1 shows sec-

1. The author is an economist at the Central Bank of Iceland's Economics department. He would like to thank Ásgeir Daníelsson, Már Gudmundsson, Gudmundur Gudmundsson, Ólafur Örn Klemensson, Thórarinn G. Pétursson and participants at a Central Bank of Iceland seminar for their constructive remarks. The views expressed in this article are those of the author and do not necessarily reflect the views and policies of the Central Bank of Iceland.

toral shares in goods exports over the period 1980 to 2002. Hitherto, fisheries have been Iceland's most important export sector with an average share of 72.5%. Aluminium production and industrial manufacturing have accounted for similar shares, at around 11-12% each, other goods 3% and agricultural products just under 2%. The share of aluminium has been increasing in recent years and amounted to 19% in 2002.

Ideas are also being examined for expanding the Norðurál smelter in Grundartangi, west Iceland, to 150,000 tpy. Under current plans this will be done in two phases. Phase one will involve an expansion of 90,000 tpy, scheduled for the beginning of 2007. Phase two, adding a further 60,000 tpy, is planned for 2010.

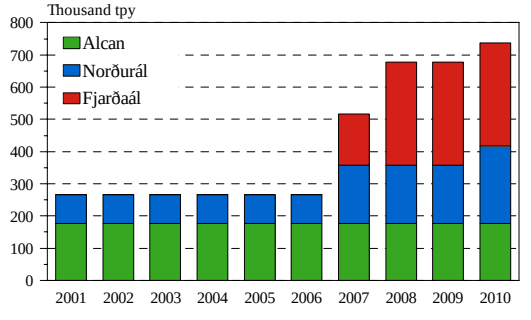
Table 1 Sectoral shares of goods exports by value (fob)

			Reweighted model with almost triple aluminium production[1]	
	Average		Average	
%	*1980-2002*	*2002*	*1980-2002*	*2002*
Marine products	72.5	62.8	60.0	47.1
Agricultural products	1.7	1.6	1.4	1.2
Industrial manufacturing	10.8	14.0	8.9	10.5
Aluminium	12.2	19.0	27.4	39.2
Other goods	2.8	2.6	2.3	2.0
Total goods exports	100.0	100.0	100.0	100.0

1. Hypothetical shares in export value from 1981 to 2002 if aluminium had weighed almost triple its actual value, i.e. if the expansions now pending had already taken place. Any crowding-out effect is ignored. *Sources:* Statistics Iceland and Central Bank of Iceland. Export value is stated in terms of purchasing power of exports, i.e. deflated by the import price index.

Some 267,000 tonnes per year (tpy) of aluminium were produced in Iceland in 2002, roughly divided between 177,000 tpy at Alcan Iceland and 90,000 tpy at Norðurál. Construction of the Fjarðaál smelter in east Iceland has already begun. It is scheduled to go on stream in late 2007 with a capacity of 320,000 tpy.

Chart 1
Aluminium production in Iceland and planned expansions until 2010



Source: Central Bank of Iceland.

It is already clear that production will be increased by at least 320,000 tpy and in all likelihood stepped up by 470,000 tpy. Assuming that these investments materialise, annual production can be expected to almost triple from 267,000 tonnes in 2002 to 737,000 tonnes in 2010. If aluminium production had already reached this level in 2002, its share in the export value of goods, other things being equal, would have been almost 40% instead of 19%, and the share of fisheries 47%.

This ignores any crowding-out effect or other impacts that would accompany an increase in aluminium production; the reweighted model assumes unchanged export value of other industries from the 2002 level.

Production and markets for aluminium and marine products

Aluminium is the third most common element in the Earth's crust after oxygen and silicon, and the most abundant metal. It does not occur in metallic form in

nature, but only in oxidised compounds. Alumina is the most common raw material for aluminium, which is processed from it by electrolysis. Although aluminium occurs in numerous mineral compounds, the only viable ore for producing it is bauxite, which contains 50% alumina. Aluminium is a virtually homogeneous commodity traded in a single global market where buyers are mainly manufacturers of durables. The four largest consumers of aluminium are manufacturers of transport equipment (motor vehicles, aircraft, ships, trains, etc.), who use roughly one-quarter of production, the packaging industry and construction industries, each accounting for around one-fifth, and manufacturers of electrical equipment (electricity transmission lines, transformers and electrical devices) with some 10%. Demand for aluminium and its price developments are therefore to a large extent determined by demand for consumer durables and the global economic situation at any time.

Although fisheries have been identified as one cause of economic instability in Iceland, the situation has improved over the past two decades. As a result of the fisheries management system, fish catches are no longer as prone to fluctuations as before. Harvesting and processing of more species has reduced volatility in the value of marine products. Exports of marine products may be divided into four main groups. Firstly, frozen products, at various degrees of added value, which are exported for consumption in Japan, the USA, the UK and Germany and account for around half of total fisheries exports in value terms. Secondly, salted and dried fish products are largely exported to Portugal, Spain and Nigeria and account for one-fifth of total value. Thirdly, fish meal and fish oil are mostly bought by the UK, Norway and Denmark, and account for around one-seventh, and finally fresh fish, the main markets for which are the USA, the UK and Germany, is responsible for one-tenth of export value.

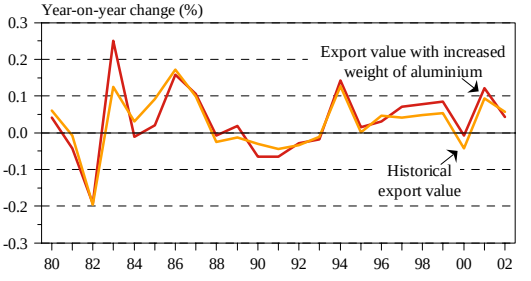
Fluctuations in goods export value from a historical perspective

In the debate about investment in the metal industry in Iceland, there have been hopes that increasing the importance of aluminium and decreasing that of fisheries would reduce the volatility of export value and thereby make the economy less prone to swings. It is interesting to examine what the impact on export value developments would have been over the period 1981 to 2001 if the volume of aluminium had been almost triple then, i.e. if the increase now pending had already taken place. Chart 2 presents such a model, assuming that all other aggregates remain unchanged. For example, no crowding-out effect is assumed to accompany the aluminium industry investments.

Chart 2

Export value 1981-2002

Historical export value and hypothetical value[1]



1. If aluminium had weighed almost triple its actual value, i.e. if the expansions now pending had already taken place by the end of the period. Other factors are assumed unchanged. Export value is deflated with the import price index up to 2002. *Source:* Statistics Iceland and Central Bank of Iceland.

What is interesting about Chart 2 is, firstly, how little effect almost tripling the export value of aluminium would have had. Fairly small fluctuations in the export value of aluminium are probably the main reason; even if Iceland multiplies its aluminium exports, there is little difference in year-on-year changes. Secondly, the apparent increase in volatility over the period 1983-1985 is worth noting. The reason is that, in response to low demand, ISAL had stockpiled production during the preceding years, then sold from its inventories in 1983. Expanded capacity at ISAL and the startup of Norðurál are also reflected in an increase in export value in 1997. From a historical perspective, an increased share of aluminium production would apparently not have dampened volatility nor counterbalanced the export value of other industries.

There is a drawback in the picture of export value volatility presented in Chart 2. Value is volume multiplied by price, and these two factors need to be distinguished in order to see where the volatility originates.

Volatility in the volume of marine products and aluminium

Aluminium production volume changes in steps. Year-on-year volume is fairly stable unless a new production unit is introduced, i.e. a new smelter or expansion. In the interim there will not be much difference in production volume between the years. Compared with marine products, aluminium is much easier to stockpile. Accordingly, inventories of aluminium are much more prone to fluctuations than marine products. There has been little consideration of the possibility that an aluminium smelter might close down or cut back production in Iceland, although the risk is nonetheless at hand. Volume changes in marine products depend upon many factors, four of which are the most important. Firstly, the size of fish stocks, which can differ significantly between the years. Changes in the size of fish stocks are mainly thought to be determined by fishing and fluctuations in recruitment. Secondly, the introduction of the quota management system. This imposes a ceiling on fishing from the stocks, but rules are also in force restricting the percentage by which quotas may change from one year to the next. Thirdly, more species are now being harvested, which serves to dampen fluctuations in volume. Fourthly, the extension of the fishing limits and Iceland's increased share in the total catch from its own waters had a great effect on volume changes.

These two industries differ sharply in the volatility of their production volume. While sizeable sudden swings can occur in fisheries, changes in aluminium production volume take place in phases which generally are foreseen. For this reason, a comparison of historical price changes for aluminium and marine products provides a better estimate of the relative volume at which price volatility is minimised. This approach makes it easier to establish whether an increased share of aluminium production will act as a cyclical stabiliser, without the findings being distorted by factors such as unforeseen changes in marine product export volume. The following scenario assumes unchanged marine production volume and examines the impact of a proportional increase in aluminium production on export revenue volatility.

Price volatility of marine products and aluminium

Marine exports comprise many different types of product which are sold in different markets. Price changes in one product category or one market therefore do not have a decisive effect on marine product export revenues (although this would not apply in the case of factors affecting all marine production from Iceland). Aluminium price formation is somewhat different, however. As a virtually homogeneous good, traded in a single market, it yields more volatile export revenues than those from marine production.

Greater export revenue volatility, which can be measured by using standard deviation, implies a higher risk in profitability of exports. Growth of export revenues is also variable, either increasing or declining. The principle that it is better to have higher average growth of export revenues for the same risk, or less risk for the same growth, is actually well known from modern portfolio theory, according to which an investor optimises his wealth by constructing a portfolio which maximises the return for a given risk. However, this methodology is in many ways unsuitable for finding the most efficient mix of industries in an economy.[2] Nonetheless, the impact of increased aluminium production on export revenue volatility can be evaluated without using portfolio theory approaches if a suitable criterion can be found. The most obvious approach is to examine the standard deviation[3] of export revenues from fisheries and the aluminium industry, then weigh them together based on their share in export value in 2002. Páll Hardarson (1998) and others have rightly pointed out that it is probably more suitable to adjust measurements of volatility according to the size of the share accruing to domestic agents. The aluminium industry is easier to examine, since there are only two companies operating in the market. It may be assumed that

2. In order to find the efficient frontier, information is needed on the return and the standard deviation in return on a given asset, while in this case it is only available for price and not return. No utility function is available for the investor, who in this case is the nation as a whole. It is also a moot point whether this analogy has any real significance, since it is inefficient to control investment volume in each industry, which is effectively what an investor does when deciding which type of securities to invest in.

3. The standard deviation is divided by the mean to produce the coefficient of variation, which is a relative measure of dispersion.

roughly 40% of operating income is ultimately allocated domestically (wages and wage-related expenses, part of energy, part of other costs and duties), while 60% of operating income accrues to foreign agents (including alumina, anodes, pot repairs, profit and financial expenses). Corresponding figures for fisheries are more difficult establish, but the National Economic Institute customarily assumed a split of roughly one-third to foreign agents and roughly two-thirds to domestic agents. The specific items in the operating statements of these industries which are dependent on product prices also need to be assessed. In the case of aluminium companies, it is the power rate and taxes which change in pace with product prices and business profitability. In fisheries the corresponding items are profit, part of wages and taxes. Export value in 2002 is then weighted according to the respective share of each industry's export revenues that accrues to domestic agents.

As long as the prices of aluminium and marine products fluctuate in sufficiently different directions, the two industries can be weighed together to leave the volatility of total export revenues lower than the sum of their respective impacts. Applying two methods[4] to evaluate the covariance of time series revealed that in an economy which is engaged exclusively in export of marine products, the introduction of aluminium exports will dampen export revenue volatility – at first – until the share of aluminium has reached a certain level, when volatility will increase once more. A comparison of price series for fisheries and aluminium shows that Iceland has already passed the level at which aluminium dampens export revenue volatility. Assuming an unchanged correlation between prices of aluminium and marine products and insignificant changes in volume, an increase in aluminium production will amplify price volatility of export revenues. If the correlation between prices of aluminium and marine products remains unchanged, it can be ascertained that increased aluminium production will not reduce the volatility of export prices, but on the contrary exaggerate it. Iceland's aluminium production is already so large that it exceeds the threshold where stepping it up will stabilise export revenue volatility. Export revenues can be assumed to fluctuate by roughly 10-20% more if aluminium production is stepped up to 737,000 tpy, all things being equal.

The possible benefits of increased aluminium production have not been evaluated here. One frequent claim has been that it will act as a cyclical stabiliser for the Icelandic economy. Admittedly it will no doubt strengthen the economy through diversification. On the other hand, export revenue volatility will increase, contrary to what has sometimes been maintained.

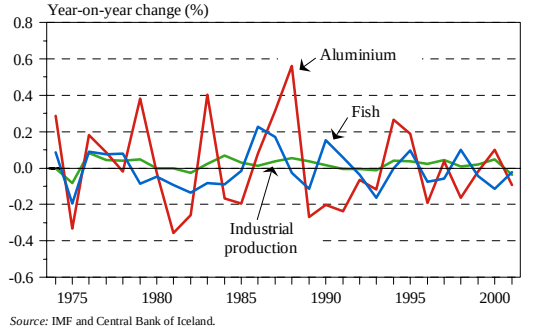
The relation of aluminium and fish products to the global cycle

Iceland's economy has tended to be more dependent on fisheries performance than on global developments. This has been changing in recent years, however, for reasons including the establishment of financial markets in Iceland. It is interesting to examine whether the effect of increased aluminium production will be to move Iceland even closer to the global community and bring its economic cycle more into line with events in neighbouring countries.

Chart 3 compares annualised price indices for marine products and aluminium with the index of industrial production in the industrialised countries,[5]

Chart 3

Prices of marine products and aluminium relative to industrial production in the industrialised countries 1974-2001



Source: IMF and Central Bank of Iceland.

4. The standard deviation of a time series can be calculated either as deviations from trend or a return. The disadvantage of calculating deviations from a trend is that the data still contain a unit root. Calculating a return eliminates the unit root, but some information from data could conceivably be lost. Both methods were applied for the sake of impartiality.

5. "Industrialised countries" refers here to Australia, Canada, Denmark, the euro region countries, Iceland, Japan, New Zealand, Norway, Switzerland, the UK and the USA.

which is used here as a reference for the global economic cycle. Aluminium prices turn out to show a much closer contemporaneous correlation with changes in industrial production compared with prices of marine products. This is hardly surprising, given that the main buyers of aluminium are manufacturers of durables, so that a global contraction would affect demand for it. Since prices of aluminium appear to be much more closely correlated to the global cycle than fish prices are, one probable effect of increased production would be that a decline in demand for durables abroad would be more strongly reflected in falling export value in Iceland. Accordingly, the Icelandic economy ought to become more closely synchronised with global trend.

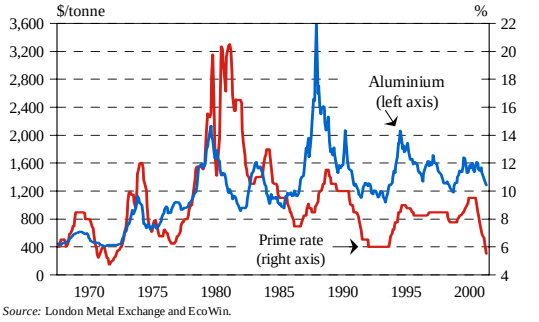
The correlation between aluminium prices and global interest rates

Landsvirkjun's investment in the Kárahnjúkar hydropower project is estimated at 95 b.kr. based on the exchange rate and prices in November 2002, and will be financed roughly three-quarters with loans, according to the Report to the owners of Landsvirkjun (2003). This investment is equivalent to around one-tenth of Iceland's gross national debt in September 2002. The agreement between Landsvirkjun and Fjarðaál stipulates that the power rate will be linked to world market prices for aluminium. It has been pointed out that the correlation between aluminium prices and interest rate reduces the interest rate risk that Landsvirkjun faces. If aluminium prices and interest rates fall at the same time, the company's contraction in revenues will be matched by lower expenses. In support of this view it has been pointed out that the daily spot price of aluminium and daily 6-month LIBOR rates are in close correlation, as Chart 4 indicates.

Since time series for 6-month LIBOR rates only go back to 1989, monthly aluminium prices can be compared with the monthly US corporate prime interest rate before then. Interestingly, Chart 5 shows that the correlation between interest rates and aluminium prices apparently holds over a longer period as well.

Chart 5

Spot price of aluminium and US prime rate 1968-2001

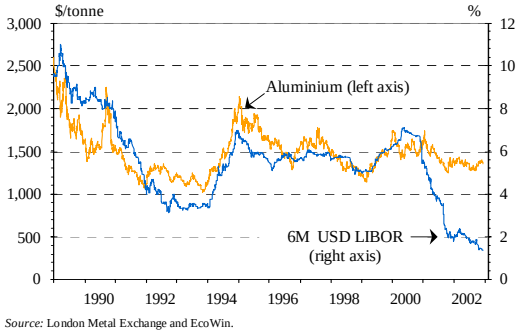


Source: London Metal Exchange and EcoWin.

Landsvirkjun's nominal debt service comprises a real interest rate and an expected inflation premium. A closer examination of the correlation between nominal interest rates and aluminium prices reveals

Chart 4

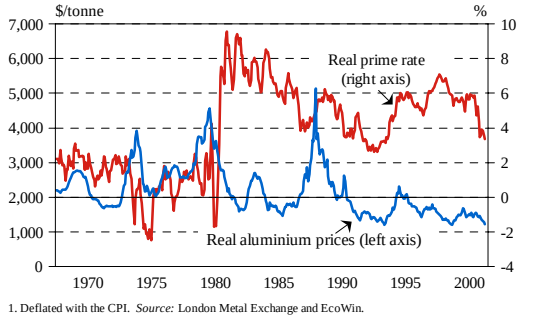
Spot price of aluminium on London Metal Exchange and 6-month USD LIBOR



Source: London Metal Exchange and EcoWin.

Chart 6

Spot price of aluminium in real terms and the US prime rate in real terms[1] 1968-2001

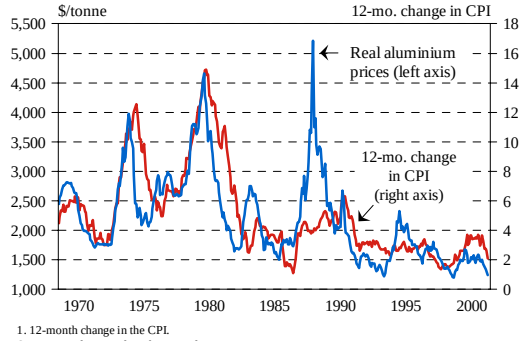


1. Deflated with the CPI. *Source:* London Metal Exchange and EcoWin.

that it is the inflation component which keeps pace with aluminium prices, rather than the interest component. Chart 6 shows that aluminium prices are not as obviously correlated with real interest rates as with nominal rates.

Chart 7

Real aluminium prices and inflation[1] 1968-2001



1. 12-month change in the CPI.
Source: London Metal Exchange and EcoWin.

Chart 7, on the other hand, shows the sharp correlation between real aluminium prices and the 12-month change in the consumer price index (CPI) in dollars.

The correlation between nominal interest rates and aluminium prices therefore reflects a correlation with price changes (for example consumer prices in dollars), and is not because aluminium prices keep pace with real interest rates. However, it is the correlation between nominal rates and aluminium prices that matters to Landsvirkjun, since debt service is made in nominal amounts. Thus changes in nominal interest rates pose less of a risk than could be expected, because aluminium prices alter in line with consumer prices.

Conclusion

Over the period until 2010, Iceland's aluminium production will increase from 267,000 to 737,000 tpy if current plans materialise.

This will mean a significant shift in the relative shares of export industries. Increased aluminium production has been described as a stabiliser which will put the economy on a stronger footing. Certainly it is better to spread risks by diversifying the export industry base, but there is also a risk of export revenue volatility.

While it is true that setting up aluminium smelters will act as an export revenue stabiliser at first, as the share of aluminium production grows it will fuel volatility again. Aluminium already accounts for a such a large proportion of export value that it has ceased to dampen export revenue volatility. Other things being equal, if aluminium production is stepped up to 737,000 tpy, this will amplify Iceland's export revenue volatility by roughly 10-20% compared with the current level.

The aluminium price index apparently correlates much more closely than the index for marine product prices with industrial production in the industrialised countries. This suggests that the global economic cycle will have more of an impact in Iceland than hitherto.

Historical data reveal some correlation between nominal interest rates and aluminium prices. If these aggregates remain in correlation in the future, Landsvirkjun's debt service and revenues from power sales to industry will be matched to some extent, thereby hedging some of its interest risk.

References

Hardarson, Páll (1998): "Mat á þjóðhagslegum áhrifum stóriðju á Íslandi 1966-1997" (*The macroeconomic impact of aluminium and ferro-silicon production and related investments in Iceland)*, *Fjármálatíðindi*, vol. 45 no. 2 1998, pp. 153-167. In Icelandic: http//www.sedlabanki.is/uploads/files/Ft98-2_7.pdf English summary: http//vefprofun.lv.is/Files/2002_10_15_macroec_impact_alumin.pdf

Ministry of Industry (1986), "Þjóðhagslegt mikilvægi stóriðju á Íslandi" (*The macroeconomic importance of the metals industry in Iceland)*, report by a committee under the auspices of the Minister of Industry.

Report to the owners of Landsvirkjun (2003): "*Arðsemi og áhætta Landsvirkjunar vegna Kárahnjúkavirkjunar*" (Landsvirkjun's return and risks in connection with the Kárahnjúkar hydropower project): http://www.karahnjukar.is/files/2003_1_7_ardsemi.pdf (in Icelandic only).

Vilhjálmsson, Jón (1983), "*Lausleg athugun á áhrifum raforkusamnings við ÍSAL á raforkuverð Landsvirkjunar til almenningsveitna*" (A broad study of the impact of the power agreement with ISAL on Landsvirkjun's electricity prices to the ordinary market), National Energy Authority of Iceland, 1983.