The effect of power-intensive industrial developments on the Icelandic economy

Report by Institute of Economic studies, University of Iceland

July 2009

IÐNAÐARRÁÐUNEYTIÐ

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Report No. C08:10

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Foreword

This report examines various aspects of the effect of power-intensive industrial developments on the Icelandic economy. It was prepared by Dr Daði Már Kristófersson, Dr Gunnar Haraldsson and Dr Sveinn Agnarsson, all Senior Researchers at the Institute of Economic Studies, and also Kristín Eiríksdóttir, an economist. In addition, I wish to thank Arnar Þ. Sveinsson, of the Economics Unit of the Ministry of Finance, for his contribution in the form of calculations derived from economic models. Dr Sigurður Jóhannesson, Senior Researcher at the Institute of Economic Studies and Ágúst F. Hafberg, Manager of Commercial Development and Communications at Norðurál Ltd, read the report over and made various useful comments. The report was prepared for the Ministry of Industry.

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Summary

This report examines various aspects of the macroeconomic and economic policy effects of power-intensive industry and related developments. An attempt is made to extrapolate and estimate what effect further power-intensive industrial projects would have on Iceland‘s economy and economic management.

First, attention is focussed on the development of power-intensive industry and its effects on the labour market in Iceland. Then an attempt is made to assess the macroeconomic implications of additional aluminium production. The report also examines the legislative framework applying to energy use; this discussion focuses on economic issues, not legal ones.

The principal findings of the report are as follows.

In the light of the relative bulk of power-intensive projects in the economy and the fact that Iceland has enjoyed almost full employment for most of its modern history, the macroeconomic benefits they confer depend greatly on their timing. If projects of this type are started during an inflationary period, the macroeconomic benefit may turn out to be small or negative, while it can be larger if they are begun during a slack period.

With easier access to foreign labour, the economic effect of heavy industrial development on the labour market is now smaller than it used to be. This means it is easier to make room for such projects on the labour market by importing foreign workers. On the other hand, the consequence of this is that the total number of persons in employment on the market now becomes larger due to large-scale industrial projects than used to be the case.

Although the share of power-intensive industry in the national economy has expanded greatly in recent decades, its countercyclical effects are great. Increased use of risk hedging by aluminium companies to offset fluctuations in the price of aluminium has also meant that the countercyclical effects of the sector have been undervalued.

The general indication is that it would be of macroeconomic benefit to embark on new power-intensive industrial development in the next few years. This is because a slack period is expected in the economy and activity of this type could be expected to be of benefit to the labour market. In view of the expected economic slack, it is probable that the crowding-out effect of such projects would be smaller than otherwise. Nonetheless, careful attention must

be given to the effects that investment in power-intensive industrial plants and power plants could have on the Icelandic króna (ISK) during the investment period.

It is important to assess the real cost of power-intensive industrial development. This can only be done by taking account of the economic value of the land and environment that is taken for the generation of electricity and production of aluminium. Risk must also be taken into account in cost calculations. The calculations in the present report do not take account of environmental values or risk.

In general, it is demanded of state-backed ventures that they involve less risk than private-enterprise ventures. Under private ownership, individual shareholders are able to sell their shares and so avoid risk. In view of the large share owned by public bodies in Iceland's power companies, it can be argues that the risk borne by the public in connection with their operation should be reduced. On way of doing this is by increasing the role of private entities in power generation, and from the point of view of stability it would be of benefit if foreign parties were to be involved to a greater extent in power generation and sales. This could be balanced by insisting that domestic parties owned a share in the power-intensive industrial plants to be built in the country.

As regards the long-term utilization of Iceland's energy resources, it is important to define the rights of the owners of the resources and land involved. Legislation on energy resources passed in spring 2008 includes provisions under which utilization of the reserves may be rented out. To ensure the macroeconomic efficiency of such utilization it must be ensured that the rental period is as long as possible and that it is possible to re-define the utilization potential.

Introduction

This report examines the size and nature of the role played by aluminium production and power-intensive industry in the Icelandic economy and the effect that heavy industrial development projects have on economic cycles. In view of the size of these investments relative to the economy as a whole, it is clear that decisions on further heavy industrial projects have an effect on the economic outlook, both in the short and the long term. The timing of further investments in this sector is also of crucial significance for economic management. Well-timed projects can curb economic cycles; poorly-timed one can add to macroeconomic instability. Attention has been drawn to this by foreign commentators on the Icelandic economy, including the OECD. It should be stated immediately that this report not only takes account of the past but seeks to look forward in time and examine the implications of additional aluminium production.

The first section examines the part played by aluminium and power-intensive industry in the Icelandic economy. Aluminium production in Iceland began in 1969 in Straumsvík, and it can certainly be said that much water has flowed under the bridge since then. The first aluminium smelter produced 33,000 tons of aluminium per year; total annual production capacity in the country is now about 791,000 tons. This immense expansion of aluminium production and the associated developments for generating the necessary electric power have had a profound effect on the Icelandic economy and economic policy. Economic cycles in Iceland were long driven by the fishing industry, but its importance as a proportion of the total has declined since the mid-twentieth century, and the same can be said of agriculture. Over the same period the importance of industry and other production has grown, with the largest role in this growth played by aluminium production and other power-intensive industries.

In the second section of the report, attention is given to the principal effects that heavy industry has on the labour market and employment trends in Iceland. Amongst other things, the timing of past developments is examined in the light of the consequences they had for the economy. The opening of the Icelandic labour market following participation in the European Economic Area has meant that launching such projects is now easier than it used to be because a large part of the workforce can be brought in from abroad. This applies particularly in periods of high economic demand when there would otherwise have been a danger that heavy-industry projects would drive wage increases on the labour market.

The third section discusses the effect that additional aluminium production would have on economic cycles. This discussion falls into two parts, one dealing with the overall effect on export earnings and the other on the possible crowding-out effect of additional aluminium production. Previous studies have argued that the countercyclical effect of additional aluminium production would be small, or even that it would amplify them. An attempt is made here to examine this question anew, and particularly to take account of the fact that power companies are making ever-greater use of risk hedging as regards the price of aluminium. The present examination reveals that the countercyclical effect of additional aluminium production on export values is far greater than was previously thought. On the other hand, it is pointed out that state involvement in electricity generation increases the risk to the nation of further development of the aluminium industry. This may be tackled by involving private entities in power development in future rather than having public bodies shoulder the entire risk. It would also be possible to reduce this risk exposure by having public bodies sell off their shares in power companies.

In the fourth section, attention is turned to the profitability of further heavy industrial development. Attention is drawn to the importance of evaluating the economic value of the land and environment which is altered by development, and methods that can be used for this purpose are discussed. There is also a discussion of the problems encountered in assessing the costs and benefits of large-scale industrial developments.

The fifth section discusses the legislative framework available to the government to direct heavy industrial development and the utilisation of Iceland's energy resources. Here, only the economic aspects of this framework are considered; legal issues lie outside its scope. It is pointed out that a clear definition of ownership rights is a prerequisite for being able to employ market forces to achieve a more efficient use of natural resources. Inevitably, power-intensive industrial projects will have various consequences for the environment. How these can be evaluated in monetary terms is discussed in the earlier sections. In this section, the focus is on various methods of reducing undesirable effects on the environment, e.g. by charging fees.

1. The share of aluminium production and other power-intensive industry in the Icelandic economy

Aluminium production in Iceland began in 1969 when the smelter in Straumsvík went on stream. To begin with, its annual production capacity was 33,000 tons; it has subsequently been enlarged to 185,000 tons. Two other smelters have been put into operation in recent years: one owned by Norðurál Century Aluminium at Grundartangi and one owned by Alcoa Fjarðaál in Reyðarfjörður, and total annual production capacity in Iceland is now nearly 800,000 tons. On 7 June 2008, the first sod was turned for the building of a new 360,000 ton smelter, owned by Norðurál, in Helguvík. This is to be built in four equal stages with a capacity of 90,000 tons each. The plan is that the first stage will go into production at the end of 2011, the second in 2012, the third in 2014 and the final stage in 2015. Rio Tinto Alcan is also planning to expand production at its smelter in Straumsvík by 40,000 tons, bringing it to 225,000 tons. Going by their applications for emission permits, it may also be expected that capacity at Fjarðaál's and Norðurál's smelters will also be expanded considerably. If all these planned expansions take place, it can be expected that total annual production capacity of the aluminium industry in Iceland will be of the order of 1,265,000 tons by 2015. In addition, Alcoa is working on an environmental impact study in connection with a new 360,000 ton smelter at Bakki, near Húsavík; this study should be complete in autumn 2009. However, no timing has been fixed for the construction of that smelter, and consequently this project is not included in Table 1-1, which shows capacity as it was in 2008, with forecasts for 2015.

Table 1-1 Aluminium production capacity in Iceland in 2008 and as planned for 2015, in thousands of tons.

			Increase	
	2008	2015	Thous. tons	%
Straumsvík	185	225	40	21.6
Grundartangi	260	300	40	15.4
Fjarðaál	346	380	34	9.8
Helguvík		360	360	
Samtals	791	1265	474	59.9

Source: Aluminium companies and Ministry of Industry.

World aluminium production came to about 40 m tons at the end of 2008, which means that Iceland's share was about 2.0%.[1] The global forecast for 2015 is about 55 m tons, making Iceland's expected share about 2.1%.

Power generation in Iceland is based on renewable energy sources in the form of hydropower and geothermal heat. The fact that electricity generated by these means is cheaper than when it is based on sources such as coal gives aluminium produced in Iceland an advantage as compared with that produced by competitors abroad. It must be pointed out, however, that this cost comparison does not take into account the value contained in the environment which may be spoiled or lost through the construction of aluminium smelters and associated power developments in Iceland. Opinion on the size of the monetary sums involved there is divided, since no studies of this aspect were carried out at the time of the construction projects in the past. Nevertheless it is clear that, generally speaking, Iceland's aluminium smelters are very environmentally-friendly, once they go into production, when compared with those elsewhere. The technology employed in aluminium production in Iceland involves the release of two types of pollutants. This occurs in the actual production process, on the one hand, and in the energy production process on the other. As has been mentioned above, the quantities released in the latter process are relatively small. Emissions from aluminium production is measured in the quantities of carbon dioxide (CO2) and polyfluorocarbons (PFC), which are converted into CO2 –equivalent units; these are expressed in relation to each ton of aluminium produced. On average, these releases are of the order of 10-12 tons per ton of aluminium produced; at the Alcan smelter in Straumsvík and the Norðurál smelter at Grundartangi, they are in the range of 1.4-1.7 tons. The reason for this huge difference is that normally, the pollution released in aluminium production and in the associated electrical generation is included in the overall figure, and most smelters run on electricity generated by the burning of coal, oil or gas.

For many decades, economic policy and discussion of economic aggregates in Iceland were dominated mainly by the fisheries sector. At that time, fisheries products formed the bulk of goods exports, and the landed fish catch and its export value were major determinants of economic cycles in the country. Over the past decade, the proportional importance of fishing in the economy has declined considerably, mainly due to the increased role of services and

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[1] See CRU International Ltd: The long term outlook for aluminium, 2008/09 Edition. London og McKinsey & Co, January 2009.

manufacturing. An examination of the trend in the value of goods exports over the past four decades reveals that the importance of fishing has declined, while that of aluminium has grown. Since 1969, when the aluminium smelter in Straumsvík went into production, the share of aluminium in goods exports has risen nearly five-fold, while that of fisheries products has fallen by almost half. In 2007, aluminium exports accounted for more than a quarter of total goods exports, by value, and in 2008 their value was greater than that of fisheries products for the first time. Table 1-2 shows a survey of the relative importance of aluminium and other export products from 1969 to 2008, broken down by period. Like fisheries products, agricultural exports have also declined greatly in importance over this time, while other manufactured goods besides aluminium have also grown in importance. These figures show clearly the great changes that have taken place in the economy and its production categories in recent decades.

Table 1-2 Goods exports, 1969-2008, by category.

	Average 1969-2008	Average 1969-1990	Average 1991-2000	Average 2001-2008	2007	2008
Aluminium	14.2	12.2	11.6	22.9	26.3	39.0
Fisheries products	70.2	74.6	73.4	54.2	41.8	36.7
Agricultural products	2.1	2.5	1.7	1.7	1.1	1.4
Manuf. other than alum.	10.3	9.0	9.8	14.4	12.6	13.1
Other goods	3.2	1.7	3.5	6.8	18.2	9.8

Source: Statistics Iceland.

Recent years have seen a substantial growth in the part played by services in exports, due largely to the rise in earnings from tourism. Table 1-3 shows the role played by the various occupation sectors in total exports (i.e. of goods and services) during the period 1969-2008. In this, aluminium’s share rose from 10% to 28%, while that of fisheries products fell from 49% to 26%.

Table 1-2 Exports of goods and services, 1969-2008, by category.

	Average 1969-2008	Average 1969-1990	Average 1991-2000	Average 2001-2008	2007	2008
Aluminium	9.7	8.6	8.0	15.1	17.8	27.8
Fisheries products	48.5	52.0	51.4	35.3	28.4	26.2
Agricultural products	1.5	1.7	1.2	1.1	0.8	1
Manuf. other than alum.	7.1	6.3	6.8	9.4	8.5	9.3
Other goods	2.2	1.2	2.5	4.5	12.3	7.0
Services	31.0	30.2	30.1	34.5	32.0	28.7

Source: Statistics Iceland.

The relative importance of export sectors in the economy is revealed more clearly when exports are shown as a proportion of GDP, as is done in Table 1-4. Goods exports counted for about a quarter of GDP in the period 1969-2009, on average. In 2007, aluminium exports counted for 6% and fisheries products for 10%. The following year, by contrast, aluminium had more than doubled, to 14%, while fisheries exports stood at 13%.

Table 1-3 Exports by category, 1969-2008 as proportions of GDP.

	Average 1969-2008	Average 1969-1990	Average 1991-2000	Average 2001-2008	2007	2008
Aluminium	3.6	3.1	2.7	5.8	6.3	14.1
Fisheries products	17.4	19.0	17.4	12.9	10.0	13.2
Agricultural products	0.5	0.6	0.4	0.4	0.3	0.5
Manuf. other than alum.	2.5	2.3	2.3	3.4	3.0	4.8
Other goods	0.8	0.4	0.9	1.5	4.3	2.2

Source: Statistics Iceland.

In recent years the OECD has drawn attention to the fact that a growth in the part played by aluminium exports in Iceland's economy could make the country too dependent on the export earnings it generates.[2] Thus, it is possible that aluminium industry could grow so large that it would increase the scale of economic cycles rather than reduce them by offsetting cycles in the fishing industry. If aluminium grows sufficiently as a proportion of the whole, then variations in its price on world markets could deepen the troughs and raise the peaks of economic cycles in Iceland.

1.1 Production decisions and input costs

Aluminium production involves the smelting of bauxite in special pots by electrolysis. To produce one ton of aluminium, two tons of bauxite are required, 0.4 tons of carbon and 14-14,500 kWh of electricity. The carbon takes the form of the anodes which are consumed in the course of production. Aluminium production is capital-intensive and also calls for specialised workers.

Production volume determines the quantities of input goods at any given time, but in the short term, production will always be dependent on the capital assets, i.e. buildings and equipment, available. Capital costs are independent of production volumes, and therefore remain constant

[2] See OECD (2006), pp. 27-30.

in the short term, but other production costs depend on production volumes and are therefore variable.

As aluminium production in Iceland is only a small part of the global total, it influences neither the world aluminium price nor that of bauxite, and the marginal cost[3] of aluminium production in terms of the price of bauxite is therefore constant. The price of electricity to the aluminium smelters in Iceland is fixed in long-term contracts, and is not made public. However, on the basis of the annual accounts of the power company Landsvirkjun it can be estimated that in recent years it has lain in the range 25-28 US mill per kWh.[4] For comparison, it may be mentioned that according to the World Bureau of Metal Statistics, the average price in the world in 2007 was 27 US mill per kWh. Thus, the price in Iceland would appear to be in the same range as that elsewhere, on average.[5]

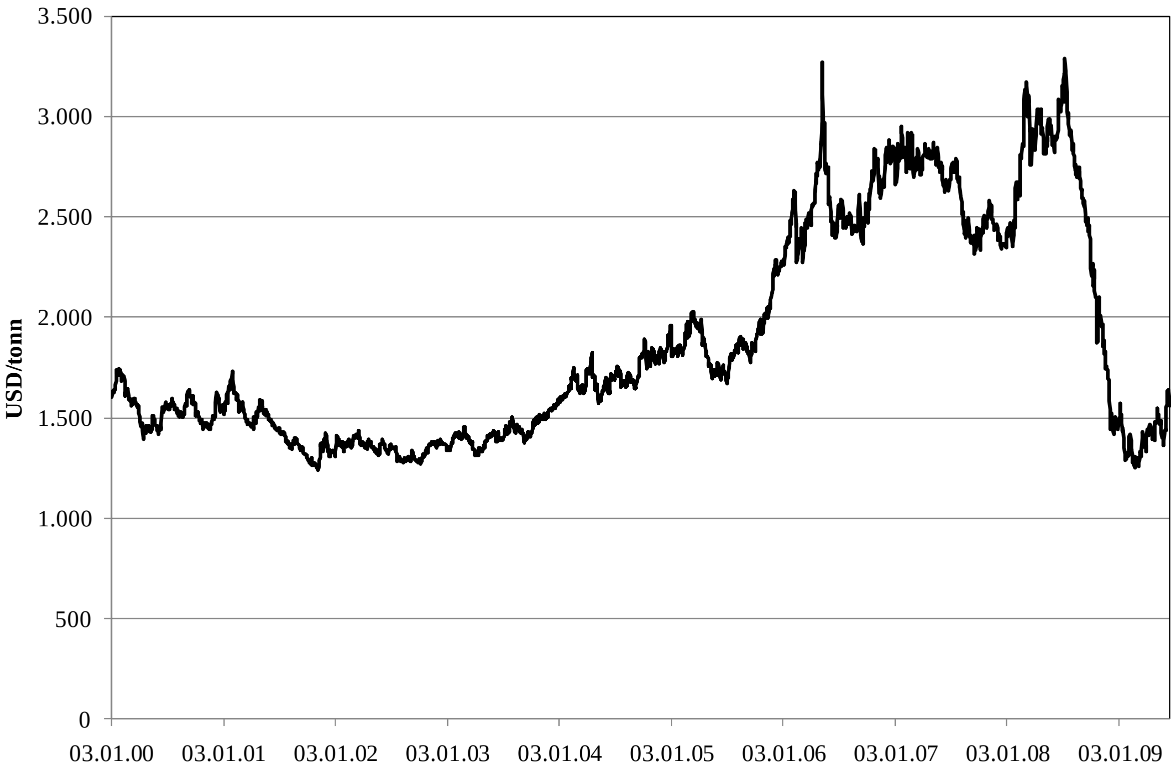

Fig 1-1 Price of aluminium on the world market from 1 January 2000 to 17 June 2009, in USD per ton.

Source: EcoWin.

[3] Marginal cost is the cost involved in the production of one unit of a product in addition to the volume being produced at any given time.
[4] One mill is one thousandth of a US dollar. A price of 25-28 mill therefore represents 2.5-2.8 US cents, or ISK 2.5-2.8, taking an exchange rate of USD 1 to ISK 100.
[5] See http://www.alunet.net/shownews.asp?ID=1957&type=3.

The price of electricity, per kWh, in domestic power-sales contracts, is directly linked to the world market price of aluminium as recorded by the London Metal Exchange (LME). As can be seen from Fig. 1, the price of aluminium was USD 1,400-1,700 per ton during 2000 and on into 2001, but fell in spring that year and remained around USD 1,250-1,400 until autumn 2003, when it began to rise again, climbing almost without interruption until it reached about USD 2,000 in March 2005. It began to rise again later that year, and remained high during the following years, though with considerable fluctuations. In July 2008 it reached USD 3,300 per ton. This was followed by a steep fall over the following months, reaching USD 1,280 in March 2009. It has risen again since then, reaching USD 1,560 per ton on 17 June 2009.

Domestic power-sales contracts also take account of the production capacity of the smelters and the cost of generating and distributing electricity. Thus, it can be assumed that the marginal cost of aluminium production in terms of electricity is constant.

Over the years, aluminium smelters in Iceland have generally paid higher wages than the minimum rates specified in collective agreements, and they have been sought-after as places of employment. Thus, they have had relatively easy access to labour, and have also succeeded in keeping their employees. It is probably fairly safe to assume that the marginal cost of aluminium production in terms of labour is also fairly constant, though rising rather than falling.

Since aluminium smelters' capital costs are extremely large, and all their other costs are fairly constant per unit of production, it is clear that the average cost must fall as production increases, or at least up to a certain point. The more a smelter produces with its capital, the lower the cost will be per unit produced. Aluminium producers will therefore choose to run their smelters at full capacity as long as the price on the world market is higher than the marginal cost[6] of production, even though the smelters are operated at a loss. This is because if the marginal cost is lower than the price of aluminium, the smelters will manage to pay all their variable costs and recover at least part of their fixed costs which they have to pay in any case in the short term. Thus, it pays for the smelters to produce as much as they possibly can, even though they run at a loss in the short term. On the other hand, aluminium producers will completely stop producing as soon as the price they obtain for their aluminium is not sufficient to meet the variable cost of producing each unit. Thus, they really only have a

[6] Strictly speaking, the reference here should be the variable cost per unit produced, but since it is assumed that the marginal cost of production is relatively constant, the outcome is the same.

choice between producing at full capacity and not producing at all. Consequently, fluctuations in production levels are rather small, and are accounted for primarily by setbacks in production, i.e. breakdowns, rather than by fluctuations in the price of their input materials or the product. World demand for aluminium has grown in recent years, but now there are signs that this will change, and a drop in demand can be expected over the coming year or two, and perhaps longer. However, there is presumably no reason not to expect a rise in demand in the longer term. In this connection it may be pointed out that in June 2009, the price in 27-month futures contracts on aluminium on the LME was considerably higher than that day's price. Lower demand will therefore increase the volume-related risk of Icelandic aluminium production to some extent, but this risk can be expected to remain relatively small as long as the aluminium smelters enjoy reasonable commercial terms as regards power prices and labour. Thus, the volume-related risk of the aluminium industry is small.

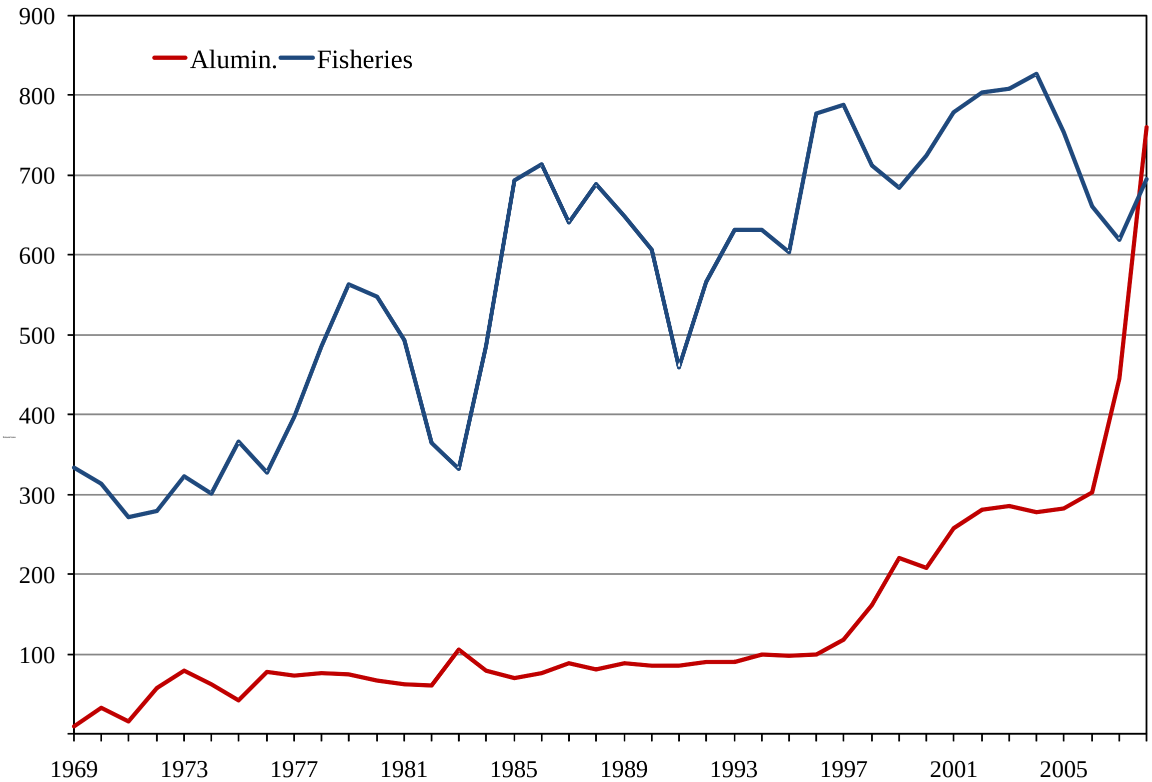

Fig. 1-2 Export volumes of fisheries products and aluminium, in thousands of tons, 1969-2008.
Source: Statistics Iceland.

The situation in the fishing industry, for example, is different. Fishing depends on conditions in the sea, over which man has limited control and − in contrast to the situation in the Icelandic aluminium industry − the fishing industry faces considerable volume-related risk in its operations. The catch landed varies from year to year, and the price on foreign markets can also fluctuate. This difference in production volume can be seen clearly in Fig. 1-2. Exports of fisheries products vary widely in volume, whereas aluminium exports have grown steadily, especially over the past ten years. If only the volume-related risk is taken into account, then aluminium production is far more stable than fishing.

1.1.1 Bauxite

All the bauxite used in aluminium production in Iceland is imported, most of it from the USA, Ireland, Australia and South and Central America. Bauxite imports have a negative effect on the balance of trade, offsetting in part the positive effects of aluminium exports. When examining the effect of aluminium on economic cycles in Iceland, it is necessary to take bauxite imports into account. Table 1.5 shows the direct effects of the industry on the balance of trade, i.e. the export value of aluminium less the import value of bauxite, as a proportion of GDP for the period 1972-2007.[7] This reveals that the effect is considerably less than appears if only the export value is examined, as was done in Table 1-3 above.

Table 1-4 Net effect of the aluminium industry on the balance of trade, 1972-2008. Percentage of GDP.

Average 1972-2008	2.7
Average 1972-1990	2.3
Average 1991-2000	2.0
Average 2001-2008	4.3
2007	4.6
2008	9.6

Source: Statistics Iceland.

Almost all bauxite produced in the world is used for aluminium production; consequently, demand for bauxite is directly related to world demand for aluminium. It is therefore interesting to examine the relationship between the price of aluminium and that of bauxite, as is done in Fig. 1-3, which shows changes in the price indices for the two in the period 1969-2007. The aluminium price index is obtained by correcting the export value for changes in the import price index; the bauxite price index is obtained by correcting the import value of bauxite for changes in the import price index. The base year for both indices is 1999. As can be seen from the figure, there is a positive correlation between the indices, and they appear to move closely in step. A rise in the world market price of aluminium results in an increase in the world market price of bauxite, and vice versa.

[7] Data on bauxite imports for the period 1969-1971 are incomplete.

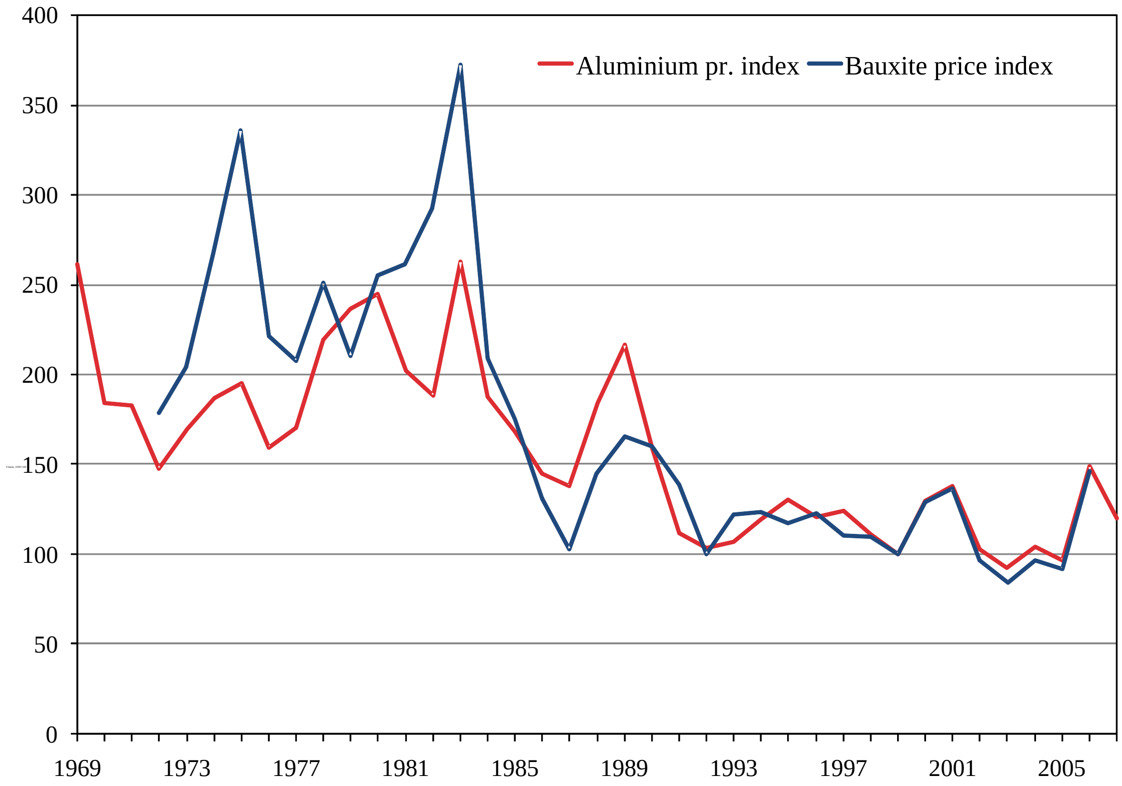

Fig. 1-3 Prices of aluminium and bauxite, 1969-2007. Index, 1999=100.

Source: Statistics Iceland.

1.1.2 Operational surplus at the aluminium smelters and its effect on the current account[8]

The balance of payments between countries is determined by transactions between domestic and foreign entities. It falls into two parts. On the one had there is the balance of trade, reflecting exports and imports of goods and services (the balance of goods and the balance of services), the balance of factor income and current transfers, and on the other hand there is the balance on the capital account, which shows the capital flows due to foreign assets and liabilities, i.e. direct investment, securities trading, other capital movements and changes in the foreign currency reserves of the Central Bank. Factor income includes wages and income on investment between countries, which in turn is determined by appreciation of share capital, dividend payments and reinvestments of profit in the form of direct investment, and interest on debt instruments and loans.

Thus, aluminium exports and bauxite imports appear in the balance of trade between countries. In times of prosperity for the aluminium smelters, when their operations result in

[8] It should be noted that the relationship between the economic concepts discussed here is shown in Appendix I.

profit, this profit for the most part flows out of the country to their foreign owners, as dividend on the one hand and as profit on the other.[9] Dividend payments appear in the balance of factor income, and therefore also in the balance of trade, while profit appears in the capital balance. Since both transfers involve payments to foreign entities, they would militate against the beneficial effect of aluminium on the balance of trade. If, on the other hand, there are losses in the aluminium industry, this result in no payment of profit being made to the foreign owners, and the owners may even have to increase their capital contribution to the operations. This inflow of capital would appear as a positive element on the capital account, so having a positive effect on the balance of payments.

In general discussion, attention is usually directed only to how large part aluminium constitutes of total goods exports or of GDP. To obtain a fuller picture of the share of aluminium exports in GDP, it is necessary to take account both of the imported input goods used in aluminium production and of dividend payments.[10] Fig. 1-4 presents a comparison of the value of aluminium exports, their net effect on the balance of trade and their net effect on the current account for the period 1997 to 2006. The top line shows only aluminium exports as a proportion of GDP; the middle line shows their net effect on the current account (i.e. the value of aluminium exports less the value of bauxite imports) as a proportion of GDP, and the bottom line shows their effect on the current account, also as a proportion of GDP. This takes into account both bauxite imports and dividend payments. It appears clearly that it can be misleading to consider only the value of exported aluminium when discussing the effect of the aluminium industry on the Icelandic economy, since the effects are found to be far smaller when the overall effect on the balance of trade and the current account are examined. This means that the tendency of aluminium exports to accentuate cycles in GDP are smaller when the industry is viewed comprehensively and it is recognized that it utilises imported raw materials and that dividend payments are made to foreign entities. Thus, foreign ownership of the aluminium smelters in Iceland reduces economic cycles. If the smelters were partly or entirely Icelandic-owned, then Icelanders would receive these dividend payments, making the balance of trade more favourable than when they are foreign-owned, but the other side of this is that the countercyclical effects of aluminium exports would be smaller. Further discussion

[9] Data from the Central Bank of Iceland and Statistics Iceland show that the majority of the profits of the Icelandic aluminium companies go to their foreign owners in the form of dividend. Nevertheless, some of the profits are also used for maintenance and investment in the smelters themselves.
[10] No account is taken here of transfers of profits, other than in the form of dividend, to foreign parties.

of this point is to be found in the third section of this report, where the focus is specifically on the effects of a possible expansion of aluminium production on cycles in the economy.

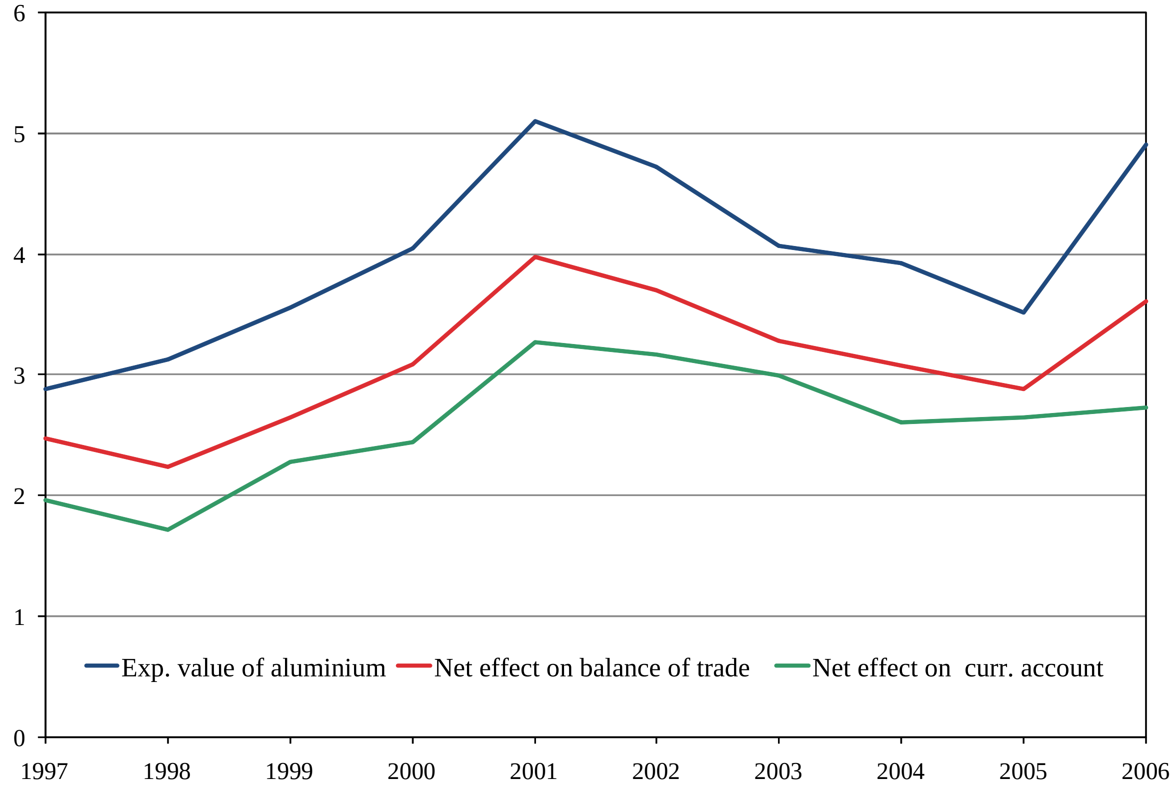

Fig. 1-4 The effect of the aluminium industry on the value of exports, the balance of trade and the current account, as proportions of GDP, 1997-2006.

Source: Statistics Iceland.

1.2 The effect of fluctuations in the exchange rate, the price of aluminium and the price of electric power

In view of the key role of electricity in aluminium production, it is important for the owners of the smelters to obtain it at the lowest possible price, and also that the supply be reliable. Similarly, it is important for the owners of the power plants that the electricity price should be sufficiently high. In Iceland it has become an established practice to link the contracted price of electricity to the world market price of aluminium, denominated in US dollars; in this way, part of the aluminium companies' price-related risk is shifted from the smelters to the power plants.

All major power companies in Iceland are wholly owned by the state or the local authorities, with the exception of HS Orka hf. and HS Veitur hf.; Geysir Green Energy owns a 32% share in these companies.[11] As is the case with many other enterprises, the directors of the power companies strive to achieve good operating results and to reduce fluctuations in performance figures. This requirement is perhaps even more stringent in the case of these companies since they are overwhelmingly in public ownership. Three Icelandic power companies are now operated as limited companies: Rarik ohf., HS Orka hf. and HS Veitur hf.; Reykjavík Energy (Orkuveita Reykjavíkur) is a partnership.

Power-development projects are normally financed with loans, particularly foreign loans, repayment of which is warranted, directly or indirectly, by the state or the local authorities. Projects of this type are always on a large scale, so capital costs often represent a large part of the expense involved, and changes in overseas interest rates have a substantial effect on the performance figures of these companies. As is stated above, electricity prices tend to be linked to the price of the product in US dollars, so changes in the world market price and the exchange rate of the ISK are of great importance regarding performance by the power companies.

To cope with the risk represented by the linking of power prices to the price of aluminium, the exchange-rate risk involved in the ISK and the risk posed by interest rates on loan capital, the power companies have increasingly made use of derivative contracts. These are financial instruments that have a monetary value which is determined by the price of the underlying assets on the market. Derivative contracts are an effective means of controlling risk, and can also be used for hedging and reducing risk in business deals. The main types of derivative contracts are forwards, futures, swaps and options. A detailed discussion of derivative contracts is to be found in Appendix II.

The main risk faced by the aluminium companies lies in the possibility that the world price for the metal will decline in the future. One way they are able to limit their price-related risk is by purchasing future sales contracts, or sale rights, for their aluminium on the London Metals Exchange (LME). In this way they can fix the current price and have it apply in the future. If the market price rises above that price, the power company will lose on a future sales contract, but would profit if the day's price were the reference point; the reverse will be

[11] Hitaveita Suðurnesja hf. was split into two companies, HS Orka hf and HS Veitur hf., in 2008.

the case in the event of a drop in the market price. Efficient risk control related to the price of aluminium therefore makes it possible for companies to reduce their price-related risk. Landsvirkjun, which is the largest company serving the power-intensive industrial sector in Iceland, is authorised to cover 100% of its price-related risk next year by derivative contracts. The authorisation to employ this type of cover will then be reduced as time passes; the company is permitted to cover only 10% of its total risk related to the price of aluminium over the next six operating years.[12] Notwithstanding the use of such protective covers, it is clear that the underlying price-related risk to the Icelandic economy will increase as the number of smelters grows and their production capacity expands.

Power companies and aluminium companies also face considerable exchange-rate risk.[13] There are two aspects to this risk. Firstly, company performance is threatened by the fact that the power supply contracts used in the aluminium industry are linked to the world aluminium price, expressed in US dollars. Thus, the exchange rate is a further risk factor on top of the risk associated with the aluminium price described above. Part of the companies' operating costs (i.e. payroll costs) is, by contrast, in ISK, though these constitute only a small part of the power companies' total costs. The second aspect of this risk for the power companies is that the investments, i.e. the power-plant and the aluminium-smelter construction projects, are financed mostly by foreign loans. The principal of these loans, the amount of the instalments paid on them and the interest charges, in ISK, are determined solely by the exchange rate of the ISK vis-à-vis the currencies in which they were taken. A stronger ISK will make it less expensive for the companies to pay off their loans; a weaker ISK makes it more expensive. If the loans are in the same currency as the price of aluminium, which is normally USD, then a certain balance is guaranteed between earnings and financial items. On the other hand, the companies face risk regarding domestic operating costs, and may have to enter in their books considerable exchange-rate losses on the loans when the ISK weakens, providing that they keep their accounts in ISK. To reduce exchange-rate risk, they can make use of exchange-rate swap agreements, and also forward contracts and options on the exchange rate of the USD and other foreign currencies on the international markets.

Interest-related risk is also an aspect of the operations of these companies. If interest rates come down in the future but the interest on the loans they have taken are fixed, then the

[12] Annual accounts of Landsvirkjun for 2007.
[13] Since Landsvirkjun keeps its accounts in USD, its risk is less than that of the other power companies. The others are also permitted to keep accounts in USD.

companies will bear a greater interest burden on their loans than the rates on offer on the markets. Nor does interest-rate risk disappear if the companies take loans with variable interest. The interest risk involved in liabilities with floating, or variable, interest is that the interest may go up in the future, so the companies will bear higher payment burdens on their loans than they do at present. To reduce the interest-related risks to their operations, power companies are able to use interest-rate swap contract through the agency of domestic and foreign finance companies.

Mention may also be made of construction-related risk, i.e. the risk that construction projects will prove to be more expensive than estimated. If the ISK is strong against the USD during the construction phase, then the project will be more expensive if it is calculated in USD.

Icelandic power companies have sometimes been criticised because of the effect that derivative contracts have on their performance; these contracts have resulted in losses in recent years. As has been stated above, however, a loss on a derivative contract does not mean that the act of entering into the contract has led to the loss, but rather that the company has not enjoyed the benefit of the protective mechanism in the contract. The price of aluminium, for example, may have risen by more than was expected, with the result that the company did not receive as much for its products as was being offered on the market. An examination of the annual accounts of the companies shows that the companies use these contracts as a means of risk management, as they are obliged to do vis-à-vis their owners, and not in order to take risk. Thus, the power companies use active measures against exchange-rate risk to reduce the effects of cycles in the aluminium industry in Iceland. They also constantly re-finance their operations, presumably paying off their old loans when it suits them in the process. When they make a profit they pay their loans off more quickly than otherwise. This has a negative effect on the capital account, and hence on the balance of payments, and overall a slight countercyclical effect on the economy. Compared with enterprises in the fisheries, power companies and aluminium companies have a wider range of hedging mechanisms available to them. There is no such thing as a derivative contract with fisheries products as the underlying asset, and never will be. In the light of this, and the volume-related risks involved in the fishing industry, it is clear that the fisheries exert considerably greater cycle-enhancing effects on the economy than does the aluminium industry, or at least after the smelters go into production. Since international financial reporting standards were introduced, the value of derivative contracts is now entered in the accounts, so the annual accounts of the power companies now give a clearer picture of their real performance than they used to.

The first legislation on Landsvirkjun, the Act No. 59/1965, contained a provision stating that power-sales contracts to heavy industry were not to result in the price of electricity to the public becoming higher than would otherwise be the case. This principle was reiterated in the Act No. 42/1983, but it was dropped from the Act No. 154/2006. There has been considerable controversy as to whether this provision was ever observed; it is difficult to assess whether the wholesale price at which Landsvirkjun sells electricity to the power utilities has, over the years, been more advantageous than that which would have applied had the company gone about its power-generation activities in another way and based its development programmes solely on the needs of the ordinary consumer market, for example.

There can be no disputing that hydropower generation evidently results in economies of scale, the larger the plant, the cheaper the electricity generated, other things being equal. The same applies to distribution of electric power: the fixed price per kWh falls as more electricity is carried over the system. Large power plants also offer the possibility of establishing larger and more secure distribution systems than would otherwise be possible. It is also obvious that it is more convenient to produce electric power for power-intensive industry, which always consumes the same amount, rather than for smaller enterprises and homes where consumption may vary greatly, both over the day and over the year. The term of contracts made with power-intensive industrial enterprises is long: 20 years or more. They purchase electric power in great quantities, and their utilisation time is very high: about 95% or more. In addition, these purchasers commit themselves to pay for a certain minimum amount of electricity each year, irrespective of whether or not they actually use it. For these reasons, the marginal costs involved in generating electric power for heavy industry may be different from those involved in generation for smaller consumers.

Right down to 1999, Landsvirkjun's principle was that the contracted price of power to heavy industry was not to be lower than the marginal cost in the long term. Landsvirkjun has also named the marginal cost the 'bringing forward' cost ('flýtingarkostnaður') as it must take into account the additional cost of bringing forward the construction of new power plants when a new power-intensive industrial concern is established. Under such circumstances, the company's operational and capital costs rise, so power sales to the industry must bear these additional costs. Landsvirkjun's marginal costs included both the generation and the distribution of the electric power, to the extent that new distribution structures were required. In those sales contracts that have subsequently been concluded with heavy industrial projects, on the other hand, the arrangement has been that they pay the average cost of power generation and all the costs of modifications to the distribution system, or else that the power price covered the entire construction cost, both as regards harnessing and distribution.

A study carried out in 1983 revealed that the public electricity utilities had from the outset derived undisputed benefit from the power-development projects that were undertaken for the aluminium smelter in Straumsvík.[14] The findings of the study indicated that the utilities would have paid more for electricity, at current prices, if the smelter and the associated power plants had not been built. However, it was found that electricity prices at the end of the 1970s and beginning of the 1980s was higher than it would have been without the aluminium smelter. Páll Harðarson (1998) also concluded that the power-intensive industry policy had improved the position of the ordinary consumer. In opposition to this, it has been pointed out that as the price of electricity to heavy industry is normally bound in long-term contracts, the public may have to shoulder burdens resulting, for example, from mistakes in investment.[15] But without further information on the cost of producing electricity for power-intensive industry, on the one hand, and for the ordinary consumer, on the other, and the price paid for it, it is impossible to say whether the public has benefited from the power-intensive industrial policy of recent decades or subsidised the power sold to these industrial plants.

There has been a substantial increase in electricity consumption by aluminium smelters in Iceland; there are now more of them and their production capacity has risen. By contrast, consumption by households has been relatively constant, following changes in the number of households in the country over the past decade or so, as is shown in Fig. 1-5.

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[14] See Jón Vilhjálmsson (1983): Lausleg athugun á áhrifum raforkusamningsins við ÍSAL á raforkuverð Landsvirkjunar til almenningsrafveitna. Reykjavík: Orkustofnun.

[15] See the discussion in Sigurður Jóhannesson (2008).

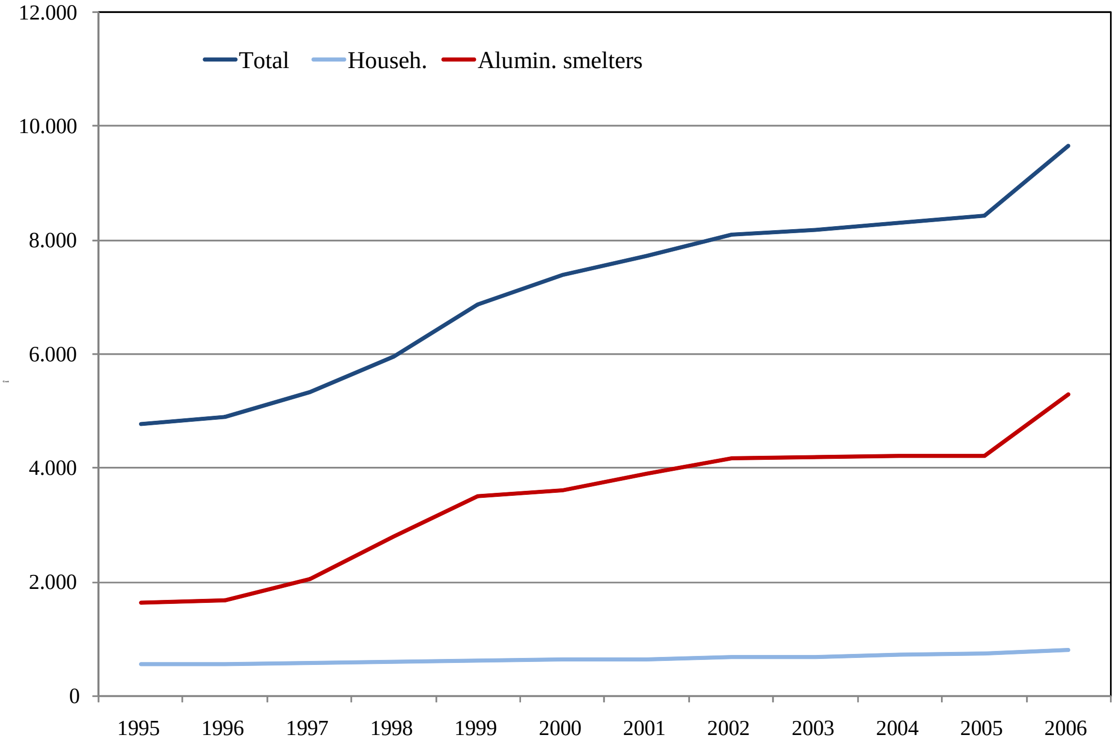

Fig. 1-5 Electricity consumption, 1995-2006.

Source: Orkustofnun.

An examination of the prices charged for electricity supplied to households in Iceland in the period 1980-2006, based on the price-level of 2007, reveals that the hugely increased consumption by the aluminium industry did not result in an increase to household consumers during the period (see Fig. 1-6).

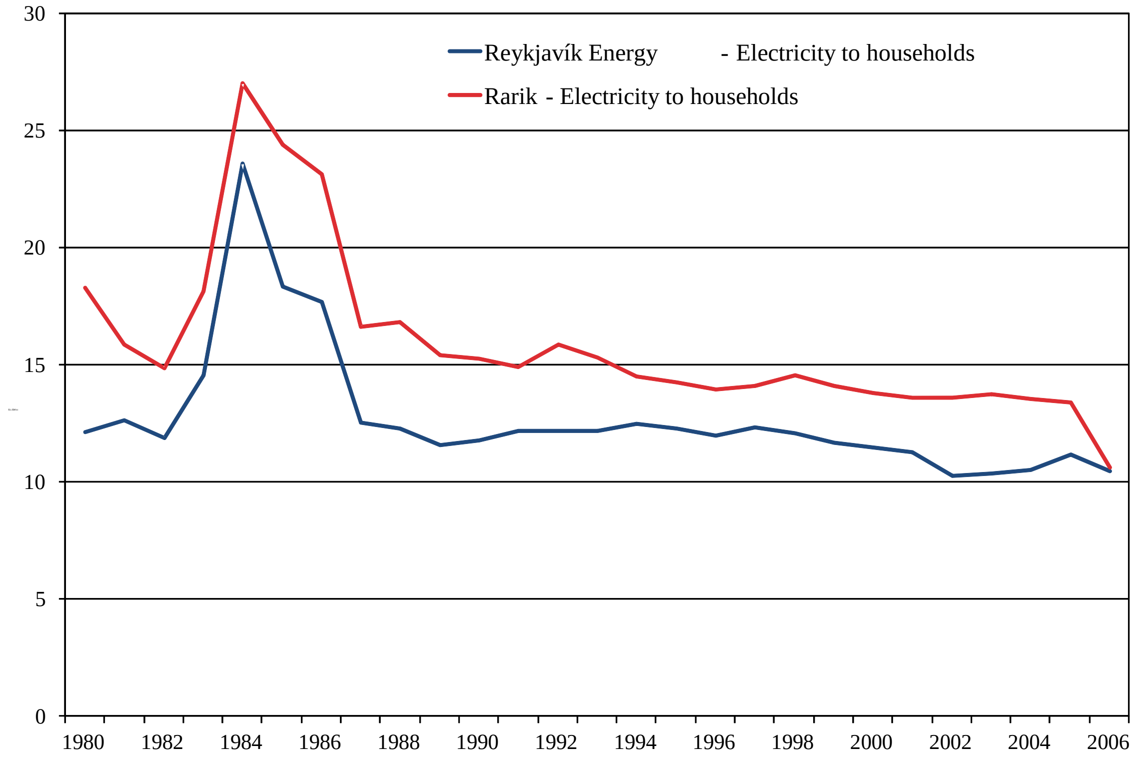

Fig. 1-6 Price of electricity to Icelandic households, at price-level of 2007[16].

Source: Statistics Iceland.

The Act No. 65/2003 introduced an important change in the Icelandic electricity market, making a distinction between electricity generation, transport, distribution and sales of electricity. It was decided to establish a single distribution company, Landsnet; Orkustofnun was entrusted with setting it earnings limits in connection with the cost of distributing electric power to the secondary distribution utilities, on the one hand, and to power-intensive industrial plants on the other. In setting these earnings limits, it was to be assessed whether access by large-scale consumers would lead, or had led, to more efficient development and utilisation of the system than would otherwise be the case.

1.3 Summary

The rapid development of power-intensive industry has changed the Icelandic economy. As aluminium exports have increased, the relative importance of other export industries has diminished. There is every indication that notwithstanding the increased importance of aluminium exports, they nevertheless have a countercyclical rather than a cycle-enhancing effect on the economy. The power companies have effectively used financial hedging mechanisms to reduce their interest-rate and exchange-rate risks. By employing active hedging methods they are able to reduce the extent of cycles in the economy resulting from heavy industrial projects. Earlier studies of electricity pricing do not indicate that the public has subsidised electricity supplies to power-intensive industry, even though such a situation may have occurred in a few isolated years around 1980. Because electricity prices to power-intensive industry are bound in long-term contracts, however, there is a danger that other consumers will have to meet the costs resulting, for example, from wrong investment decisions. Without further information on the costs charged to the power-intensive industries and the marginal costs involved in electricity generation for these industries and for the ordinary consumer, it is not possible to say whether electricity sold to power-intensive industries has been subsidised. Increased sales of electricity in recent years have not resulted in higher prices to smaller consumers. The price of aluminium, on the other hand, has risen again in recent months following a very large drop in the preceding months, and forecasts

[16] Based on changes in the consumer price index.

allow for a further rise in demand for aluminium in the coming years, with further price increases.

2. Effects on the Icelandic economy

Large-scale construction projects such as the building of an aluminium smelter and the associated power developments can have a substantial effect on the Icelandic economy during not only during the investment phase but also during the smelter's operational phase. The principal focus in this discussion will be on the 'crowding-out' effect; attention will also be given to the effect on the exchange rate during the construction period. Consideration is first given to the effect in a time of full employment, as has generally been the situation in Iceland in past decades, and then to the difference made if there is unemployment.

2.1 *Interest and exchange rates*

In a closed economic system, increased demand for credit can be expected to drive domestic interest rates up. In an open economy, where the investments concerned are partly or entirely financed with foreign loans, the situation may be different. Under such circumstances, the crowding-out effect on domestic interest rates may be little or none. On the other hand, a greater inflow of foreign capital strengthens the exchange rate of the currency in use in the economy if this is a floating exchange rate. Irrespective of whether the investments are finances with domestic or foreign credit, it can be expected that they will increase inflationary demand in the economic system, and that it will therefore prove necessary to raise interest rates.

Investment in heavy industry and power generation in Iceland has for the most part been financed with foreign loan capital. It may therefore be expected that the crowding-out effect on the domestic credit market has not been great. The impact on the exchange rate, on the other hand, may be greater and more complex. It is important to bear in mind here that when large-scale projects such as aluminium smelters are undertaken, every stage of the timing is known in advance. The investment phase and the total volume, and even the breakdown of investments each year, are all known, which opens up various possibilities for investors. Traditional crowding-out effects mean that a stronger ISK will reduce the competitiveness of Iceland's exporting and competitive industries. It has been pointed out that this could reduce the scope that other occupational sectors have to grow and develop, not least in the case of those which, in some cases, might have generated greater added value than heavy industry does, and perhaps grown more quickly.[17] If, in addition to this, it is expected that the investments will keep the exchange rate of the ISK high and relatively stable, then Icelandic entities may become more interested in taking foreign loans, and foreign currency-buyers will be more interested in investing in the Icelandic króna. Admittedly, this depends on there being a sufficient interest differential between Iceland and other countries; in expansionary periods, such a differential may be formed if monetary measures are taken to avoid overheating of the economy. The development projects themselves encourage expansion, and it is necessary to raise interest rates in order to dampen down this tendency unless other measures are taken elsewhere in the economy to make room for the addition of the projects.

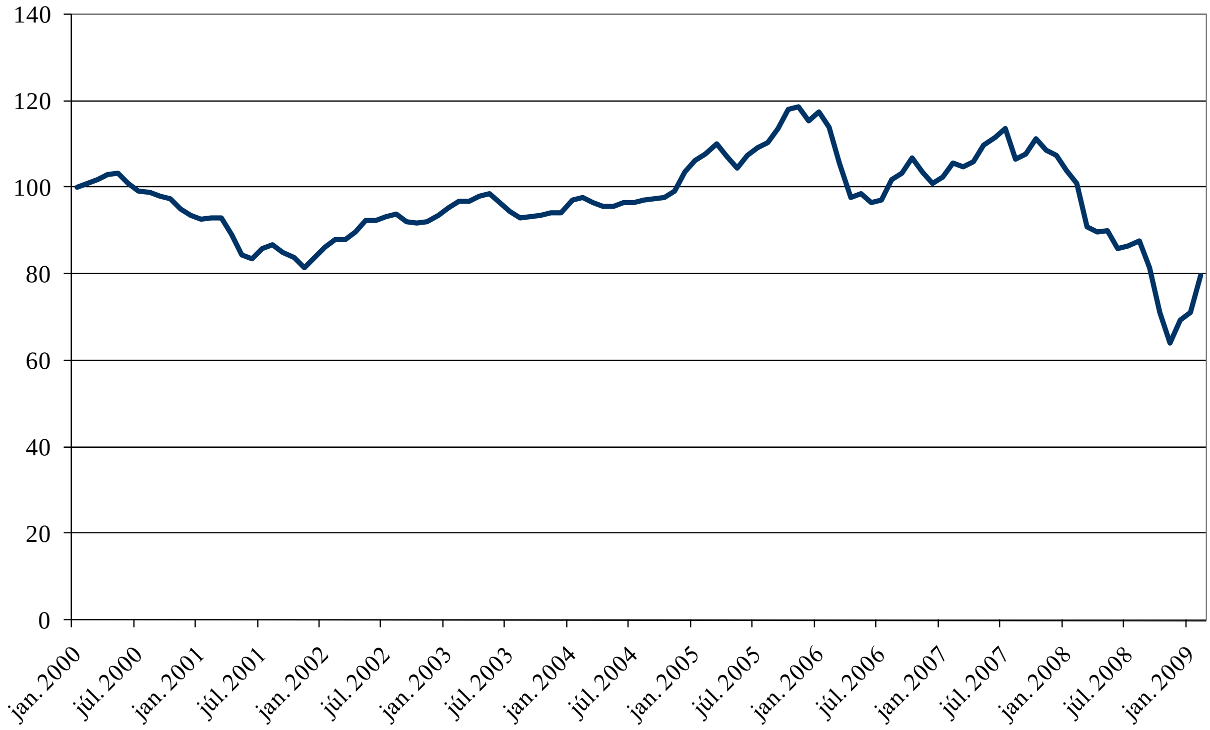

Fig. 2-1 Real exchange rate of the Icelandic króna, 2000-2009. Index, January 2000=100.

Source: Central Bank of Iceland.

These were precisely the conditions that came into being in Iceland in the years 2003-2007. It was credible that the króna would remain strong while the construction projects in the east of the country were in progress, and consequently that there would be relatively little risk involved in taking foreign loans over the short term, e.g. to cover the purchase of consumer durables. It probably would have been imprudent, on the other hand, to have allowed for as much slack in government economic policy as actually proved to be the case and that the

[17] Gylfi Zoëga (2008).

brunt of anti-inflationary measures would therefore be borne by monetary policy. However, this is what happened, and the result was that interest rates in Iceland were much higher than they were abroad. It must also be stated that the situation in the global economy at this time was rather unusual. Interest rates were at an historical low; access to capital was easy, asset appreciation was substantial and demand and private consumption were high. All these things added to expansionary demand in Iceland: foreign credit flowed into the country, which in turn made the ISK still stronger and made foreign borrowing an even more attractive option. While no assessment will be made here as to how great a part of the upswing of these times can be attributed to heavy industrial and power development, it is obvious that the fact that these projects were so clearly circumscribed in terms of timing presented various opportunities which domestic entities were able to take advantage of regarding the taking of foreign loans, at the same time opening up certain possibilities for foreign investors.

2.2 The labour market

2.2.1 Short-term effects

Large, labour-intensive projects can have a considerable impact on a small labour market like that of Iceland. Demand for labour increases, and with a high level of employment (i.e. low unemployment) it is only possible to meet this additional demand by means of additional participation in employment, longer working hours, or else by workers moving from other enterprises, or by the importing of workers. These imported workers then either man the new positions or take over the jobs held by those who have changed job. Otherwise there is the danger that increased demand will drive wages on the labour market up with the result that the construction projects wipe out other, more poorly-paid jobs. The situation is different when there is unemployment; then it is more likely that it will be possible to embark on major projects without wages rising and other jobs being lost.

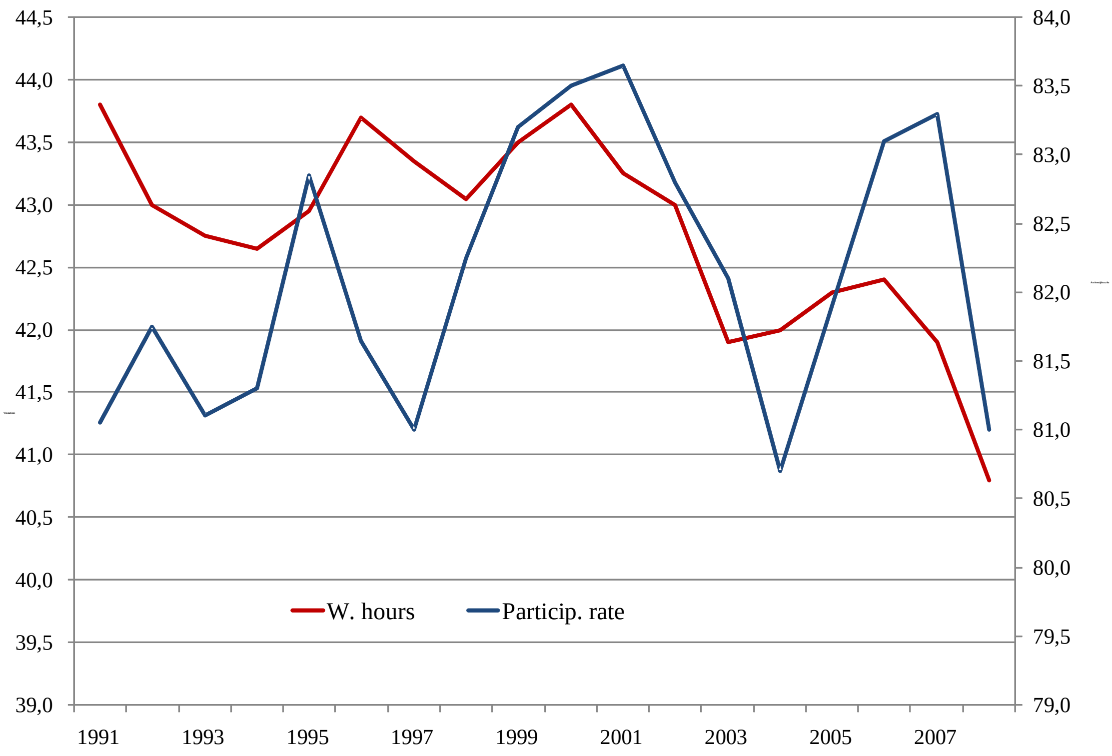

Fig. 2-2 Employment participation rate and working hours, 1991-2008.

Source: Statistics Iceland.

As can be seen in Fig. 2-2, the employment participation rate was in the range 81-83% during the period 1991-2008, which was the highest level recorded within the OECD. On the other hand, studies do not indicate that there was any unequivocal correlation during this period between this rate and economic cycles.[18] Working time, on the other hand, appears generally to have shortened in recent years. According to surveys by Statistics Iceland, it was about 44 hours per week in 2000 and just under 42 hours in 2008. Thus, the trends in employment participation and working time in the most recent years scarcely indicate that there was much slack in the labour market to absorb the new jobs that have been created through power-intensive industrial developments recently. Without importing labour it would therefore scarcely have been possible to man these jobs unless by transferring workers between jobs. However, there has been a substantial increase in the number of foreign workers on the Icelandic labour market in recent years. Figures from Statistics Iceland show that there were about 3,400 foreign nationals working in Iceland in 1998; by 2005 the number had risen to over 9,000. That year, the Directorate of Labour issued nearly 6,400 work permits; the number rose to 10,200 in 2006 and to 10,700 the following year. The number of work

[18] Gunnar Haraldsson, Gylfi Zoëga, Sigurður Jóhannesson og Sveinn Agnarsson (2007).

permits issued in 2008 dropped in 2008 to about 6,000. The total number of workers on the labour market (i.e. both employed and unemployed) rose by 13.4% in the period 2003-2008, from162,400 in the first year to 184,000 in the last. The Directorate of Labour estimates that 10-11,000 foreign workers were still active on the Icelandic labour market at the change of year 2008-2009.

The rise in the number of foreign workers on the labour market reduced wage pressure on that part of the market on which they were active. There is no doubt that their appearance on the market resulted in smaller wage increases than otherwise would have taken place, and consequently in a small rise in general price levels.

Some of these foreign workers took jobs that fell free when other workers, foreign and Icelandic, were taken on by Norðurál and Fjarðaál and in related activities in recent years. If they settle in the country and continue to be active on the labour market, the conclusion will be that the developments of recent years in the aluminium industry have resulted in an expansion of the Icelandic labour market, with a higher rate of economic growth than would have taken place without these projects. However, it is too early to say how great the growth effect may have been, since satisfactory data is not yet available.

2.2.2 Long-term effects

Wages in heavy-industrial production plants are generally higher than those offered for other comparable jobs, as can be seen from Table 2-1, where average earnings from worker's main occupations are compared with estimated annual salaries in aluminium production industry for 2005; more recent figures are not available. Data from Statistics Iceland on average employment earnings are used for all occupational sectors except aluminium production; Statistics Iceland does not publish such a finely-categorised breakdown within sectors. Instead, the number of workers employed in the aluminium smelters in 2005 was estimated, and production-based figures from Statistics Iceland regarding sectoral wage costs were used to estimate average wages in the aluminium industry. Assuming that 800-900 people worked in the aluminium smelters in 2005, it can be estimated that their average annual wages were ISK 3,950,000 - 4,450,000. For comparison, the average wage for Iceland as a whole was just under ISK 3,000,000. According to this, wages in the aluminium smelters were 33-50% higher than average wages in the country as a whole.

Table 2-1 Average wages in main employment in Iceland, 2005. ISK thousands.

		Prop. of wages in alum. ind.	
	Av. wage	Lágt mat	Hátt mat
Agriculture	1,000	0.25	0.22
Fishing	4,400	1.11	0.99
Fish processing	3,160	0.80	0.71
Industry other than fish processing	3,100	0.78	0.70
Aluminium prod., low estimate	3,950	1.00	
Aluminium prod., high estimate	4,450		1.00
Power utilities	4,300	1.09	0.97
Construction	2,940	0.74	0.66
Commerce, office and certain repair trades	2,620	0.66	0.59
Hotel and catering	1,750	0.44	0.39
Communications and transport	3,140	0.79	0.71
Financial services	5,120	1.30	1.15
Real-estate and business services	3,590	0.91	0.81
Public administration	3,180	0.81	0.71
Education	3,040	0.77	0.68
Health and social services	2,380	0.60	0.53
Other services	2,350	0.59	0.53
All occupational sectors	2,950	0.75	0.66

Sources: Statistics Iceland and authors' own calculations.

This comparison may be unfair, however. Firstly, it should be stated that wages for the whole of Iceland were lower at this time than they were in the metropolitan area, where the average figure was ISK 3.1 million in 2005. Since aluminium smelters were in operation only in Straumsvík and at Grundartangi that year, average wages in the metropolitan area might be a better reference figure than average wages for the whole country. Secondly, aluminium smelters have generally been in the position of being able to select from among candidates for jobs. It might therefore be expected that those who go to work there have wages that are rather above the average. Taking these factors into account, it could be expected that workers in the aluminium smelters generally have wages that are 20-40% higher than elsewhere. The fact that most workers in the aluminium smelters work shift work has not been taken into account here.

The movement of workers from more poorly-paid jobs to positions in the aluminium industry results in an increase in the added value generated in each job, and consequently to higher GDP. This applies not only to jobs in the aluminium smelters themselves, but also to jobs directly associated with the smelters but taking place elsewhere. Thus, GDP rises both when a tradesman starts work at an aluminium smelter (his previous job having been lower-paid) and if an engineer begins work at a consultancy specialising in work for an aluminium smelter if his wages are higher there than they were in his previous job. In this way, the addition of an aluminium smelter can crowd out other, less well paid jobs; this crowding-out effect will presumably result in an increase in GDP because the new jobs generate more added value.[19]

2.3 Aluminium smelters and unemployment

Governments typically resort to measures to reduce unemployment during times of recession and crisis. Compensatory measures of this type are nevertheless of a completely different nature from the construction of an aluminium smelter, and are usually on a smaller scale. According to Páll Harðarson (1988), a large part of the benefit that has accompanied the construction of the aluminium smelters in Iceland up to now can be attributed to the fact that those projects were embarked upon at fortunate times, i.e. when slack was present in the economy. This is seen clearly in Figure 2-1, which shows unemployment and the timing of the aluminium-smelter projects in Iceland. The smelter in Straumsvík and the Búrfell power plant were built in the late 1960s, when the collapse of the herring fisheries shook the Icelandic economy. Unemployment, which had been 0.3%, on average, during the period 1957-1967, rose to 2.2% in 1968 and to 5.0% the following year, but declined sharply after that and had dropped to 0.9% in 1972. In the following years unemployment remained at or under 1%, and it was not until after 1990 that it began to grow again. In the years 1992-1998 it was generally around 4%, reaching a peak of 5% in 1995. It was during these years that work on the expansion of Straumsvík and the construction of a new smelter, at Grundartangi, was beginning.

This analysis by Páll Harðarson has received some criticism.[20] It has been pointed out that other profitable measures besides power-intensive industrial projects could have been used to combat unemployment. And it has been said that it is perhaps an exaggeration to regard earnings during economic depressions as profit, as is done in Harðarson's study, since workers have to earn them by doing work.

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[19] No allowance is made here for the fact that the added-value resulting from capital may have been greater in the previous job. If this is the case, then it is not certain that the new jobs in fact add to GDP.
[20] See Sigurður Jóhannesson (2008).

Unemployment has been far higher, notwithstanding the economic boom, than it was, on average, 20-30 years ago. The average rate from 2003 to 2008 was 2.1%, which is twice the average level in the years 1965-1988, which nevertheless includes the recession of the 1960s. The main reason for this is that in the past, the government valued low unemployment far more highly than price stability, and purchased high employment at the cost of high inflation. The findings of statistical studies indicate, by contrast, that natural unemployment, i.e. the unemployment rate that accompanies a constant inflation rate, is about 3%.[21] At this level of unemployment, there is neither slack nor excess demand on the labour market; equilibrium prevails. This was exactly the situation found in Iceland when work began on the enlargement of the Norðurál smelter and the construction of the Fjárðaál smelter at the beginning of the 21st century: unemployment stood at an average of 3% in the years 2002-2004. Thus, it is not possible to say that slack existed in the economy, even though unemployment was greater than the average of 20-30 years previously.

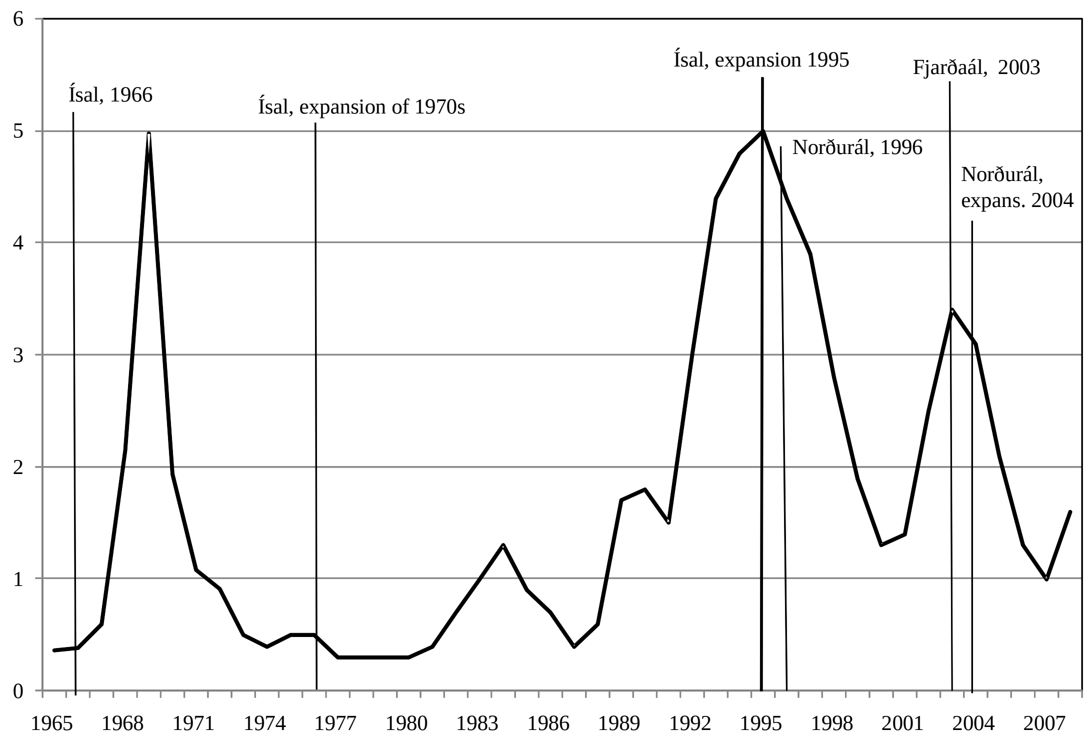

Fig. 2-3 Unemployment and the timing of decisions on aluminium-smelter projects, 1965-2008.

Source: Statistics Iceland, Alcan á Íslandi, Norðurál Century Aluminium and Alcoa á Íslandi.

In autumn 2008, however, unemployment shot up, from 1.3% in September to 4.8% in December. In January 2009 it was 6.6%, and had reached 8.7% in May that year.

[21] See Þórarinn G. Pétursson (2002).

2.4 Local effects on residence patterns and the labour market

Modern market economies are in constant evolution. New occupations replace old ones, and new enterprises replace old. In Iceland, 75% of the population worked in agriculture and fishing at the beginning of the 20th century; in 2008 this figure had declined to less than 6%. Part of the explanation for this is of course that the numbers of jobs in other occupations has increased, but many who used to work on the land and at sea have also changed their occupation. New enterprises open up where there is greater hope of profit; workers move to where wages are higher. In an economy where there is full employment, market forces will ensure that there is sufficient work for individuals on the labour market. In the short run, however, the situation may of course arise that the jobs on offer do not suit the unemployed. A systemic problem of this type may also exist in the long term. In Iceland, however, for most of the past half century, there has been a good employment situation and unemployment has been low, though there have been occasional years when it has been greater, as has been described above.

Heavy industrial development creates jobs, both in the production plant and outside it. New capital comes into the locality when a new factory is built. Input goods must be brought in for the construction phase, so there is plenty of work for transport and freighting workers. Those who actually build the installation need services of various types. Shops experience a boom in sales; schools have to be built, and so on. And those who work in the shops and the schools need services, and so the pattern goes on. This many-sided effect resulting from the project have been described as a 'multiplier effect'; by taking all aspects into consideration it is possible to obtain a clearer picture of the full effect of an investment such as the building of an aluminium smelter. Some of this multiplier effect is felt outside the locality of the smelter itself. For example, extra activity in the locality will also call for work in administration and services in the capital city. From this point of view it would be more natural to speak of economic relations rather than the multiplier effect, since it can be assumed that those who work at the project under examination would have derived earnings from some other source if the project had not been undertaken.

Thus, even though it is possible to demonstrate how large a part industrial plants play in the economy, this is not to say that the jobs involved are a pure extra in the sense that nothing else could have come in their stead. To say that would be to suggest that labour and capital would not be utilized unless they are invested in a particular project, which is far from the truth.

When there is a high level of employment, it is possible to man jobs in heavy industry either by abolishing other jobs or by importing labour to take the new jobs and/or those that are lost elsewhere. The economic benefit of the jobs created, both in the aluminium smelter and outside it, is therefore determined by how much better paid these jobs are than the others available to the same workers. If the new jobs are, for example, 25% better paid than others that were on offer, then this 25% is the economic gain in having these jobs created in heavy industry rather than elsewhere.

If on the other hand there is an unemployment situation, then it becomes rather more possible to see these jobs as a pure addition. Nevertheless, this will only actually be the case if it seems certain that no other measures would have been taken to cut unemployment instead. If there is full employment when a new aluminium smelter is opened, creating 500 direct jobs and 500 indirect (related) jobs, it is therefore not possible to view this number as a pure addition. Those who now find work, in the smelter and outside it, were presumably employed somewhere else before. Higher wages, better terms of service or other factors, however, have probably caused them to decide to change job. If the aluminium smelter had not been built, these persons would probably either have continued in their old jobs or looked for work in a new field. And if these new jobs had not been created in the aluminium smelter, then other jobs would have come into being elsewhere in the economy, as the case has been in Iceland over the past half century.

Offsetting the new jobs that are created when a particular operation starts up is the crowding-out effect. The new operation stimulates competition for labour. Wages rise in the locality, and interest in the economy may also rise. Thus, operations become more difficult in other sectors. Crowding-out effects are generally greater when a larger area is examined. If one examines the whole world, the crowding-out effect of individual development projects is small; in the long run it is zero. But the addition may be considerable if one considers a locality or provincial district. A few years ago, for example, it was estimated that the arrival of 400 workers for the aluminium smelter in Reyðarfjörður (the actual figure proved to be 450) would lead to an increase in the number of man-years worked in the Fjarðabyggð area by one thousand. This estimate assumes that the number of workers at the smelter will begin to drop by 1% per year a few years after it goes into production due to streamlining of operations. It may be assumed that the effect on the number of jobs in the country as a whole will be far smaller.[22]

Thus the multiplier effect does not measure the gain for the community, even though it may be considerable. For example, people may be offered better jobs than were available before. There may also be some gain in the fact that the infrastructure will be utilized better due to the higher level of economic activity. However, it should be noted that in many places the infrastructure is overused rather than underused. Part of the benefit of the projects will fall into the lap of people in other localities. Some of the foreign workers who were employed on the building of the Kárahnjúkar Power plant, for example, probably did not have the choice of other equally attractive jobs, but the gains of their work and their wages belong to them, and not to the people who were living in the East of Iceland at the time when it was decided to embark on the construction project. The wages of the local people rose, which means that their position improved, but prices (e.g. the price of property) also rose in the area, offsetting in part the effects of their higher wages. In general, it can be assumed that the multiplier effect will not have much effect on people's economic standing unless the market is distorted in some way.[23]

In general, great caution must be exercised when interpreting analyses that are based on a division into primary (or basic) jobs and derived jobs. In 1759 the French writer Quesnay devised his 'economic table' to analyse the workings of the economy. He divided labour into productive classes (in agriculture) and unproductive: he regarded commerce and services as unproductive. In his system, the entire economy rested on the agricultural sector. Still today in Iceland, reference is often made to 'value creation' as being something that takes place mainly in particular occupational sectors. Most economists have long since abandoned such a division.

2.4.1 Activity relating to the aluminium smelters

Though it is questionable whether it is possible to create jobs through individual investments, it is possible to have an influence on where jobs will come into existence, i.e. in which occupations and in which parts of the country. Thus, it may be useful to examine the

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[22] Valgerður Sverrisdóttir, Minister of Industry (2005).
[23] See, e.g., Boardman, Greenberg, Vining and Weimer (2006), pp. 124-125.

multiplier effect when considering the impact of development projects on a locality or the advancement of particular occupational sectors.

It is difficult to make assertions as to exactly what impact power-intensive industry has on residence and the labour market of the localities involved. Each and every locality has its peculiarities as regards the labour situation and the flexibility of its workforce. Nonetheless, it is clear that the development of heavy industry creates various jobs, relating both to the power-plant developments, the construction of the production plants and their operation. In some cases these will be specialised jobs, which possibly might not have come into being otherwise; in others, they are of a more general nature, e.g. jobs in various types of service. Furthermore, it must be borne in mind that when, for example, an aluminium smelter is built, this is not a short-term project, but something that is going to be in operation for decades. Thus, the building of an aluminium smelter may be a firm anchor for the business life of the area in question. This permanence, and the fact that the wages paid are often better than those in comparable occupations, may then attract new labour to the area, and thus expand its labour market. It is also possible that workers will move from other, less reliable, jobs in the district. If the building of the aluminium smelter results in a greater number of jobs in the area, both of a direct and indirect nature, then this is generally viewed as an advantage for the area in question, even though it is incorrect to regard the new jobs as constituting a macroeconomic advantage in cases where the workers are simply moving between jobs.

Three principal methods have been used to assess the local impact of new large-scale enterprises such as aluminium smelters: employment multipliers, income multipliers and local input-output analysis. Using employment multipliers, all jobs in the area under consideration are divided into primary and indirect and derived jobs, and then the proportions between them are calculated. This produces an estimate of how many other jobs are behind each job in the primary category involved. Primary production in this case is production that is mainly sold to persons outside the locality. Agriculture, fishing, tourism and industry are generally regarded as primary occupations. Other economic activity in the area consists of various types of services and work connected with obtaining input goods for the primary occupations. It can be argued that the primary occupations are the basis of the economic life of the region and that other occupations there are derived from them. It should be pointed out that primary occupations are not unchangeable over time, and that sometimes new primary occupations are established.

This method is applied, for example, in the report by Nýsir from 2002 on the effect of the enlargement of the aluminium smelter in Straumsvík. There, it is also pointed out that when there is full employment, a new enterprise may crowd others out within the same area by attracting labour to it and this is not made up by an increased inflow of workers into the area. Under these circumstances, the multiplier effect will be less. The conclusion in the Nýsir report was each new job in the aluminium smelter may create 1.0-1.8 man-years of employment in indirect and derived jobs.

The report by the Institute of Economic Studies, dating from 2005, on the macroeconomic effects of the Fjarðaál aluminium smelter in Reyðarfjörður, uses input-output analysis to assess the production multiplier and job multiplier resulting from that project. In this way it is possible to arrive at the factors of production in the economy demanded by an individual enterprise. The conclusion reached in the report is that for each króna by which demand for the production of aluminium and ferrosilicon rises, production in other sectors rises by ISK 1.25. In the same way, it is calculated that each job in aluminium and ferrosilicon production creates 1.43 jobs elsewhere in the economy. The Institute of Economic Studies' report states that the multiplier effect in some sectors, for example in hotel and catering operations and other industries besides heavy industry, is less than in aluminium production, while it is greater in other occupations, such as construction, agriculture and fishing.

It may be assumed that close to 1,400 people were involved in jobs at aluminium smelters in Iceland in 2008. If it is assumed that the job multiplier in aluminium production is 1.4, then it can be assumed that almost 2,000 other jobs were connected with the operations of the aluminium smelters in indirect and derivative ways, and therefore that about 3,400 people lived from aluminium production. This represents about 1.8% of the workforce. It must be reiterated that under full employment, it can be assumed that these primary jobs would have come into being in other occupations if the aluminium-production projects had not been undertaken, and that the indirect and derived jobs would have been connected to other lines of employment.

Apart from electricity, the products and services that large enterprises like aluminium smelters purchase from other companies cover a wide range. Examples include legal services, engineering services, construction contractors' services, goods purchased from contractors, banking services and transport and freighting (both domestic and international). In some cases these are companies that base their existence mainly on business with the smelters, and may even have specialised in this field. For example, in 2008, about 300 people worked exclusively for Fjarðaál in Reyðarfjörður, yet not in the smelter itself, and about 120 people worked exclusively for Alcan á Íslandi hf., though not in the smelter in Straumsvík. Altogether, it can be assumed that purchases by the three aluminium smelters of domestic products and services in 2008 amounted to about ISK 25 billion, their domestic payroll came to about ISK 10 billion and their taxes and public levies to central and local government to about ISK 2.5 billion.[24]

The proportion between sums spent on the purchase of products and services (other than electricity) and wages can be interpreted as a multiplier or index, indicating how much production in occupational sectors other than power production increases for each ISK 1 which the company pays in wages. Based on the above assumptions regarding purchases by the aluminium companies of goods and services, it can be assumed that this multiplier had a value of 2.5 in 2008, i.e. that for every króna which the aluminium companies paid in wages, ISK 2.5 were spent on the purchase of other goods and services.

2.4.2 Effect on residence patterns

Two new aluminium smelters have been built in Iceland in recent years: one at Grundartangi, on the outer fringes of the metropolitan area, and one in central part of the Eastern region. Both of them are pillars of the economic life of their regions, and there is no doubt that they have strengthened the basis of the local communities. Here follows an account of the changes in population and residence patterns since they went into operation.

Western Iceland

A ferrosilicon smelter was built at Grundartangi, in Hvalfjörður, in 1977-1981, and it was enlarged in 1998-99. An aluminium smelter was built at Grundartangi in 1997-98 and expanded three years later. These heavy industrial developments were a tremendous boost to the economic life of the area. The same may be said of the construction of the Hvalfjörður tunnel, which was opened to traffic in 1998. This resulted in a shortening of the road from the metropolitan area to Akranes and Borgarnes, and also other parts of the West of Iceland, and it can be said that Reykjavík’s area of influence now reaches well up into Borgarfjörður.

[24] Corporate tax, social insurance tax and property taxes.

At the end of 1997 Akranes had a population of just over 5,100, and there were nearly 3,300 people in Borgarbyggð and 540 in Hvalfjarðarsveit.[25] Ten years later, the population of Akranes had risen to 6,630, that of Borgarbyggð to 3,747 and that of Hvalfjarðarsveit to 641. Thus, the total increase was 2,082, or nearly one quarter.

Table 2-2 Population growth: Akranes, Borgarbyggð and Hvalfjarðarsveit, 1997-2008.

			Difference	
	1997	2008	Fjöldi	Hlutfall í %
Akranes	5,127	6,630	1,503	29.3
Borgarbyggð	3,267	3,747	480	14.7
Hvalfjarðarsveit	542	641	99	18.3
Total	8,936	11,018	2,082	23.3

Source: Statistics Iceland.

The largest part of the population increase in Akranes can be attributed to the fact that more people have moved to the town than away from it. Such movements have not played such a decisive role in the growth of Borgarbyggð and Hvalfjarðarsveit. During the ten-year period, nearly a thousand more people moved to Akranes than moved away from it, 233 more to Borgarbyggð and 33 more to Hvalfjarðarsveit. The majority of these people moved there from outside the country, while both Borgarbyggð and Hvalfjarðarsveit lost people to other local government areas inside Iceland. Akranes, on the other hand, absorbed people both from other local government areas in the West of Iceland region and from other parts of the country.

Table 2-3 Population movements in the local government areas Akranes, Borgarbyggð Hvalfjarðarsveit, 1997-2008.

	Between local g. areas within same region	Between regions	Betw. countries	Total
Akranes	354	326	319	999
Borgarbyggð	-37	-17	287	233
Hvalfjarðarsveit	-14	-35	82	33
Samtals	303	274	688	1,265

Source: Statistics Iceland.

[25] Based on the local government areas as defined in 2007.

It is possible that some part of the movements of population described above can be attributed to the development of power-intensive industry at Grundartangi, but no attempt will be made here to determine how much. A recent report on the effect of the Hvalfjorður tunnel on living conditions and demographic development in the West of Iceland pointed out that the tunnel had increased variety and security on the labour market.[26] It improved connections between the labour market of the metropolitan area and that of the Western region, and development of the power-intensive industries at Grundartangi benefited from this, since it improved access to qualified workers. Shorter travelling times probably made the area near Grundartangi a more attractive place to live.

The East of Iceland

The population of Iceland's Eastern Region in 2003 was just over 12,000; five years later it had risen by more than 1,300.[27] As can be seen from Table 2-5, there was a decline in population in the marginal areas in the north and the south, with an increase in the central area.

Table 2-4 Population of local govt. areas in the Eastern Region, 2003 and 2008.

LGA	2003	2008	Difference Fjöldi	%
Langanesbyggð	533	511	-22	-4.1
Vopnafjarðarhreppur	741	674	-67	-9.0
Borgarfjarðarhreppur	140	142	2	1.4
Seyðisfjörður	741	716	-25	-3.4
Fjarðabyggð	4,055	4,736	681	16.8
Fljótsdalshérað	2,705	3,707	1,002	37.0
Fljótsdalshreppur	93	143	50	53.8
Breiðdalshreppur	258	197	-61	-23.6
Djúpavogshreppur	493	456	-37	-7.5
Sveitarfélagið Hornafjörður	2,304	2,110	-194	-8.4
Total	12,063	13,392	1,329	11.0

Source: Statistics Iceland.

A closer look at the figures showing changes of residence shows that in all the areas within the Eastern Region, with the exception of Fljótsdalshérað, the population fell as a result of

[26] Vífill Karlsson (2004).
[27] See Sveinn Agnarsson (2008).

domestic relocation; this is shown in Table 2-5. On the other hand, more people moved to all the areas from abroad than vice versa.

Table 2-5 Movement of population in local govt. areas in the Eastern Region, 2003-2008.

LGA	Between local govt. areas within same region	Between regions	Betw. countries	Total
Langanesbyggð	-47	-53	45	-55
Vopnafjarðarhreppur	-15	-103	5	-113
Borgarfjarðarhreppur	2	-7	13	8
Seyðisfjörður	-20	-61	41	-40
Fjarðabyggð	-13	-86	642	543
Fljótsdalshérað	138	255	356	749
Fljótsdalshreppur	-28	5	77	54
Breiðdalshreppur	-33	-46	20	-59
Djúpavogshreppur	-18	-67	20	-65
Sveitarfélagið Hornafjörður	-9	-313	63	-259

Source: Statistics Iceland.

The above examples show how important the relocation of population between countries can be for the survival of local communities, and that notwithstanding periods of great upswing in the economy, it can be difficult to prevent people from moving out of the rural areas.

2.5 Summary

The effects that heavy industrial investments have on the labour market are of many types. Average wages in heavy industry are higher than those on the general private labour market. Aluminium smelters are popular workplaces and they seem to attract qualified workers. Studies show that the timing of power-intensive industrial ventures in Iceland in the past was fortunate in the sense that they coincided with slack periods in the national economy. This was not the case, however, with the recent enlargement of Norðurál and the construction of Fjarðaál. In these cases, the unemployment level was similar to what is considered compatible with a steady price level, even though it was certainly higher than the average of previous decades. Increased use of foreign labour on power-intensive development projects in recent years has reduced their impact on the domestic labour market, so reducing the surge in demand that normally accompanies them. Aluminium companies purchase goods and services of many types from domestic suppliers, and various companies perform specialised tasks for them. In 2008, total purchases by the three companies of goods and services amounted to about ISK 25 billion, domestic wages to about ISK 10 billion and taxes and public levies to central and local government to about ISK 2.5 billion. The establishment of aluminium companies clearly has a positive effect on the local economy and community. It appears that establishment of aluminium companies does not have a detectable effect on the general drift of population from the rural areas to the largest population centres in the country. On the other hand, the building of a large company like an aluminium smelter can have an effect on the demographic and employment pattern in the region in question. Thus, there are many indications that the developments in the central area of the Eastern Region have drawn vital strength from the areas in the north and south of the region, and also that people have left positions in the fishing industry to take new jobs that were created by the coming of the aluminium smelter.

3. Macroeconomic effects of increased aluminium production

Considerable discussion has taken place about the impact of further aluminium production on economic cycles in Iceland; this has focussed on the effects of both investment in aluminium smelters and the exporting of aluminium.[28] Production cannot be increased significantly without new investment in aluminium smelters and the power plants associated with them, and in view of the scale of these investments, their timing can have a considerable effect on the economy. Further investment in this occupational sector can both dampen and enhance economic cycles, depending on the state of the economy at the time. It is also part of the nature of things that additional aluminium production will increase national exports; these earnings will also affect economic cycles, both in the long and the short term. The first section of this report discussed in general terms the countercyclical or cycle-enhancing effects of heavy industry, both in the past and the present. In this section, an attempt is made to look ahead and examine the impact of a possible increase in aluminium production on economic cycles in Iceland. Attention is given firstly to the effect of increased export earnings, next to the possible crowding-out effect of the necessary construction projects, i.e. the effects on economic growth, the labour market and the financial markets. Finally, some questions involving various premises regarding the price of aluminium and its effect on the Icelandic economy are considered.

3.1 Aggregate impact on export earnings

Iceland is a small, open economy in which foreign trade plays a large role. For example, exports of goods and services constituted 32-40% of GDP in 1980-2008, rising to 45% in 2008. This is similar to the situation in other small, open economies, such as those of the other Nordic countries, but much higher than that in larger economies such as that of the USA, where the comparable figure is 11-13%. In view of how much of the economy is dependent on foreign trade, it is even more important to maintain a steady exchange rate. An important factor in achieving stability in this area is to keep the value of goods exports as steady as possible. A sudden and unforeseen drop in the value of exports will reduce demand for the currency, resulting in a fall in the exchange rate, while an unforeseen rise in the value of exports will similarly result in an increase in the exchange rate of the currency. Iceland's decades of experience of one-sided exports of fisheries products, with the concomitant cycles

[28] See, e.g., OECD (2007).

due both to poor catches at home and unstable prices on foreign markets, emphasise the importance of keeping a steady exchange rate. In general, the rule is that the more varied exports are, the smaller will be the unforeseen fluctuations in their value. It must be stressed, however, that while stability in export earnings is important, the main thing is that export industries, like other occupations, should be profitable.

For many decades, the focus in Iceland was on heavy industry as a means of diversifying exports. The principal argument was that heavy industry would increase stability in Iceland's exports; the fluctuations in fish catches and the prices of fish products were not connected to fluctuations in the prices of industrial products such as aluminium. On the other hand, the price of aluminium, like that of any other raw material, does fluctuate, and an economy that only exported aluminium would experience fluctuations in its export earnings. It was considered that power-intensive industry's dampening effect on economic cycles would be greatest to begin with, while the products still formed a relatively small part of exports, declining slowly until cycles would once again start to increase in amplitude in view of how large aluminium exports would loom in overall exports. At this point, the same sort of problem as had characterised the economy when fisheries products accounted for the bulk of exports would recur: one-sidedness in one direction would be replaced by one-sidedness in another. This view was expressed, for example, in the articles by Páll Harðarson (1998) and Axel Hall and Ásgeir Jónsson (2001) and the study by Magnús Fjalar Guðmundsson (2003).[29] The conclusions reached in these earlier studies are all similar, i.e. that the countercyclical effects are negligible, and that cycles have even become more pronounced as aluminium has become a larger export item. The first section of this report presented arguments for the view that the countercyclical effects of the aluminium industry were underestimated in earlier studies. The methods applied in the two articles mentioned above were similar. They are based on historical figures regarding the price of aluminium according to export reports, the volumes being adjusted to assess their effect on the value of exports.

The present report applies the same sort of methodology as Axel Hall and Ásgeir Jónsson (2001) and Magnús Fjalar Guðmundsson (2003) in order to assess the effect of increased aluminium exports on fluctuations in export earnings. An attempt is also made to identify the volume of aluminium exports that would have kept cycles to a minimum, given various

[29] See Axel Hall og Ásgeir Jónsson (2001) and Magnús Fjalar Guðmundsson (2003).

premises regarding hedging methods. The entire period since aluminium exports began is examined, i.e. from 1969 to 2007.

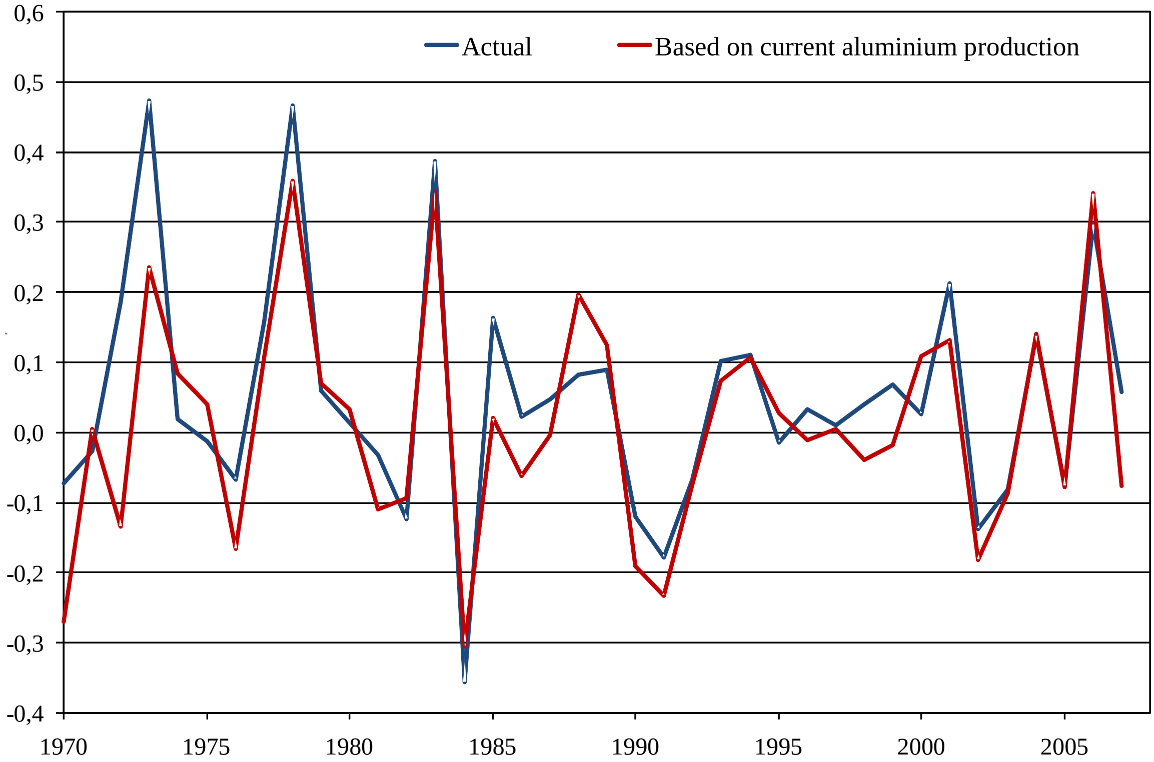

Fig. 3-1 Changes in export values, based on actual historical data and the estimated current volume of aluminium exports (780,000 tons).

Source: Statistics Iceland and authors' own calculations.

Fig. 3-1 shows that export values have fluctuated substantially from year to year. There is no correlation between changes in the export value of aluminium and that of fisheries products; consequently, whether they fluctuate in the same or opposite directions is coincidental, as can be seen by comparing the lines representing actual historical aluminium production and a fixed figure of 780,000 tons. If the variance in the yearly changes in export value is taken as a measure of cycles, it is found that it is rather smaller in the case of current aluminium production volume than in that of historical volumes, which may be interpreted as meaning that additional aluminium production would have reduced fluctuations in export values. This conclusion is rather different from those of earlier studies, which is explained by the fact that they were based on far shorter periods than the present report. The quantity of aluminium that would have minimized variance in the change of export values turns out to be only 213,000 tons. This indicates that the increase in aluminium exports over the past few years has rather contributed to the amplitude of fluctuations in export values. However, it is necessary to pause and examine the implications of the fact that aluminium producers are able to defend themselves against price fluctuations by using hedging instruments, as is discussed in detail in the first section of this report. Systematic use of risk hedges reduces the impact of price fluctuations on the companies' performance. The extent to which producers of aluminium in Iceland make use of risk hedges, but if the scale of their use by Landsvirkjun, where all short-term risk is covered, is anything to go by, then a conservative estimate is that 25-50% of their risk at any given time is hedged.[30] Two hypothetical premises are examined here to assess the effect of risk hedging on the optimal production volume. One of these is that the futures market in aluminium is efficient and sufficiently large for the Icelandic aluminium industry not to have any influence on pricing. The other is to assume that forward contracts are made for up to three years, with short-term contracts playing the maximum role and long-term contracts the minimum. This must be considered as a cautious arrangement, since longer contracts do exist on the market. Assuming that 25% of risk is hedged, a production volume of 680,000 tons of aluminium would have minimized fluctuations in export values. If the extent of cover had been 50%, then production of 1,800,000 tons would have minimized the fluctuations. Still greater use of hedging instruments, e.g. involving the use of longer-term contracts, would reduce price risk still further, resulting in a still further increase in the quantity required to minimize fluctuations in export values. Therefore, it is obviously important to take account of the potential that aluminium companies have to cover themselves, and consequently the economy, against price-related risk. This would seem to indicate that earlier studies have underestimated the countercyclical effects of aluminium exports on Iceland's export values.

It is reasonable to ask, in the light of these findings, whether the aluminium industry can expand still further without amplifying cycles in the economy. Notwithstanding what has been said here, the answer to this question is not an unequivocal 'yes'. Two points, in particular, must be borne in mind. Firstly, the general rule is that a varied range of exports is a better solution, in the long run, than reliance on one-sided exports, even though it is possible to protect oneself against price fluctuations in particular sectors. Varied exports offer greater resilience against major setbacks and long-term downturns in particular sectors. Secondly, the scale of public investment in the energy sector opens the door to further risk regarding the performance of this sector through commercial links to the aluminium producers. Over the

[30] Annual accounts of Landsvirkjun for 2007.

past 10 years, for example, per capita capital ownership in the energy sector has risen from just under ISK 800,000 to nearly ISK 1,500,000 per capita, in 2007 prices. For comparison, per capita capital ownership in residential property is estimated at ISK 4,600,000. Generally speaking, it is considered appropriate to set more stringent demands regarding moderation in risk taking when the public invests commonly-owned funds in an operation than in the case of a purely private business. A shareholder in a limited company can sell his shares whenever he chooses if he believes that the returns do not justify the risk. In the case of public investment, the individual has no such course of action open to him. It should be pointed out that the risk involved in new investment in power-intensive industry can be reduced by reducing public ownership of the power companies. It would be particularly advantageous, from the point of view of stability, if the power companies were to be owned by foreign parties. In that case, the same principles would apply regarding the effect of economic cycles on export earnings as apply in the case of the aluminium smelters. Foreign parties would be saddled with the majority share of the operational risk of these companies, with the result that, for example, fluctuations in the price of aluminium would have a negligible effect on the current account balance. A high price, with a corresponding increase in the export value of aluminium, would result in profit which would be paid out to the foreign owners; this would appear as negative factor income, with very little effect on the current account balance. A drop in the price of aluminium, on the other hand, would result in a lowering of the value of exports, but this would be offset by positive factor income due to lower dividend payments or contributions to the foreign owners resulting from a loss on operations. Since the lifetime of hydropower plants is, all other things being equal, far longer than their depreciation time, hydropower plants can, if they are properly maintained, yield their owners income that is far in excess of their costs. In order to prevent foreign parties from creaming off this excess income, it would be possible to have special provisions in the sales contracts for the power companies stating that Iceland would own the power plants at the end of the depreciation period or, at the latest, when the generation licences expired. Precedents exist for such provisions in Iceland. As an example, the harbour at Straumsvík was built at Alusuisse's expense, but it was made over to the Port of Hafnarfjörður as its possession after 25 years' operations in the service of the aluminium smelter, and the Icelandic state will acquire 100% ownership of the Hvalfjörður tunnel at the end of its depreciation period.

3.2 The effect of the proposed developments on principal economic aggregates

At the beginning of 2009, the Economic Unit of the Ministry of Finance prepared a special economic forecast for the Ministry of Industry in connection with the proposed building of an aluminium smelter in Helguvík and the possible enlargement of the smelter in Straumsvík. For comparison, another forecast was prepared in which it was assumed that neither of these planned projects would actually take place. Below, use is made of these forecasts and of the new economic forecast by the Ministry of Finance dating from May 2009.

The cost of building a new aluminium smelter in Helguvík and the enlargement of the smelter in Straumsvík, together with the associated power-generation projects, is estimated at about ISK 400 billion, at nominal values for the period 2008-2015. It is assumed that the exchange rate of the US dollar will be in line with the exchange-rate index forecast. This is equivalent to about 3% of estimated GDP for the period. The main effort would be put into the projects in the years 2010-2012, when it is estimated that the cost will be 4.4-4.5% of GDP. Assuming that the planned enlargement of the Straumsvík smelter will not take place, then the projects could cost ISK 340-345 billion.

Table 3-1 Start-up costs of power plants and power intensive industrial plants, 2008-2015, at each year's price-levels in billion ISK.

	2008	2009	2010	2011	2012	2013	2014	2015	Total
Industrial installations									
Al. smelter in Helguvík									
Enlargement, Straumsvík									
Installations, total	7.9	6,3	37,6	51,8	45,5	31,0	27,3	15,2	222,5
Power plants									
HS and OR for Helguvík									
Landsvirkjun for Straumsvík									
Landsnet									
Power plants, total	5.0	15.6	32.5	39.6	31.9	21.5	23.8	9.4	179,3
Install. and power pl., tot.	12.9	22.0	70.0	91.4	77.4	52.4	51.1	24.7	401,8
Gross Nat. Prod. (GDP)	1,414	1,518	1,533	1,635	1,736	1,824	1,955	2,110	13,725,0
Fraction of GDP	0.9	1.4	4.6	5.6	4.5	2.9	2.6	1.2	2.9

Source: Ministry of Finance.

The forecast by the Ministry of Finance assumes that GDP will contract by 10.6% in 2009 even if the projects listed above are begun, while the contraction without them would be 10.9%. The basic forecast then assumes economic growth of 0.5% in 2010, while without the power-intensive projects it allows for a contraction of 0.7% in GDP. It is also envisaged that economic growth will be greater in 2011 and 2012 if the projects are included, declining in 2013-2015 and remaining level in 2016. In the first part of the forecast period it is assumed that investment in primary sector industries will drive economic growth, while in the latter part of the period growth will first and foremost be attributable to higher export levels. Thus, the projects will keep domestic interest rates higher than otherwise, resulting in less private consumption and also less investment in other occupational sectors. This crowding-out effect will be particularly felt in the latter part of the period.

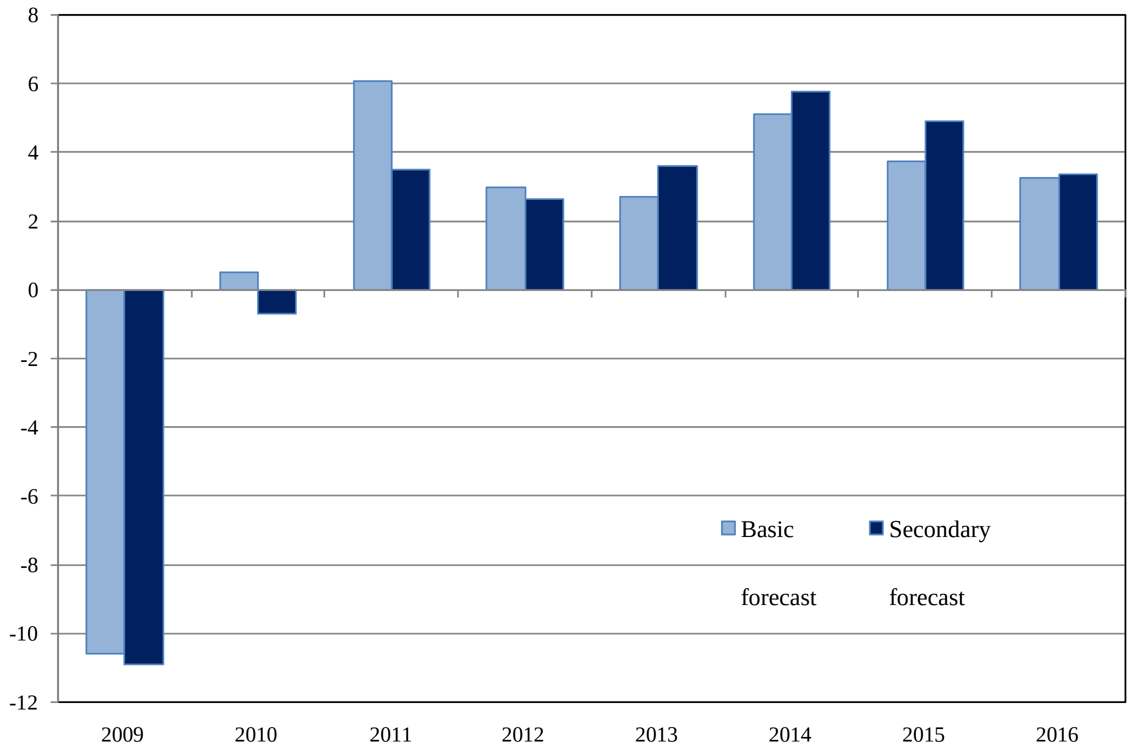

Fig. 3-2 Economic growth forecasts for 2009-2016.

Source: Ministry of Finance.

If these forecasts by the Ministry of Finance prove to be correct, it can be assumed that if the projects are undertaken, GDP in 2012 could be similar, in real terms, to what it was in 2007 and 2008. If on the other hand none of the projects are undertaken, then it is likely that this level will not be reached again until 2014. According to the primary forecast by the Ministry of Finance, GDP in 2016 will be about 15% higher than it was in 2007, or 12% higher if none of the projects listed above in the field of power development and heavy industry are undertaken.

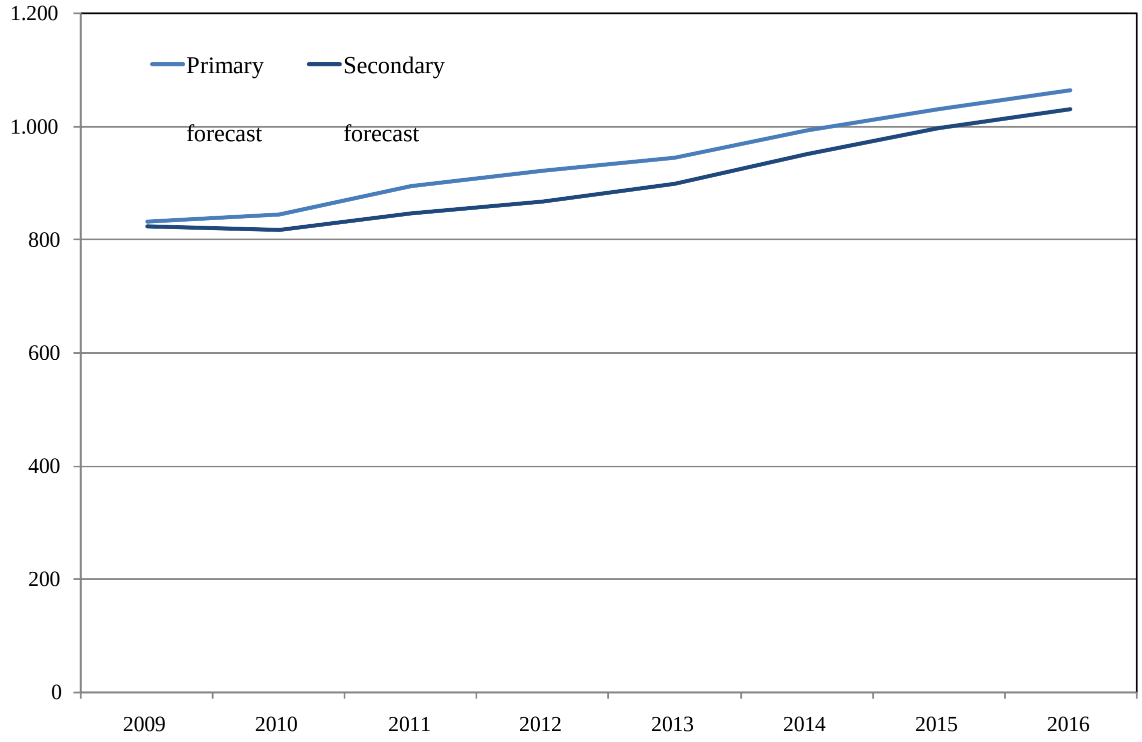

Fig. 3-3 Change in GDP, 2007-2016. ISK billions at fixed prices.

Source: Ministry of Finance.

The forecast by the Ministry of Finance assumes that both private consumption and investment in primary sectors will be greater in 2009 and 2010 if the power-intensive projects are undertaken than if they are not. In the following years it is also assumed that investment, as a proportion of GDP, will be greater in the primary forecast scenario than in the secondary forecast scenario. The difference will be greatest in 2011, when it is assumed that investment will be six percentage points higher if the projects are undertaken. The difference is reduced in the following years, and by 2016 it is assumed that investment in primary sectors will be greater in the secondary scenario than in the primary. Private consumption, on the other hand, will be smaller in the years 2012-2015 in the primary scenario. The main explanation for this is that as a result of the projects, interest rates will be higher than otherwise, which will reduce consumption. It is estimated that the projects would result in interest rates in Iceland being, on average, 1-2.5% higher than they would be without them.

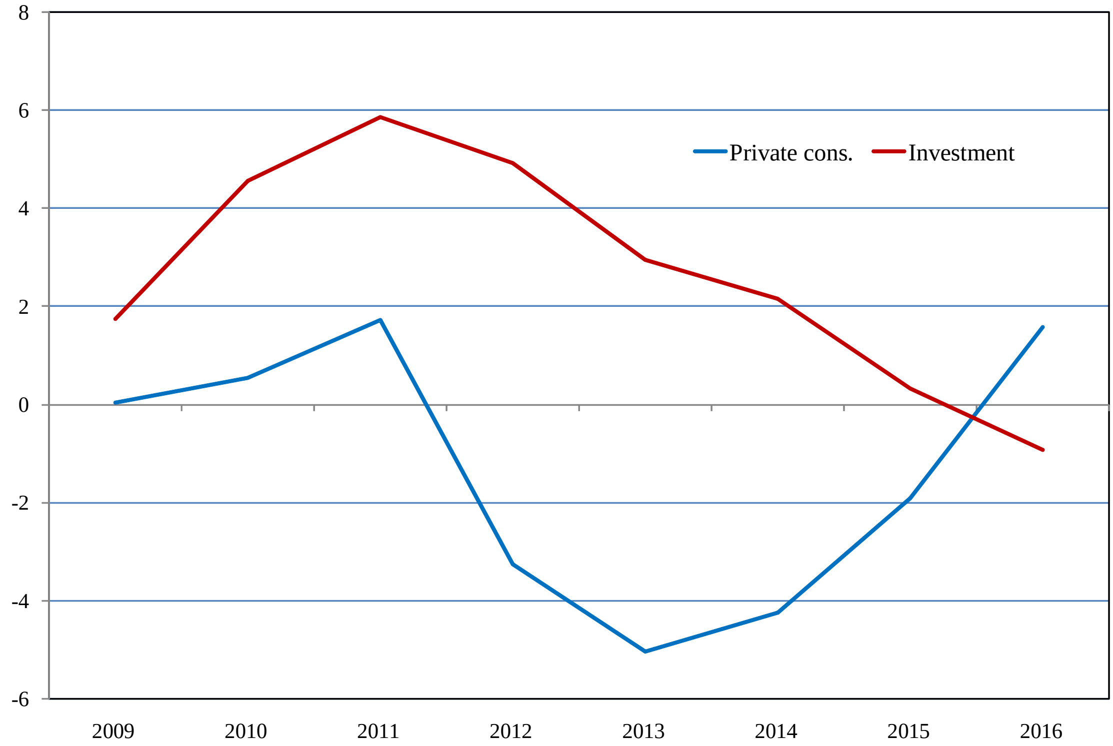

Fig. 3-4 Private consumption and investment in primary occupational sectors; difference between values according to the primary and secondary forecasts for 2009-2016. Percentage of GDP.

Source: Ministry of Finance.

Increased importing of investment goods in the coming years would mean a smaller surplus on the capital account if the power-intensive projects were undertaken than if they were not. Thus, in 2009-2012 it is assumed that the surplus will be 1-2.5% smaller. In the latter part of the period, on the other hand, the forecast in which the projects are included predicts that the balance of trade would improve due to the large increase in aluminium exports. In that part of the period, exports of goods and services are seen as the main force driving economic growth.

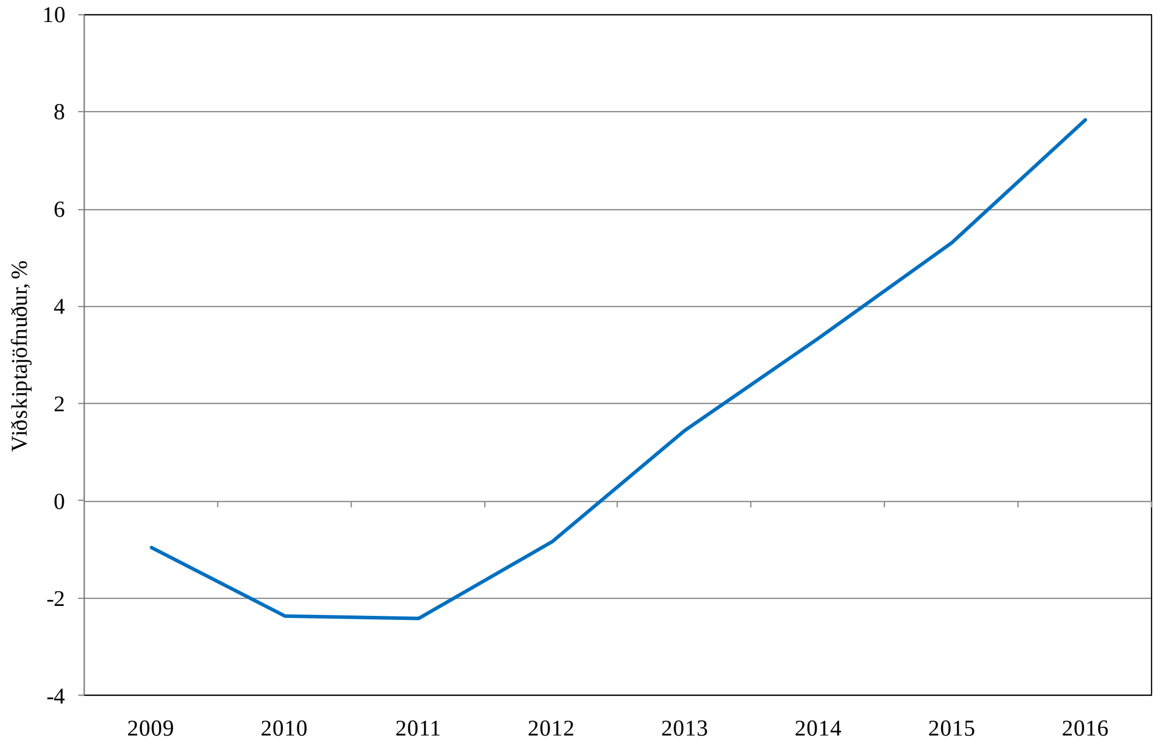

Fig. 3-5 Current account balance: difference between values according to the primary and secondary forecasts for 2009-2016. Percentage of GDP.

Source: Ministry of Finance.

Recorded unemployment in Iceland was 1% in 2007 and 1.7% the following year. In the past few months, on the other hand, unemployment has risen sharply, and the Ministry of Finance's forecasts allow for it being 9% in 2009 and 9.6% the following year, or half a percentage point higher if the heavy-industrial projects do not take place. The difference over the following three years would be even greater, i.e. about 1 percentage point, and thereafter the difference would be reduced, and by 2016 it is assumed that there would be more unemployment in the primary scenario than in the secondary.

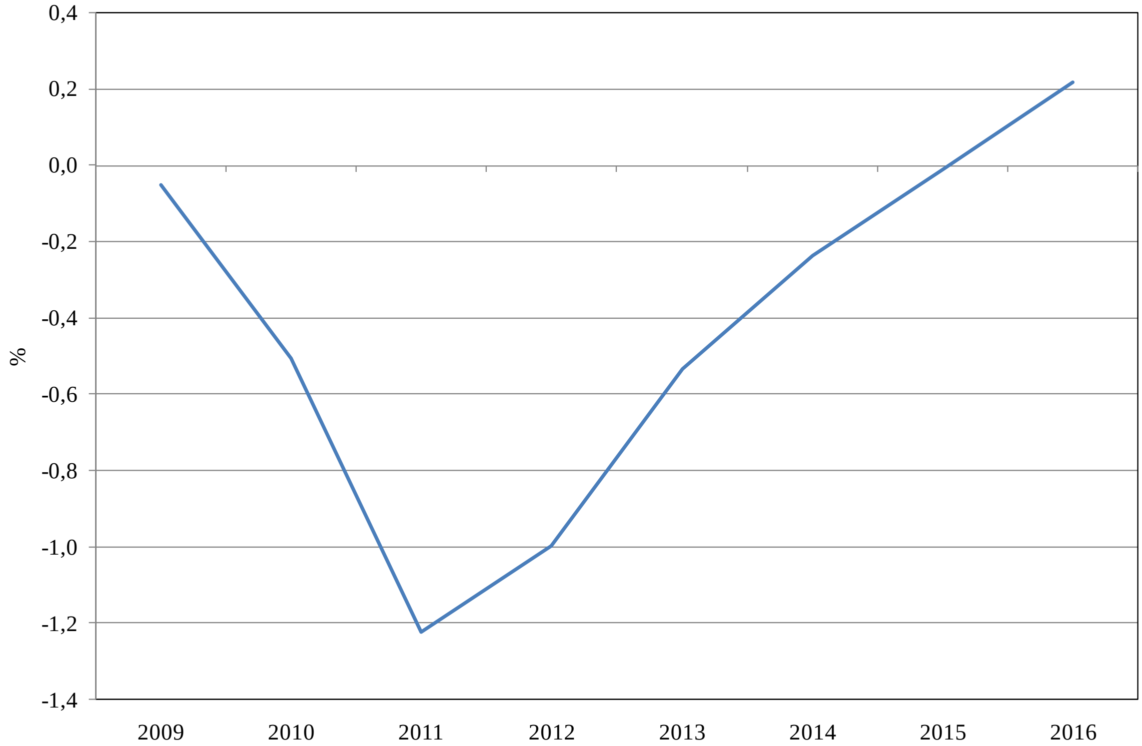

Fig. 3-6 Unemployment rates: difference between values according to the primary and secondary forecasts for the period 2009-2016. Percentage of the workforce.

Source: Ministry of Finance.

The Ministry of Finance's forecast allows for the average aluminium price per ton being USD 1,444 in 2009, USD 1,563 in 2010, USD 1,663 in 2011, USD 1,763 in 2012, USD 1,863 in 2013, USD 1,963 in 2014 and USD 2,000 in 2015-2017. For comparison, the specialist company CRU forecasts an average price of USD 3,440 per ton for the period 2013-2030, and the McKinsey company regards it as unlikely that the price will remain under USD 2,400 in the long term.

3.3 Summary

Iceland's economy is small and open, and it is in the interests of all parties to avoid large fluctuations in the exchange rate of the króna and in export values. There are various indications that increased aluminium production would result in greater stability than would otherwise be the case. On the other hand, the development projects themselves would have crowding-out effects of various types which would have to be taken into account. Public ownership of majority shares in power companies mean that the risk associated with the power-development projects would be borne by Iceland. If the power companies were to some extent foreign-owned, this would reduce this risk, in the same way as operational risk of the power-intensive production companies themselves is borne by foreign parties.

There is every indication that the planned power-intensive projects would have a positive effect on the economy in the coming years, since the outlook is that there will be room for them. In the longer term, on the other hand, forecasts allow for greater economic growth without these heavy-industrial projects, because the projects themselves would lead to higher domestic interest rates which would crowd out other investments and reduce consumption. Unemployment would be lower right up until 2015. Furthermore, the heavy-industrial projects would strengthen the exchange rate of the ISK, so weakening the competitive position of Icelandic companies.

4. Profitability of power-development projects

One of the most important premises for the public sector's being able to promote further power-intensive industrial development is that it will yield satisfactory profits. However, it is not enough to examine only the clearly-delineated profitability of selling electric power for aluminium production, as private companies do; a government must take other factors into account which may influence the well-being of its citizens. These factors are not included in profitability assessments by companies, partly because of market failures and narrow frames of reference regarding the impact of the construction projects; nevertheless it is vital that they be included when analysing costs and benefits. This section of the report focuses on the profitability of power developments. Attention is drawn, first to the necessity of including environmental costs in such calculations; then a rough cost-benefit analysis of further aluminium production is carried out. In this, it is assumed that the projects discussed above will be undertaken, but the environmental cost will not be included; no assessment of environmental cost has been made in connection with these projects.

4.2 Environmental cost

The environment itself provides a range of services and creates considerable value: from being source of raw materials for production and the final destination of waste to being the setting for leisure activities and the enjoyment of nature. Only a fraction of the services that the environment provides is priced on the market. This does not mean that other aspects of these services are not valuable, but rather that the market fails to control their utilization in an efficient manner. There are various reasons why the market fails to do this. Frequently, the environment is defined as a public good, which means it is difficult to charge a fee for its use, even though that use results in costs both for the individual or for society as a whole. In performing a cost-benefit analysis of industrial projects, it is necessary to assess all costs, including environmental costs in relation to environmental goods that are not evaluated on the market. Economic methods have been developed to asses the value of environmental goods; attention is given to these in an appendix to this report. These methods are used in many parts of the world where development results in destruction of the environment. The stage has now been reached where, for example, such an assessment is obligatory in connection with all major investment projects in Norway and in the USA. Little use has been made of these methods of assessing environmental costs in Iceland, though attention may be drawn to two studies that were made of the value of the environment that was impacted by the power-plant development at Kárahnjúkar. Further details of these are given in Section 4.2. The framework plan on the utilization of hydropower and geothermal resources that was approved by the cabinet in February 1997, and put into practice in 1999, included provision for all power-harnessing alternatives in Iceland to be assessed and ranked. In doing this, their impact on the natural environment, natural monuments and culturally important sites was to be taken into account.

A great deal of public debate has taken place regarding the environmental impact of power-development projects and heavy-industrial development over the years, in fact, to such an extent that one can say a major awakening has taken place in this area. Considerable disputes arose concerning the Kárahnjúkar Power Plant and its implications for the natural environment on the northern side of the Vatnajökull glacier. Many people pointed out that the present arrangements for assessing profitability of power-development projects did not include any direct assessment of the cost represented by the destruction of environmental quality. All that is done in the environmental impact study is to assess what the impact might be, but the last and most important step, involving a monetary assessment of the environmental consequences, is not taken. Thus, decision-makers are entrusted with evaluating whether the environmental impact is worth more than the profit generated by the development projects. The tendency has been to embark on the projects as long as their profitability is acceptable, irrespective of the impact on the environment. In this way, decision-makers have indirectly evaluated the environment, coming to the conclusion that it is generally of less value than the profits expected of the development projects. Obviously this arrangement is fundamentally flawed, and may result in the taking of wrong decisions, though no statement is made here as to whether this has been the case up to now. It would be sensible for the government to demand an assessment of this type as part of the environmental impact assessment of major projects in order to ensure that the profits generated by the investments justify the environmental costs.

4.2 Economic assessment of environmental impact

Environmental quality is not traded on the market, and in the nature of things it has no market price. This does not mean, however, as is stated above, that environmental quality is of no value, but merely that market forces do not provide any guidance through pricing regarding the most efficient methods of utilization. There are four aspects to the underlying value of the environment. The first is its use value, i.e. the value when the goods involved in the environment are used. Second is the option value of environmental goods, i.e. the value involved in the option of utilizing the goods at some later date. Thirdly, the mere existence of environmental goods constitutes an existence value, and fourthly, the environment has a bequest value for future generations, since the quantity of most environmental goods is limited and it may be extremely costly to regain environmental quality once it has been lost.

It should not be concluded that there is any one universally valid formula or sum that could reflect the value of the environment that is sacrificed in connection with power-development projects in Iceland at any given time. The value of environmental goods depends on the circumstances in each given location, and not least on the emotional attachment of people to individual areas. An area that is considered unique in Iceland, not to mention in the world, will always be assigned a higher value, using the methods described here. Economic assessments of the value of the environment in Iceland are conspicuous by their absence. If such an assessment is made in the future regarding areas where it is planned to carry out power developments, they will give an indication of the real opportunity cost of other areas that are to be sacrificed for power plants.

Obviously, great care must be taken when making an economic assessment of the environment so as to avoid errors in the result. It must also be borne in mind that the value of the environment is always assessed indirectly in terms of other goods expressed on a monetary scale. This may result in environmental quality being overvalued, compared with other goods since, among other reasons, the existence value of other goods sold on the market is not included in their valuation.

One of the methods used to assess environmental effects is ‘contingent valuation’. Further details of this method are given in Appendix III, but briefly it may be said to involve an attempt to find out the value for the consumer of the changed conditions resulting from interference with the environment.

Contingent valuation was applied in two independent studies of the Kárahnjúkar area. In one of these, David Bothe estimated the environmental cost of the Kárahnjúkar Power Plant as part of his doctoral studies at the University of Köln.[31] This took the form of a random survey of 1,000 people from the National Register in Iceland, questions being sent to the recipients by post. The response rate was only 33.6%, which must be considered low. Bothe’s findings

[31] Bothe (2004).

were that the average willingness to pay was ISK 5,000 per family per year, and that the total environmental cost of the development was ISK 2 billion. The other study was made by Nele Lienhoop as part of her doctoral studies at the University of Aberdeen.[32] The main aim of this study concerned methodology and not the valuation of the environment. She employed a method using both interviews and postal questionnaires. She took 53 interviews, which must be regarded as a very small sample for assessing environmental costs with any accuracy. Her findings indicated that the average willingness to pay amounted to ISK 18,000 per family per year. No aggregate valuation of the environmental cost was expressed, but from these figures it can be deduced that the aggregate environment cost of the project was about ISK 7 billion. Both of these studies were made with inadequate resources and there is a considerable element of uncertainty regarding the valuations; consequently, it would be necessary in future to undertake a detailed and more accurate study in order to obtain better information regarding the environmental cost accompanying large-scale ventures of this type.

4.3 Cost-benefit analysis of increased aluminium production

Cost-benefit analysis[33] (CBA) is a method used to rank various projects according to their profitability. CBA is widely used in the Western world to rank projects with a social dimension, and some countries have gone so far as to make its use obligatory according to law. The method involves an attempt to assess all the implications, positive and negative, of a specific project in monetary terms over the lifetime of the project. This is done by calculating all benefits and costs arising during the lifetime of the project at present-day values, using a particular discount rate. If the residual discounted value of the benefit is positive, then it is considered macroeconomically advantageous to undertake the project in question; if it is negative, this is considered disadvantageous. The costs and benefits of a new project consist of the discounted increases in earnings and expenses that it will involve for the community. Thus, to a large extent it involves analysing marginal costs and marginal benefits.

CBA is rooted in microeconomics and welfare economics. In a microeconomic sense, players on the market (i.e. consumers and producers) will seek to maximize their welfare. Producers aim at maximizing their profits, while consumers aim at maximizing the benefit they receive from consumption, taking into account their assets and earnings. From the point of view of

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[32] See Lienhoop and MacMillan (2007).
[33] Hereinafter abbreviated to CBA.

welfare economics, the trend is always towards maximizing the benefit of the total system, i.e. the aggregate benefit of the members of the community.

The building of aluminium smelters and other power-intensive installations generally involves the construction of power plants, which entail considerable environmental impact, and hence effects on general welfare. For this reason, broad cost-benefit analytical assessments of such projects should be made before work begins on the projects. When a CBA is to be carried out on the impact of building an aluminium smelter on the economic system as a whole, it is necessary to take account only of the costs and benefits that will affect domestic parties, and not those that concern the foreign owners of the smelters. With this in mind, the cost and benefit items may be set out, roughly, as follows. It is assumed that full employment prevails at the time when the projects are undertaken.

Costs

- domestic start-up costs of related power-plant developments.
- operational costs of the power plants and the distribution system used to sell electric power to the aluminium smelters.
- environmental impacts, pollution and other external impacts.
- the crowding-out effects of the aluminium smelters.

Benefits

- higher wages for employees of the aluminium smelters and related companies.
- power companies' earnings from the sale of electricity.
- public revenues, direct and indirect, from the aluminium smelters.
- scrap value of the power plants after their lifetime ends.

It is not possible to assess the costs and benefits involved in all these elements, as this would require data that is not available regarding the operations of the companies involved, both in the present and in the future. It is also obvious that the cost of building the smelters themselves is borne by the foreign companies that own and run them. The construction projects themselves only have a beneficial effect on the domestic economy if the labour and capital involved would not be used in an equally profitable way somewhere else in the economy. Here it is assumed that there is little or no unemployment, as has generally been the case in Iceland over the past half-century, as is stated above. With full employment, the construction projects result first and foremost in the temporary transposition of jobs between occupational sectors. Under such circumstances, it is not possible to assume net macroeconomic effects other than the increased profit of the companies involved in the construction work, and higher wages of their workers, as compared with the situation as it otherwise would have been. If slack is present in the economy and there is unemployment, the effects could be far greater, since some of the workers who are employed on the construction work were probably previously without work. The rent of resources involved in the sale of electric power by power companies will have a positive macroeconomic effect, assuming that it would not be possible to sell the power to other production companies. Finally, both the construction and operation of the aluminium smelters result in negative external effects in the form of pollution and the disruption of untouched natural environment; this is on the debit side of the balance.

To compare costs and benefits that come about over the lifetime of a project, it is necessary to apply a discount rate. When carrying out a CBA of the macroeconomic profitability of aluminium smelter projects, it is most appropriate to employ a social discount rate, i.e. the discount rate demanded by society, regarding the social impact caused by use of the smelter. It is also appropriate to take account of the returns that could have been obtained from other investments.[34] Sometimes, however, it may be sensible to deviate from this point of view. Jón Þór Sturluson (2005) points out, for example, that when looking at older investments in power-intensive industry it is not possible to use ordinary discounting coefficients because the foreign capital that was raised for those investments would not have been available for other investments.[35] However, this does not change the fact that electric power generation in Iceland has yielded lower profitability levels than many other parts of the economy. The report by ParX (2007) on the future siting of Reykjavík Airport and a chapter of a book by Sigurður Jóhannesson (2008) contain detailed discussions of some theories that lie behind the determination of a communal discounting coefficient for public projects in Iceland, based on available market data. The conclusion in the ParX report is that a normal required rate of return in communal projects in Iceland is currently 5%, at fixed prices; with normal confidence limits, the rate should be expressed as 4-6%. Sigurður Jóhannesson (2008) also points out that a complete picture of the profitability of investments in heavy industry can

[34] This refers to the long-term required return on investment, not the marginal cost of capital. In the short term, the marginal cost of capital may deviate from the long-term required return.
[35] Jón Þór Sturluson (2005).

only be obtained by taking into account the tax concessions that heavy industry has generally received. The report by the Institute of Economic Studies (2007) contains a survey of the required rate of return in various countries (see Table 4-1). It should be stated that in France various discount rates are applied, depending on whether costs or benefits are involved. The rate in the former case is 5%; in the latter it is 8%, A comparison of the conclusions in the table and those of the foregoing discussion is compatible with the fact that capital costs in Iceland have generally been higher than those of the countries presented for comparison.

Table 4-1 Required return on investment in selected countries. Percentages.

Germany	3.0
Sweden	4.0
Netherlands	4.0
Finland	5.0
Britain	3.5
Norway	5.0
France	5.0 and 8.0

Source: Institute of Economic Studies (2007).

4.3.1 Macroeconomic costs and benefits of smelter construction in Helguvík and the enlargement of the Straumsvík smelter.

As is stated above (see table 3-1), the total cost of the aluminium smelter development in Helguvík and the enlargement of the smelter in Straumsvík, together with the power-plant investments and the laying of power lines, is estimated at ISK 400 billion. This includes construction of power plants by Landsvirkjun, Reykjavík Energy (OR) and Suðurnes Regional Heating (HS) in connection with the smelters, and also the cost to Landsnet for the construction of the electric power distribution system to the smelters, together with the construction cost of the smelters themselves. Based on a required rate of return of 5%, the cost is equivalent to ISK 325 billion. Even if this investment is spread over an eight-year period, it is clear that the scale of the project is very substantial.

One of the basic premises in calculations of the macroeconomic implications is whether or not slack is present in the economy at the time of the execution of the projects. In the following calculations, the general assumption is that there will be slack in the economy until the end of 2012, as was assumed in the forecasts that were specially made for this report by the Ministry of Finance. For comparison, the impact will also be estimated allowing for full employment during the construction phase; the contrast will illustrate the great difference depending on the state of the economy. However, as is stated above, there is every indication that there will be considerable unemployment in Iceland in the coming years.

Let us first consider the effect of these investments on the national economy. The largest part of the investments are spent on imported raw materials and equipment which have little or no effect on the economy. Domestic costs are estimated at about 30% of the total investment; about half of this sum is payroll cost. If there is no slack in the economy, then it is assumed that the net effect on the economy would be the companies' earnings less the direct costs borne by those involved in the construction projects. Net profit of companies in the construction industry is, on average, about 7.5% of their turnover, according to figures quoted from their annual accounts by Statistics Iceland. If there is slack in the economy, it is assumed that total wage costs associated with the projects, minus the shadow price (imputed price) of wages[36] plus the aforementioned profits will constitute their earnings. In addition, it is assumed that in a slack period, 1.8 jobs are created elsewhere in the economy for every job created in the construction of the aluminium smelters, and that those jobs will generate macroeconomic benefits of the same order as the direct jobs. This ratio of derived jobs is in accordance with the findings of the Economic Institute's report of 2005. Conclusions regarding the present value of the total investment, together with the estimated macroeconomic effects of the projects, based on various premises regarding required return on investment, are presented in Table 4-2.

Table 4-2 Present value of overall investment, with estimated macroeconomic effects of the projects, based on various premises regarding slack in the economy and required return on investment. ISK billions.

		Macroecon. effect	
Required return %	Pres. value of investment costs	No slack	Slack in first 4 years
3	348	16	62
5	325	15	59
7	305	14	56

Source: Institute of Economic Studies.

[36] The shadow price of labour is estimated here as unemployment benefit less the cost of public capital (16%), with 20% added to represent the opportunity cost of free time.

As can be seen from Table 4-2, the macroeconomic effect could vary greatly, depending on the degree of slack present in the economy.

The operations of aluminium companies will have a beneficial effect on the economy as long as their profitability levels are better than those of other companies. Admittedly, the aluminium companies are foreign-owned, so that only that part of this profit differential which remains in the country in the form of corporate tax can be considered as a direct earning item. According to a survey of companies' annual accounts by Statistics Iceland, average corporate profit in Iceland is 11% of turnover, while that of power-intensive industrial concerns is 17% of turnover. In the following calculations, it is assumed that the price of aluminium will be USD 2,000 per ton and that production costs will be ISK 1,660 per ton. It is also assumed that productivity of labour in the aluminium industry is one third higher than in companies in general, as may be expected on the basis of the difference in wages of workers in the aluminium smelters and general wage levels (see Table 2-1). Furthermore, it is assumed that for each job in the aluminium industry, wage turnover equivalent to 1.5 jobs in an aluminium smelter will be created in companies that are directly connected with the aluminium industry, i.e. engineering consultancies, transport and freighting companies and other service providers. When there is slack in the economy, and unemployment, it can be assumed that these effects will be seen in full; the situation is different when there is full employment, in which case no indirect or derived effects are expected. Thus, it is assumed that those who enjoy these indirect and derived effects will gain as much from dealing with the aluminium companies as they would have if they had dealt with other companies. Estimates of the scale of related work is based on expenditure by the aluminium smelters in Iceland in recent years, and is more or less in line with an earlier study by the Institute of Economic Studies (2005). In this estimate it is assumed that unemployment would be 1% less if the projects were undertaken, i.e. that about 2,000 fewer individuals would be without work. This represents a rather larger reduction of unemployment than is assumed over the construction period in the forecast by the Economics Unit of the Ministry of Finance. On the other hand, it is assumed that many more people would be involved in the projects, directly or indirectly, and therefore a substantial proportion of them would presumably move across from other jobs. It is also assumed that the labour force on the labour market would grow by 1% per year. Table 4-3 presents the macroeconomic effects of the operations of the aluminium smelters, based on the premises outlined above.

Table 4-3 Present value of the macroeconomic effects of the operations of the aluminium smelters. ISK billions.

Required returns %	Smelters	Derived jobs	Higher tax revenues	Total
3	37	2	17	55
5	27	2	4	32
7	21	2	0	23

Source: Institute of Economic Studies.

It is difficult to estimate what the power companies' earnings from electricity sales to the new aluminium smelters would be. Contracts on power prices are confidential matters between purchaser and seller. In addition, power prices are to some extent linked to world aluminium prices, and fluctuations in the exchange rate of the króna can also influence actual earnings from power sales. However, there is no way of estimating the profitability of power-development projects without any premises regarding electricity prices. The method adopted here is to use materials from the annual accounts of Landsvirkjun for the years 2006 and 2007, taking into account changes in aluminium prices and the exchange rate of the ISK. Using the figures of the annual accounts regarding earnings from power sales to power-intensive industry and variable costs, it can be expected that the contribution margin from power sales to the industry, less net production costs,[37] could lie in the range ISK 1.4 milljón/GWh to ISK 1.6 milljón/GWh.[38]

The present value of the investments in the power-development projects may be calculated on the above premises. Looking ahead to the year 2055, since the lifetime of the aluminium smelters may be taken as not less than 40 years, the following figures are obtained regarding returns on the investments over and above the required rate of return, within the range that can be assumed for required returns and contribution margin.

[37] The item "Power" is subtracted from earnings, together with one third of other costs and distribution costs, and it is assumed that this will be spread equally across all production. Other operating expenses, i.e. in connection with studies and 2/3 of distribution costs and other expenses are calculated as being borne by the present production.

[38] A certain variability in the contribution margin is assumed in these calculations, due to uncertainty regarding electric power prices, costs, the price of aluminium and the exchange rate of the ISK.

Table 4-4 Present value of investments in power plants for the Helguvík smelter and the enlargement of the Straumsvík smelter, based on various premises regarding contribution margin in power sales and required rates of return.

Required return, %	Contr. margin in power sales, ISK m /GWh		
	1.4	1.5	1.6
3	55	63	78
5	-2	3	14
7	-33	-30	-22

Source: Institute of Economic Studies.

Obviously, the lower the required rate of return and the higher the contribution margin, the higher the profitability. Taking the mean of the scale regarding contribution margin, the projects will be profitable if the return on investment is 5%.

Finally, consideration must be given to the environmental impact accompanying the projects. The production of aluminium is accompanied by the release of substantial quantities of greenhouse gases. This causes environmental damage which must be taken into account when assessing macroeconomic viability. Certain environmental damage must also be allowed for in the construction phase, e.g. in view of the land that is disturbed, the siting of the smelters themselves and the high-tension power-supply lines. These impacts should be set off against the beneficial effects of the projects. Without special studies, it is impossible to say anything about the scale of such impacts. To allow oneself to draw conclusions on the basis of studies made of the Kárahnjúkar area, which were referred to above, is not a viable option, since the circumstances there were totally different. Table 4-5 presents a summary of the macroeconomic effects of aluminium smelter projects based on various premises regarding the required return on investment. It is assumed that there will be slack in the economy until the end of 2012, and the present contribution margin of power sales to heavy industry has been used as a basis (cf. Table 4-4).

Table 4-5 Present value of macroeconomic effects of the aluminium smelter projects, ignoring environmental costs, assuming the existence of slack in the economy until the end of 2012 and contribution margin of power sales to heavy industry of ISK 1.5 million/GWh. ISK billions.

Required return, %	Construction	Operation	Jobs derived from operation	Total
3	62	116	2	180
5	59	34	2	95
7	56	-9	2	49

Source: Institute of Economic Studies.

For comparison with the figures in Table 4-5, it may be mentioned that if a full employment level is assumed during the construction and operation phases, with a 5% required return on investment, the aggregate macroeconomic effect of the projects, at current prices, would be about ISK 43 billion, i.e. about ISK 50 billion lower than shown in Table 4-5. This highlights the large difference in the macroeconomic effects of further development of the aluminium industry depending on how they are timed in the context of economic cycles. This finding is in line with the conclusion presented in Section 3 that the macroeconomic benefit of the projects would be far greater when there is slack in the economy. Economic slack reduces the negative impacts of the projects on the current account, the exchange rate and interest rates, in addition to which it also enhances their beneficial economic effect. If, on the other hand, such projects are undertaken during a period of inflationary expansion, it is likely that their beneficial effects will be far smaller, since they would result in greater economic imbalance and stimulate demand and inflation. If a decision on undertaking the projects is taken despite expansionary tendencies in the economy, then it is of vital importance that this be taken into account in economic policy so as to create sufficient flexibility to accommodate the projects, e.g. by cutting down on other public projects or by raising taxes. The impact on the ISK in such cases would have to be given careful attention.

4.4 Summary

The findings of this cost-benefit analysis indicate that the planned construction of an aluminium smelter in Helguvík and the enlargement of the smelter in Straumsvík would have a considerable effect on the national economy. Both the construction projects themselves and the operation of the companies would create employment and generate profit. In terms of the present state of the Icelandic economy it may be expected that the net macroeconomic benefit could amount to about ISK 95 billion at current prices, based on a 5% required return on investment.

However, two points should be borne in mind regarding these findings. Firstly, no account has been taken of the environmental cost; it is extremely difficult to guess what this would be without special studies being made of, for example, the value of the environment which would be disturbed or destroyed by the developments. And secondly, no account is taken of the fact that all large-scale investments that are undertaken at a time of unemployment and economic contraction are positive for the economy and result in macroeconomic benefit. A fuller picture would be obtained if it were known what other projects the public sector could consider undertaking, directly or indirectly, at the same time, e.g. other types of employment projects or improvements in the transport system in Iceland, such as bridges, roads or tunnels. The macroeconomic benefits of the aluminium smelters and power plants could then be compared with that of these other projects, and in this way it could be ensured that the alternatives that would generate the maximum benefit would be chosen.

The magnitude of macroeconomic effects depends to a large extent on the premises chosen regarding the required return on investment, the prices of electric power and aluminium and whether or not there is slack in the economy. If substantial crowding-out effects of these projects are to be avoided, it would be better to select a time for them when there is considerable unemployment, as is forecast in the coming years. Otherwise, measures must be taken to accommodate the projects in the economy by cutting back on other public works or by tax increases. In the light of the experience of previous years, it is of particular importance to give careful consideration to the effects that the projects could have on the exchange rate of the ISK and how these possible effects would be compatible with public economic policy.

5. The legal framework and control of the use of natural resources

Aluminium smelters in Iceland use electricity which is generated by hydroelectric or geothermal power plants. A large part of the hydropower and geothermal rights in Iceland is under public control in one way or another. This is partly because of the delineation of public lands, private land and grazing land in legislation, where it is specified that the state is the owner of land and all appurtenant rights and perquisites. Also, central government and the local authorities own many of the real estate properties which have hydropower or geothermal exploitation rights, and also many land units that are considered as having substantial natural resources, including groundwater, geothermal heat or hydropower potential. Furthermore, contracts with private parties have conveyed usage rights pertaining to hydropower and geothermal resources to the state, with the result that the ownership of energy resources has increasingly been transferred to the state.[39] The Director of the National Energy Authority has estimated the possible division of ownership of high-temperature resources as being 46% in public lands, 42% in public ownership of other types and 12% in private ownership.[40]

5.1 The Water Act

The Water Act, No. 20/2006, applies to running and standing water, whether it is above ground or underground. This act was to take effect on 1 November 2008, but its commencement has been postponed until 1 July 2010. The objective of the Water Act is to establish the ownership of water and promote the rational, efficient and sustainable utilization of water resources. Under the Water Act, in all utilization of water rights, care is to be taken not to disrupt water, water channels, the water biome, ecological systems or landscape more than is necessary. All immovable property, including public lands, is accompanied by the right of ownership of the water that is on it or under it, or which runs through it. Property-owners' rights of utilization of energy is restricted by the provision that no person is thereby deprived of the use of water and no person shall be caused unreasonable difficulty regarding such use, and the water used in this way may not be spoiled so as to cause any person substantial inconvenience. The permission of the National Energy Authority is to be sought in order to set up a water supply or alter a water supply if the area of the reservoir following the operation is 1,000 m2 or greater when the water is at its highest level. If the water supply is

[39] Oral communication with Sigurður Líndal, Professor of Law, and Birgir Tjörvi Pétursson.
[40] Draft legislation amending certain statutes in the field of natural resources and power.

part of the harnessing of a river for electricity generation, the supply permit shall be regarded as part of the power-development licence under the Electric Power Act, and permission is to be sought under that act.

5.2 The Electric Power Act

The Electric Power Act, No. 65/2003, applies to electrical generation and distribution and the sale of electricity, irrespective of the energy source. The objective of the Electric Power Act is to promote a macroeconomically efficient electric power system, so supporting economic activity and maintaining settlement on the land. A licence from the Minister is required for building and operating electric power plants. Before a licensee is able to start development work on privately-owned property under the licence, agreement must have been reached with the owners of the land and the owners of the power resources regarding recompense, or a decision on compulsory possession must have been taken. If no agreement is reached on recompense and compulsory possession has not been requested within 90 days of the issue of the licence, it expires. The same applies to the utilization of natural resources in public lands, as appropriate. If the company does not reach agreement with the landowners or owners of the natural resources in connection with development under the Electric Power Act, including recompense for use of land, water rights, geothermal energy rights or other natural resources, the Minister may take over the necessary land, quality of land, man-made structures, facilities and other rights owned by the landowner by compulsory possession and make them over to the company in question. The Minister may authorise the company to exercise the compulsory possession, in which case it bears all costs involved in the compulsory possession. The Minister may enter into contracts with the distribution company and other parties authorised under the Electric Power Act to carry out developments on land owned by the state regarding recompense for land and the quality of land involved in each individual case. The parties in charge of the property shall be consulted.

5.3 The Natural Resources Act

The Natural Resources Act, No. 57/1998, with subsequent amendments, applies to the study and utilization of natural resources in the earth; under this Act, the right of ownership of resources in the earth pertains to property.[41] On public land, however, natural resources in the earth are the property of the Icelandic state unless other parties are able to demonstrate that

[41] Hereinafter referred to as the Natural Resources Act.

they hold a right of ownership. Utilization of natural resources in the earth is subject to a licence from the Minister of Industry, whether what is involved is the utilization of natural resources in privately-owned land or in publicly owned land, and the landowner does not have a priority right to a utilization licence regarding natural resources in his own land unless he has previously received a licence to carry out studies. Before the holder of a utilization licence begins extraction on privately-owned land, he must have reached agreement with the landowner of the land regarding recompense, or received authorisation for compulsory possession. When utilization licences are granted, care is to be taken to ensure that the utilization of natural resources in the earth is advantageous from a macroeconomic point of view and utilization that has already commenced in the immediate vicinity must be taken into consideration. If the Minister considers that an applicant for a utilization licence does not meet these requirements, he may refuse to grant the utilization licence or set special conditions in the utilization licence reflecting this situation. The Minister of Industry may enter into a contract with the holder of a utilization licence regarding recompense for natural resources in land owned by the state following consultation with the party in charge of the property.

Draft legislation was submitted to the Althingi on the amendment of the Natural Resources Act at its 133rd legislative session in 2006-2007, and it is receiving attention in the Committee on Industry. The bill allows for an augmentation of the scope of the Natural Resources Act to cover the use of hydropower for electricity generation. Provision is also made by which the issue of licences for the study and utilization of resources would be transferred from the Minister of Industry to the National Energy Authority. Furthermore, the decision on whether resources in the earth, and hydropower resources on privately owned land would be studies or utilized would lie entirely with the owner of the property in question, who would be able to enter into a contract on study and utilization with any party of his choice, though subject to the condition that that party meet the other conditions imposed by law and acquire the necessary licences. On public lands and land owned by the state, the permission of the National Energy Authority is required for study and utilization, and also the permission of the representative of the state who exercises control over the area in question.

The committee report submitted with this bill proposed that the Althingi formulate long-term policy regarding the study, protection and utilization of the natural resources covered by the Act No. 57/1998, i.e. minerals, geothermal energy, groundwater, thermophilic bacteria in hot springs and the hydropower potential for electricity generation. A comprehensive long-term policy of this type, however, could mean extensive restrictions on the right of ownership and business development, since it is conceivable that areas or resources that would be placed under protection in the proposed policy, would be in private ownership and that the possibility of their being utilized would be reduced by the protective cover. Even though it is recognized that the legislature may impose general limitations on the right to dispose of property without any compensatory liability applying, when communal interests in the broadest sense are being protected, the committee argues that this authorisation does not involve permission to suspend completely the rights that reside, constitutionally and in general terms, in the title of ownership. Therefore, the committee says, this is a difficult course of action.

The committee proposes that when this policy is drawn up, particular attention be given to the findings of the studies and assessments of possible power-plant development options that were submitted in the report on the Stage 1 of the framework plan on the utilization of hydropower and geothermal energy, and also the findings of the studies and assessments of Stage 2 of that framework plan, which is supposed to be made known in 2009. The committee calls for a definition and enumeration in the utilization section of the plan of the areas and/or resources that are regarded as being exploitable for power production without substantial environmental impacts. In the protection section of the plan, there should then be a definition and enumeration of the areas and/or resources that are to be protected. In order to resolve cases that may arise before future policy has been formulated, the committee proposes that it be permitted to grant new study and utilization licences for alternatives in Environmental Category A in Stage 1 of the framework plan and for those alternatives in Environmental Category B regarding which no special comments have been made on the grounds that their environmental value is regarded as important. It is also proposed that, with the approval of the Althingi, it should be possible to issue further study and utilization licences for areas that are not listed with the unconditional alternatives in Environmental Categories A and B in Stage 1 of the framework plan, though not until studies and assessments of the same type as those on which the conclusions of the framework plan are based have taken place.

In its report, the committee also made proposals on how selection should be made between applications for study and utilization licences under the Act No. 57/1998, on the study and utilization of natural resources in the earth (the Natural Resources Act). These state that four main methods have been used overseas for allocating licences for studies and utilization: the comparison method, the auction method, the lottery method and the ‘first come, first served’ method. When the comparison method is used, the choice is made between the applicants on the basis of which of them best meets the conditions or demands made, e.g. regarding financial strength, technical capability, knowledge and experience in the relevant field, work schedule, operating plan, future vision, extent, utilization of the energy resource, the impact on the environment, services, price, quality, investment, etc. The advantages of using this method are, principally, the fact that it makes it possible to choose between applicants on the basis of particular criteria which it is decided in advance are to carry the most weight regarding the choice. On the other hand, the government faces the requirement of defining its criteria and aims in advance. At the same time, the government is given the opportunity of seeing what companies are prepared to do in order to obtain the licences, and thus it may be possible to achieve certain subsidiary aims. The flaws of this method, on the other hand, are that it may be very time-consuming to assess the qualifications of the applicants and difficult to determine which of them is the best, and to cite relevant reasons for this choice.

Under the auction method, the licence in question is awarded to the applicant that is prepared to pay the highest price for it. It may therefore be considered that the parties that receive licences pay the community for the use of the limited resource. There are many different ways of putting this into practice. The advantages are, particularly, that it is a simple and transparent method, and because of how simple it is to compare bids, there is little likelihood that the outcome will be criticised. On the other hand, there has been considerable debate about the danger that a high bid price will be recovered directly through pricing. This, however, will be determined to a large extent by the competition that exists on the market in question.

The lottery method is a simple, though random, means of choosing between applicants. It guarantees them all the same chance, assuming that it is executed properly. Various conditions can be set for participating the lottery, and it is also possible to charge a fee for the licences on offer. This method may also be applied in other ways, e.g. in a draw between applications that are considered equally good. The main flaw in the method is that it involves the giving away of items of value, since it is not really likely that a realistic payment will be received for the resource in question. If licences are assignable, it is likely that the party that receives the licence will sell it to the highest bidder. It is also rather unlikely that the party best qualified to utilize the resource will the one that is drawn out by lot.

The final method consists of simply granting the licence to the party that is first to apply for it. This is a simple method which makes it possible to guarantee transparency and equality by advertising in advance when and where the licence will be granted. As with the lottery method, there is however the risk that real value will not be obtained for the resource and that the licence will be sold to the highest bidder. Also, there is no certainty that the party receiving the licence will be the best qualified to make use of it. Furthermore, it can be expected that applications will be made for the licence purely to prevent others from gaining access to the resource in question. This process can lead to over-investment and waste.

In the view of the committee, the best approach would be to use the first two methods in Iceland, i.e. the comparison method and the auction method or, as appropriate, a combination of the two. The committee is of the opinion that the same rules should not apply to licensing of resources in privately-owned land, on the one hand, and state-owned land, on the other, whether the land involved is public land or land owned by the state on the basis of traditional ownership rights. When land is privately owned, the owner himself ought to decide whether, and with whom, contracts are made regarding the study and use of resources. In the case of land owned or administered by the state, the licences should be advertised, with appropriate conditions stated. The next step would then depend on whether there was one applicant or more than one. In the former case, a contract would be made for a suitable recompense; in the latter case an auction would be held, the highest bidder receiving the licence. The general principle would be that a study licence would confer priority right to utilization, though without excluding the possibility of making study the independent purpose of the auction.

The Act No. 58/2008 introduced some amendments to legislation in the field of natural resources and energy. The state, local authorities and enterprises that are wholly owned by them, are not permitted to assign permanently, directly or indirectly, the right of ownership of geothermal energy, groundwater over and above the needs of households and farms, and water with a harnessable generating potential of more than 10MW. Notwithstanding this provision, allowance is made for the assignment of these rights to the state, local authorities and enterprises that are wholly owned by them, in addition to which it is possible to grant temporary utilization rights for up to 65 years at a time. The Prime Minister is empowered to negotiate contracts for the rent of utilization rights under the control of the state.

5.4 The effect of various premises on the temporary rental of water rights

Clearly-defined ownership rights are a basic premise for markets to operate efficiently. Price formation of assets on a market depends on it being possible to assign the assets freely without the threat of confiscation by other parties. All restrictions of the right of ownership and utilization of natural resources prevent the possibility of their prices being formed in a normal way and reflecting the true value of the resources.

The basic principle of the current legislation in the sphere of natural resources and energy states that the landowner owns the resources and energy found on the land. On the other hand, it is debatable how far down into the ground or how high up into the air this right of ownership extends. In addition, the state has considerable authorisation to take possession of the resources in question, and the exploitation of the resources is dependent on permission from the Minister of Industry. The Act prescribes the efficient utilization of resources and requires that environmental considerations be observed. Assessments of the environmental impact of power-plant developments have always involved the analysis of the possible effects on the environment, but that part of the environment that is in fact disturbed or destroyed is not evaluated in monetary terms. Therefore, decisions regarding power-plant developments have always been supported by subjective assessments by decision-makers to the effect that the gains involved will be greater than the value of the environmental quality that is lost.

The Water Act and associated legislation reflects the government's caution and fear of losing the ownership of energy resources to foreign parties. In this way, the government believes it is guaranteeing Icelandic households and companies reliable access to power supplies for the future. The Act No. 58/2008 placed even stricter controls on the right of ownership and utilization of energy resources than before, since the state and local authorities are not permitted to sell or assign natural resources permanently. Furthermore, the Prime Minister is charged with determining rent for utilization rights under the control of the state. It must be considered questionable whether such price-control on the part of government authorities, which are often guided by considerations other than those of the maximization of profit, will result in a rent that will reflect the true value of these rights. On the other hand it is clear that the government can, theoretically, ensure the rational timing of power-development projects on the basis of economic cycles and ensure that environmental issues are taken into consideration.

If temporary leases of water rights for power generation are employed, attention must be given to various things. The length of such leases is of great importance, the general rule being that the longer the lease, the greater the efficiency in the utilization of the resource. This is because the longer the term of the lease, the closer the conduct of the parties utilizing the resource will resemble the conduct of owners. As the end of the lease period approaches, there is a danger that the lessee will take decisions that could damage the long-term interests of the owners of the resources who have rented them out. In general, it can be said that the more encumbrances or restrictions imposed in the lease, the less efficiently the economic incentives will operate in the direction of efficient utilization. The idea behind a lease is to retain ownership of an asset while allowing others to make use of it. Rental income is the fee that the lessee is prepared to pay for the use of the resource.

5.5 Levies for environmental impact; other methods

In Economics there are well-known methods, theoretical and applied, for remedying external impacts that consumption or production by one party in an economic system may have on others. Emissions of carbon dioxide are the main aspect of the external effects and the damage that aluminium smelters cause the community, and in fact the entire world, after they go into production. One of the ways of making aluminium smelters responsible for the peripheral damage they cause involves the use of emission (pollution) quotas, emission taxes and emission permits which can be traded on the market. All these methods demand a great deal of certainty regarding the effect and magnitude of these external impacts in order to arrive at the most efficient way of dealing with them for the economy as a whole. The legislature can also influence the external effects in the economy, for example by clearly defining ownership rights and issuing regulations on emission standards.

5.6 Ownership rights

Clearly defined ownership rights means that the rights are defined for all categories of asset, ad that they are applied, the owner bearing the full costs and enjoying the full benefits of the asset. Moreover, the right of ownership must be assignable so that it is possible to buy and sell the assets concerned on the market. In order that the owners have an incentive to preserve their assets, it must also be guaranteed that they cannot be confiscated.

Coase (1960) demonstrated that if the right of ownership is clearly defined and there is no transaction cost, the original disposal and ownership of resources will not affect the most efficient solution for the economy as a whole. Under such circumstances, the players in the economic system will agree between themselves that the right to cause negative consequences for others, e.g. in the form of pollution, will end up in the hands of those who value it most highly, i.e. those who are prepared to pay the most for the right to pollute. Nevertheless, Coase himself pointed out that a world without transaction costs is an extremely unrealistic proposition, since transaction costs are all the costs associated with effecting transactions between parties, including the time spent on negotiations and the cost of actually making the contract, monitoring costs, the cost of finding the contracting parties, etc. In a world of transaction costs, the original right of ownership is therefore crucial for the efficiency of the final result regarding the distribution of resources. If the transaction cost his high, it will not be a desirable solution for the economic system that the players agree among themselves as to who is to have the right to cause others economically unfavourable effects.

Coase’s theories can be applied to Icelandic aluminium smelters and their polluting emissions. If the right of ownership is defined in such a way that the smelters have the right to pollute, then it will depend on the transaction cost whether or not the players in the economic system will pay them to pollute less. If, on the other hand, the right of ownership is defined in such a way that individuals in the economic system have the right to demand a clean atmosphere, then it will also depend on the transaction cost whether the aluminium smelters will pay each and every one of them for the right to pollute. Because the negative effects of aluminium smelters on each individual citizen are normally very small, on the other hand, it can prove to be a very difficult matter for these parties to unite and stand as a single entity against the aluminium smelters. The transaction cost to them may simply be greater than the benefits of taking the measures necessary. Consequently, there is a danger that pollution will be greater than the level that would be most advantageous for the economic system as a whole, and therefore other methods must be sought for reducing polluting emissions from the aluminium smelters.

5.7 Pollution (emission) taxes

The state is able to take measures to make the players in the economic system take account of the marginal damage (‘negative externalities’) they cause others through their activities. The marginal damage to the community caused by aluminium producers is the difference between the marginal cost of production borne by the community as a whole and the marginal costs borne by the producers themselves, ‘marginal costs’ being defined as the costs resulting from the production of one unit in excess of a specific production volume. In the case of aluminium producers, the marginal damage they cause the community takes the form of the pollution they emit in the course of production. Pigouvian taxes are taxes that fully take account of this marginal damage and therefore encourage producers to consider the marginal social cost resulting from their production. In the case of aluminium producers, Pigouvian taxes therefore function as a sort of emissions tax or pollution tax.

Fig. 5-1 below shows how Pigouvian taxes can be applied to limit production, and hence polluting emissions. If the producers do not take pollution into account, then the volume of production will be determined where the marginal cost is equal to the marginal benefit, i.e. at quantity M0, the marginal benefit being the benefit to the producer of producing one extra unit. Imposition of a Pigouvian tax is equivalent to forcing the producer to take account of the social marginal cost of their production. In this case, the production value will be determined where the social marginal cost (SJK) is equal to the marginal benefit of production, i.e. at quantity M1.

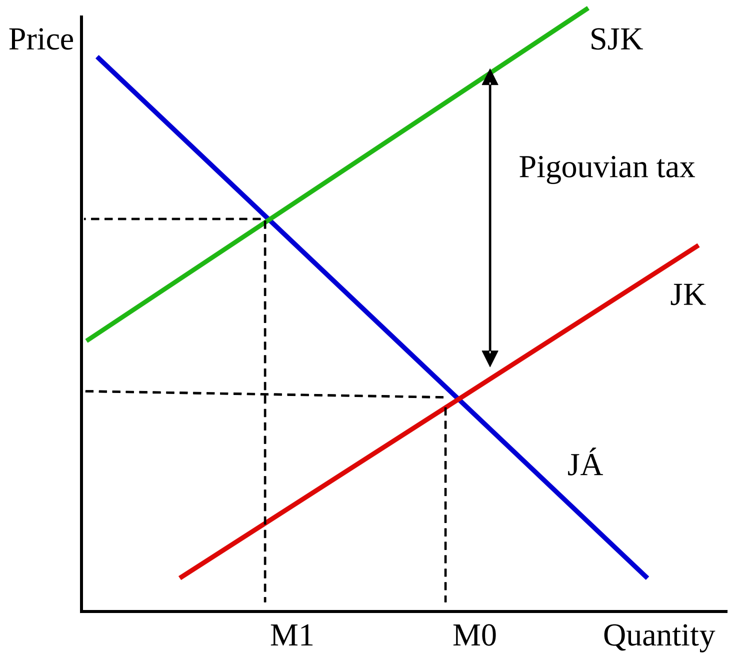

Fig. 5-1 Pollution tax.

Flat pollution taxes do not at all mean that it will be equally expensive for all producers to cut their pollution. On the contrary, flat taxes mean that those producers for whom cutting production is cheapest will cut more, proportionally, than those whose anti-pollution measures are already expensive. A pollution tax of the type discussed here, on the other hand, produces an efficient outcome for the economy.

Theoretically, pollution taxes are an extremely efficient and effective solution. In practice, however, it may prove very difficult to determine exactly how high the tax should be in order to achieve a pollution level that is most acceptable for the community. The fact that the production companies have far better data than the government regarding the costs they bear of pollution controls, i.e. that information is asymmetrical, means amongst other things that the transaction cost of devising the correct tax will be great. In addition, in most cases it proves extremely difficult to assess accurately the marginal damage suffered by the community as a result of polluting emissions. In the case of aluminium producers, this consists of the release of carbon dioxide into the atmosphere, which is much more of a global problem than a local problem experienced by those who live close to the smelters. It is known that the aluminium industry in Iceland releases about 1.5 tons of carbon dioxide for each ton of aluminium produced, and that the global aluminium industry is responsible for about 1% of releases of carbon dioxide in the world, including the volumes released in the course of raw material freighting.[42] In 2007, the production capacity of the Icelandic aluminium industry was 438,000 tons per year. On the basis of this production volume, the Icelandic aluminium industry releases just under 660,000 tons of carbon dioxide into the atmosphere each year. However, the quantity of emissions is not enough to devise an efficient pollution tax: for that, it is necessary to have a valuation of the marginal damage which this pollution causes to the community, i.e. the real cost borne by the community due to the emissions. Account must be taken of the fact that what is of crucial importance is not the flow of carbon dioxide out into the atmosphere, but the accumulation of the gas in the atmosphere, as it remains there for a long time. The effect of the carbon dioxide that is released today is not apparent, and will not be fully apparent, until years or decades have passed. The effect on life on earth and on the health of mankind of pollution that is released into the atmosphere is not fully foreseeable.

5.8 Assignable pollution permits

Pollution permits provide for a pre-determined permissible quantity of polluting emissions, or for the accumulation of such emissions in a specified and delineated area. In fact, the permits create a market for a permitted quota of pollution and a market price for each unit of

[42] Viðskiptablaðið, 23 April 2008.

pollution, determined by supply and demand for the permits. In order for a market in pollution permits to serve its purpose, the right of ownership of the permits must be clearly defined and there must be effective supervision to ensure that pollution is within the stated limits. It must be ensured that it will be more expensive for producers to pollute more than they are permitted to do than to purchase permits on the market. It is possible to impose this condition by means of severe fines for unlawful pollution. In addition, the time-frame of the permits must be defined in advance.

Pollution permits can either be divided between producers in a particular area, e.g. according to their proportions of the total production volume, or evenly between them, or else they can be sold by auction. Permit holders can then use them themselves or trade them on the market. Those producers that do not use their full permits can therefore sell the remainder to others.

Assignable pollution permits encourage producers to reduce their polluting emissions by installing extra anti-pollution equipment, since the underlying market price of the permits will result in additional opportunity costs of production. Those producers who bear low costs of anti-pollution measures will therefore reduce their emissions by a large amount, proportionally, and sell their permits on the market to other producers who have high anti-pollution costs. Producers whose anti-pollution costs are high will therefore keep hold of their permits and even purchase additional permits on the market from producers who are able to install anti-pollution equipment in the least expensive possible way. This method will achieve the permitted volume of pollution in the most economically efficient way. Thus, decisions on the siting and design of anti-pollution equipment is transferred from the government to the private companies. Experience shows that in this way it is possible to reduce pollution to the same extent as by other methods, but with far less expense.

As is stated above, polluting emissions from aluminium smelters are far more of a global problem than a local problem of the Icelandic nation. A domestic market for pollution permits would place burdens on Icelandic aluminium smelters, in comparison with those abroad, and so weaken their competitiveness on the world market. The best solution to the global problem of pollution from aluminium smelters would therefore be to establish a global market for pollution permits for the industry.

5.9 Summary

A large part of the electrical power generated in Iceland is derived from hydropower sources; consequently, the legal framework of water utilization is of great importance regarding the future potential for power generation in the country. The aim of the Water Act is to clarify and define the right of ownership over water. From a pure point of view of economic efficiency, it is vital that the right of ownership be clear and as complete as possible, in the sense that owners of these rights be granted the broadest possible authorisation to exercise their right of utilization of the resource. In this connection, the duration of leasing rights is of great importance. The longer the lease, the more economically efficient the utilization of the resource will be. Also, it is important to reduce restrictions on rights so as to make it possible to respond to new circumstances and opportunities that may arise in future. Auctions could be used when assigning rights held by the state in order to ensure that the maximum returns on the resources will accrue to their owners.

Various methods can be used to adjust for market failure in the utilization of natural resources. Corrective taxes can be applied to remove negative externalities in the exploitation of natural resources. This method can give good results in many situations, but it requires a great deal of skill and knowledge on the part of those who apply it. Another method is to establish a well-defined system of ownership. If the system of ownership is applied rationally, the companies themselves ought to solve the problems of externalities in their operations. In a way, the new Water Act can be seen as a step in this direction. If assignable pollution permits are to be used, then it is important to assure that such permits can be traded on a global market and not merely within Iceland, as this would damage the competitive position of the aluminium companies that operate in this country as compared with aluminium companies elsewhere.

6. Bibliography

Alcan á Íslandi. Vefslóð http://www.alcan.is

Alcoa á Íslandi. Vefslóð http://www.alcoa.is

Alunet, vefslóð: http://www.alunet.net/shownews.asp?ID=1957&type=3.

Alþingi: Frumvarp til laga um breytingu á nokkrum lögum á auðlinda- og orkusviði, Vefslóð: http://althingi.is .

Alþingi: Lagasafn: Auðlindalög, Vefslóð: http://althingi.is

Alþingi: Lagasafn. Vefslóð: http://www.althingi.is ,

Alþingi. (2007). Frumvarp til laga um breytingu á nokkrum lögum á auðlinda- og orkusviði. 135. löggjafarþing 2007-2008, þingskjal nr. 688, 432. mál. Vefslóð: http://althingi.is

Axel Hall og Ásgeir Jónsson. (2001). *Áhættan við álið*. Viðskiptablaðið, mars 2001.

Boardman, Anthony E., Greenberg, David H., Vining, Aidan R. og Weimer, David L. (2006). *Cost-Benefit Analysis. Concepts and Practice.* 3. útgáfa. Bandaríkin: Pearson Prentice Hall.

Bonneville Power Administration, vefslóð: http://www.bpa.gov/power/pl/regionaldialogue/aluminum_industry_impact_2005.pdf

Bothe, David. (2004). *Kontingente Bewertung von Umweltkosten als Entscheidungsgrundlage Das Kárahnjúkar-Wasserkraftwerkprojekt auf Island*. Kölner Forschungen zur Wirtschafts- und Sozialgeographie. Selbstverlag im Wirtschafts- und Sozialgeographisches Institut der Universität zu Köln. Köln.

Carbon Positive, vefslóð: http://www.carbonpositive.net/

Coase, Ronald. (1960). The Problem of Social Cost. *Journal of Law and Economics*, október 1960, bls. 1-44.

Cropper, Maureen L. og Oates, Wallace E. (1992). Environmental Economics: A Survey. *Journal of Economic Literature*, Vol. 30, No. 2, bls. 67-740.

CRU International Ltd (2007): The long term outlook for aluminium. London.

Energy Information Administration, vefslóð: http://www.eia.doe.gov/emeu/international/elecprii.html.

Friðrik Már Baldursson (2001) „Náttúran, stóriðja og nýskipan raforkumála“, erindi á ráðstefnu Viðskipta- og hagfræðideildar Háskóla Íslands, (31. október).

Geir Guðmundsson (2006). Sjávarorka og möguleg virkjun sjávarfalla á Íslandi. Erindi flutt á Orkuþingi 2006.

Gérard Bélanger og Jean-Thomas Bernard (2007): Subsidies for aluminum producers: Benefits that don’t add up, *Economic Note*, Montreal Economic Institute, http://www.iedm.org/main/show_mediareleases_en.php?mediareleases_id=141

Gielen, D. J. (1998). *The Future of the European Aluminium Industry: a MARKAL Energy and Material Flow Analysis*. Vefslóð: ftp://ftp.ecn.nl/pub/www/library/paper/1998/alcon2.pdf

Grjotheim, Kvande og Zhuxian: Key Improvements to Hall-Héroult since the end of world war II. *JOM* , nóvember 1994, bls. 32-35.

Gunnar Haraldsson, Gylfi Zoëga, Sigurður Jóhannesson og Sveinn Agnarsson. (2007). *Vinnumarkaður og stjórn peningamála.* Ársskýrsla Hagfræðistofnunar Háskóla Íslands.

Gylfi Zoëga (2008): Stofnanaumhverfi, frumkvöðlakraftur og vægi „grundvallaratvinnuvega". Í Valur Indimundarson (ritstj.): *Uppbrot hugmyndakerfis: Endurmótun íslenskrar utanríkisstefnu 1991-2007*. Reykjavík: Hið íslenska bókmenntafélag.

Hagfræðistofnun. (2003). *Mat á þjóðhagslegum kostnaði vegna líkamstjóns í umferðarslysum.* Skýrsla nr. R03:01. Marías H. Gestsson og Ragnar Árnason. Reykjavík: Hagfræðistofnun Háskóla Íslands.

Hagstofa Íslands, vefslóð: www.hagstofa.is

Hanley, Nick, Shogren, Jason F. og White, Ben. (2007). *Environmental economics in theory and practice.* 2. útgáfa. New York: Palgrave Macmillan.

Hindriks, Jean og Myles, Gareth D. (2004). *Intermediate Public Economics.* 2. útgáfa. Háskólafjölritun.

Hull, John C. (2006). *Options, Futures, And Other Derivatives.* 6. útgáfa. New Jersey: Prentice Hall.

Iðnaðarráðuneytið, vefslóð: http://www.idnadarraduneyti.is/media/Acrobat/KPMG_skyrsla.pdf

Iðnaðarráðuneytið, vefslóð: http://www.idnadarraduneyti.is

Iðnaðarráðuneytið (1996), *Framtíðarskipun orkumála, tillögur um breytingar*.

Jón Þór Sturluson, (2005): ,,Afkoma Landsvirkjunar og þjóðhagsleg áhrif stóriðju", í Sigrún Pálsdóttir (ritstjóri), *Landsvirkjun* 1965- 2005.

Landsvirkjun (2007): Ársreikningur Landsvirkjunar 2007, Vefslóð: http://www.landsvirkjun.is

Landsvirkjun, vefslóð: http://www.landsvirkjun.is/search.asp?catID=9&SearchType=Simple

Lienhoop, Nele og MacMillan, Douglas. (2007). Valuing wilderness in Iceland: Estimation of WTA and WTP using the market stall approach to contingent valuation. *Land Use Policy* No. 24, bls. 289–295.

Magnús Fjalar Guðmundsson. (2003). *Áliðnaður og sveiflur í útflutningstekjum*. Peningamál 2003/3, bls. 41-47.

Morgunblaðið 18. janúar 2000: Arðsemin er lykilatriðið.

Norðurál – Century Aluminium á Íslandi. Vefslóð: http://www.nordural.is

OECD (2006): Economic Outlook, 27-30.

OECD (2007): Iceland, Economic survey, 2007.

Orkustofnun. Vefslóð: http://www.orkustofnun.is

Orkuveita Reykjavíkur. (2007). *Orkuveita Reykjavíkur – Samstæða - Ársreikningur*. Vefslóð: http://www.or.is

Páll Harðarson. (1998). *Mat á þjóðhagslegum áhrifum stóriðju á Íslandi 1966-1997*. Fjármálatíðindi, 45. árgangur síðara hefti, bls. 153-167.

Richard Conway (2006). *The economic impact of the Washington State Aluminum Industry*, http://www.bpa.gov/power/pl/regionaldialogue/aluminum_industry_impact_2005.pdf

Ríkisútvarpið, vefslóð: http://ruv.is/heim/frettir/frett/store64/item73762/

Sameinuðu þjóðirnar, *Tax Incentives and Foreign Direct Investment*, (New York og Genf, Sameinuðu þjóðirnar, 2000), http://www.unctad.org/en/docs/iteipcmisc3_en.pdf

Seðlabanki Íslands. Vefslóð: http://www.sedlabanki.is

Sigurður Jóhannesson (2008): Hver er ávinningur Íslendinga af fyrirgreiðslu við erlenda fjárfesta. Í Valur Indimundarson (ritstj.): *Uppbrot hugmyndakerfis: Endurmótun íslenskrar utanríkisstefnu 1991-2007*. Reykjavík: Hið íslenska bókmenntafélag.

Sveinn Agnarsson (2008): Austurland árið eftir, *Vísbending*, 22. tbl. 20. júní.

Valgerður Sverrisdóttir iðnaðarráðherra (2005): Skýrsla um raforkumálefni, bls. 78, á heimasíðu Alþingis.

Valgerður Sverrisdóttir iðnaðarráðherra: Svar iðnaðarráðherra við fyrirspurn Jóns Bjarnasonar um ívilnanir til álvera á landsbyggðinni, 26.4. 2006.

Viðskiptablaðið 23. apríl 2008.

Viðskiptablaðið, 1. febrúar 2008, bls. 28-30.

Vindorka, vefslóð, http://www.vindorka.com/Frodleikur.htm.

Vífill Karlsson (2004): *Samgöngubætur og búseta. Áhrif Hvalfjarðarganga á búsetuskilyrði og búsetuþróun á Vesturlandi*. Samtök sveitarfélaga á Vesturlandi.

Vísindavefur HÍ, vefslóð: http://visindavefur.hi.is/svar.php?id=2014.

Þórarinn G. Pétursson. (2002). *Verð- og launamyndun í litlu opnu hagkerfi*. Fjármálatíðindi 49. árgangur síðara hefti, bls. 3-22.

Munnlegar heimildir:

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Samtal við Sigurð Líndal lagaprófessor.

7. Viðauki I: Þjóðhagsreikningar

Verg landsframleiðsla samanstendur af einkaneyslu, samneyslu, fjárfestingum, vöru-skiptajöfnuði og þjónustujöfnuði. Vöruskiptajöfnuður er fob verðmæti útfluttra vara að frádregnu fob verðmæti innfluttra vara. Þjónustujöfnuður er fob verðmæti útfluttrar þjónustu að frádregnu fob verðmæti innfluttrar þjónustu. Þjónustujöfnuður inniheldur m.a. allar samgöngur milli landa, neyslu íslenskra ferðamanna erlendis sem og neyslu erlendra ferðamanna hérlendis. Viðskiptajöfnuður samanstendur af vöruskiptajöfnuði og þjónustujöfnuði auk hreinna þáttatekna og rekstrarframlaga. Til þáttatekna teljast öll laun og launatengdar greiðslur og tekjur af fjárfestingum á milli landa þar á meðal vaxta- og arðgreiðslur. Allar greiðslur til innlendra aðila frá erlendum aðilum hækka þáttatekjur og öfugt. Til rekstrarframlaga teljast allar greiðslur sem hvorki stafa af vöru- né vinnuframlagi. Hér er meðal annars um að ræða styrki til þróunaraðstoðar og neyðarhjálpar. Fjármagnsjöfnuður samanstendur af breytingum á hreinni stöðu erlendra skulda[43] og eigna[44]. Jákvæður fjármagnsjöfnuður endurspeglar því versnandi skuldastöðu þjóðarbúsins. Greiðslujöfnuður við útlönd er samtala viðskiptajafnaðar og fjármagnsjafnaðar og lýsir hann streymi erlends gjaldeyris til og frá landinu. Halli á greiðslujöfnuði endurspeglar rýrari stöðu gjaldeyrisforða þjóðarinnar og afgangur endurspeglar aukinn gjaldeyrisforða. Yfirlit yfir framangreinda þjóðhagsreikninga og samhengi þeirra er að finna í töflu A. 1.

Tafla A. 1 Þjóðhagsreikningar og samhengi þeirra

+	Einkaneysla	+	Útflutningur fob	+	Erlendar lántökur
+	Samneysla	-	Innflutningur fob	+	Lækkun erlendra eigna
+	Fjárfesting	=	Vöruskiptajöfnuður	-	Endurgreiðsla erlendra skulda
+	Vöruskiptajöfnuður			-	Aukning erlendra eigna
+	Þjónustujöfnuður	+	Þjónustutekjur	=	Fjármagnsjöfnuður

[43] Hér er átt við lántökur innlendra aðila erlendis að frádregnum lántökum erlendra aðila hérlendis.
[44] Hér er átt við eignir innlendra aðila erlendis að frádregnum eignum erlendra aðila hérlendis.

= Verg landsframleiðsla

\+ Fjármagnsjöfnuður

= Vergar þjóðartekjur

\- Þjónustugjöld

= Þjónustujöfnuður

\+ Vöruskiptajöfnuður

\+ Þjónustujöfnuður

\+ Þáttatekjur

\+ Rekstrarframlög

= Viðskiptajöfnuður

\+ Viðskiptajöfnuður

\+ Fjármagnsjöfnuður

= Greiðslujöfnuður

8. Viðauki II: Afleiðusamningar

Framvirkir samningar eru samningar um að eiga viðskipti með tiltekna vöru eða fjármálagerning á fyrirfram ákveðnum tíma í framtíðinni á fyrirfram ákveðnu verði. Munurinn á framvirkum samningum og stöðluðum framvirkum samningum er sá að með hina síðari er verslað í kauphöllum en ekki með þá fyrri. Stöðluðu samningarnir eru öflugt áhættustýringartæki ef rétt er farið með þá. Kauphallir tryggja að staðlaðir framvirkir samningar séu efndir en flestir þeirra leiða þó ekki til viðskipta á gjalddaga því þeim er lokað fyrir þann tíma. Hægt er að nota framvirka samninga hvort tveggja til þess að verja sig fyrir verðhækkunum eða verðlækkunum á undirliggjandi eign.

Skiptasamningar eru samningar milli tveggja aðila um að skiptast á mismunandi greiðsluflæði yfir ákveðið tímabil. Vanalega hafa fjármálastofnanir milligöngu í skiptasamningum gegn gjaldi og ábyrgjast greiðsluflæði beggja aðila. Helstu tegundir skiptasamninga eru gjaldmiðlaskiptasamningar og vaxtaskiptasamningar. Vaxtaskiptasamningar ganga út á það að annar aðilinn greiðir hinum fasta vexti á tiltekinn höfuðstól en fær í staðinn fljótandi vexti. Með slíkum skiptasamningum eru báðir aðilar að nýta sér hlutfallslega yfirburði sína í tilteknu vaxtaformi, þ.e. föstum eða fljótandi vöxtum, til þess að ná betri kjörum í hinu vaxtaforminu. Gjaldmiðlaskiptasamningar ganga út á það að samningsaðilarnir skiptast á greiðsluflæði í mismunandi gjaldmiðlum til þess að verja sig fyrir óhagstæðum sveiflum á gengi gjaldmiðla. Hér gæti til dæmis verið um að ræða að útflutningsfyrirtæki sem hefur tekjur í erlendri mynt en gjöld í innlendri mynt skiptist á greiðsluflæði við fyrirtæki sem hefur tekjur í innlendri mynt en gjöld í erlendri.

Valréttarsamningar eru fjármálagerningar sem veita kaupendum rétt til þess eiga viðskipti með tiltekna undirliggjandi eign á fyrirfram ákveðnu verði á fyrirfram ákveðnum tíma í framtíðinni. Munurinn á valréttarsamningum og framvirkum samningum er sá að valréttarsamningarnir veita rétt til viðskipta sem kaupandinn nýtir sér einungis ef það er honum hagstætt. Kaupendum framvirkra samninga er hins vegar skylt að uppfylla þá á gjalddaga hvort sem það er þeim hagstætt eður ei. Af þessum sökum er dýrara að kaupa valréttarsamninga en framvirka samninga.

9. Viðauki III: Mat á umhverfisgæðum

Til þess að tryggja skilvirka nýtingu og stjórnun á umhverfisgæðum þarf að beita öðrum verðmatsaðferðum en fást á markaði til þess að meta verðgildi þeirra. Verðmatsaðferðir þær, sem fjallað er um hér á eftir, eiga það sameiginlegt að leitast við að draga fram undirliggjandi greiðsluvilja neytenda út frá atferli og athöfnum þeirra. Skiptast þessar aðferðir í aðferðir *afhjúpaðs vals* og aðferðir *yfirlýst vals*. Þeim aðferðum sem hér á eftir verða gerð skil hefur víða verið markvisst beitt undanfarna áratugi við mat á verðmætum umhverfisins með góðum árangri.

a. Mælikvarðar á hagrænt virði

Þegar um er að ræða umhverfisgæði eru greiðsluvilji (e. *willingness to pay*) og bótavilji (e. *willingness to accept*) þeir mælikvarðar sem hvað oftast eru notaðir á hagrænt virði gæðanna. Báðir mælikvarðanna grundvallast á nytjahagfræði og mæla þeir þann neytendaábata sem hlýst af breyttum aðstæðum. Greiðsluvilji gengur út á það að finna þá hámarksupphæð sem neytandinn er reiðubúinn til þess að greiða til þess að ná fram ákveðinni ráðstöfun gæða og/eða auðlinda. Bótavilji gengur hins vegar út á það að finna þær lágmarksbætur sem neytendur eru reiðubúnir til þess að sætta sig við í staðinn fyrir það að njóta verri gæða og/eða auðlinda. Í sumum tilvikum getur verið um að ræða töluverðan mun á hagrænu virði eftir því hvor mælikvarðinn er notaður.

Greiðsluvilji er sá mælikvarði á hagrænt virði gæða sem oftar en ekki er notaður þegar um er að ræða gæði sem eru utan markaðar. Í sinni einföldustu mynd má segja að sá neytendaábati sem neytendur hljóta af tiltekinni ráðstöfun gæða samsvari hámarksgreiðsluvilja þeirra fyrir því að ná fram þessari tilteknu ráðstöfun. Neytandinn væri því jafnvel settur fyrir og eftir tiltekna ráðstöfun ef hann þyrfti að greiða sem samsvarar neytendaábata sínum til þess að ráðstöfunin yrði að veruleika. Í flestum tilvikum er það þó eingöngu nálgun á vandamálinu að láta neytendaábata endurspegla greiðsluvilja og leiðir það til bjagaðs mats á greiðsluvilja.[45]

Bótavilji í sinni einföldustu mynd er sá neytendaábati sem bæta þyrfti neytandanum upp ef ákveðin ráðstöfun gæða og auðlinda væri tekin af honum. Þannig má hugsa sér að bótavilji endurspegli þá peningalegu upphæð sem borga þyrfti einstaklingum samfélagins fyrir það að

[45] Réttara mat á greiðsluvilja fæst með því finna svokallaða Hicks efndabót (e. *Hicksian compensating variation*) en ítarlega umfjöllun um hana er að finna í Viðauka IV.

missa af ákveðnum landsvæðum undir uppistöðulón virkjana, raflínur, eða aðrar þær framkvæmdir sem breyta náttúrunni frá því sem nú er.

Erfitt getur reynst í framkvæmd að styðjast við efndabætur og jafngildisbætur sem greiðslu- og bótavilja neytenda þar sem notagildi er ómælanlegur mælikvarði á vildir þeirra. Auk þess leiðir samlagning þessara mælikvarða ekki endilega til gegnvirkrar (e. *transitive*) röðunar valkosta þó svo að vildir neytenda séu gegnvirkar. Í gegnvirkni felst sá eiginleiki að neytendur séu samkvæmir sjálfum sér í vali á neyslusamsetningum. Til þess að greiðsluvilji tryggi gegnvirka röðun valkosta þurfa notagildisföllin að vera þannig að undirliggjandi eftirspurnarferla sé unnt að leggja saman til þess að fá markaðseftirspurnarferil og allir neytendur í hagkerfinu verða að standa frammi fyrir sama verði. Sakir þessa hafa verið þróaðar aðferðir sem leitast við að fá neytendur til þess að afhjúpa greiðslu- og/eða bótavilja sinn með einum eða öðrum hætti og þannig er í raun fundin leið framhjá notagildisföllum.

Vandamál getur skapast við notkun greiðsluvilja sem mælikvarða á hagrænt virði gæða þar sem hann veltur á auði neytenda. Því meiri sem auður þeirra er þeim mun hærri verður greiðsluvilji þeirra fyrir verðbreytingum á tilteknum gæðum. Afleiðingar þessa eru þær að breytt tekjudreifing leiðir til annars greiðsluvilja og þar af leiðandi til annarrar forgangsröðunar verkefna. Einnig skiptir máli hverjir eigi hagsmuna að gæta af tilteknu verkefni upp á það að gera hverra greiðsluvilja eigi að taka með í reikninginn. Í þessu samhengi hefur oft verið bent á að ráðstöfun náttúruauðlinda hefti valmengi komandi kynslóða og því ætti réttilega að taka greiðslu- eða bótavilja þeirra með í reikninginn. Vert er þó að benda á að flestir taka að einhverju leyti tillit til ófæddra afkomenda sinna þegar þeir afhjúpa vilja sinn með einhverjum hætti.

b. Aðferðir afhjúpaðs vals

Aðferðir afhjúpaðs vals (e. *revealed preference*) leitast við að draga ályktanir af þeim greiðsluvilja sem neytendur afhjúpa með raunverulegri hegðun sinni á markaði. Fyrir gæði sem verslað er með á markaði er má segja að lágmarksgreiðsluvilji neytenda endurspeglist í markaðsverði, eða m.ö.o. þá afhjúpar fólk greiðsluvilja sinn með því að versla á markaði og greiða markaðsverð. Gæði sem ekki er verslað með á mörkuðum bera ekki markaðsverð og því verður að draga ályktanir um greiðsluvilja neytenda af hegðun þeirra á mörkuðum sem eru á einhvern hátt tengdir umræddum gæðum. Á meðal aðferða afhjúpaðs vals eru ferðakostnaðaraðferðin, aðferð ánægjuverðs (e. *hedonic price method*) og aðferð sem dregur ályktanir um greiðsluvilja út frá útgjöldum neytenda til þess að forðast kostnað.

1.1.3 Ferðakostnaðaraðferð

Ferðakostnaðaraðferðin er aðallega notuð til þess að meta greiðsluvilja neytenda fyrir margs konar frístundasvæði eða náttúruminjar. Kostnaður neytenda af ferðum til viðkomandi staða veltur þá á landfræðilegri staðsetningu þeirra sem veldur því aftur að neytendur hafa mjög mismunandi greiðsluvilja. Sé upplýsingum safnað um ferðir og dreifingu ólíkra neytenda er hægt að meta eftirspurn eftir viðkomandi gæðum sem ákvarðast af ferðakostnaði. Ferðakostnaður veltur m.a. á vegalengdinni sem ferðast er um, ferðamátanum (t.d. einkabifreiðar eða almenningssamgöngur) og tímavirði vegfarenda. Til þess að ábyggilegt verðmat fáist á viðkomandi umhverfisgæðum þarf því að safna tiltölulega yfirgripsmiklum og einstaklingsbundnum gögnum auk þess sem ákvarða þarf einhvern gæðastaðal fyrir umhverfisgæðin. Gallinn við þessa aðferð er sá að hún tekur ekki tillit til kostnaðarins (og þar með staðkvæmdarinnar) sem hlýst af ferðum til annarra sambærilegra frístundasvæða eða náttúruminja. Auk þess er ekki hægt að nota hana til að meta tilverugildi viðkomandi umhverfisgæða, þ.e. hún metur einungis til verðs raunverulega eftirspurn eftir ferðum til viðkomandi staða en ekki virði þess að gæðin séu til staðar almennt. Einnig er vert að athuga að það getur verið verulegum vandkvæðum bundið að ákvarða gæðastaðal mismunandi umhverfisgæða og tímavirði vegfarenda.

Þegar gæðastaðall umhverfisgæða breytist, meðal annars vegna notkunar, s.s. virkjanaframkvæmda, er unnt að meta áhrif þeirra breytinga á heimsóknir til staðarins til verðs með svokölluðu endurteknu hendingarkenndu nytjalíkani (e. *random utility model*, RUM). Jafngildir þetta í raun því að meta staðbundin velferðaráhrif af virkjanaframkvæmdum. Verður ekki farið nánar út í þá sálma hér.

1.1.4 Aðferð ánægjuverðs

Með s.k. aðferð ánægjuverðs má meðal annars meta verðgildi tiltekinna umhverfisgæða út frá fasteignaverði í nálægum byggðum. Gengur aðferðin út á það að flokka verðgildi tiltekinna gæða, sem verslað er með á markaði, eftir undirliggjandi þáttum með aðhvarfslíkani (e. *regression analysis*) þar sem ein stýribreytanna er umhverfisgæði. Jaðaráhrif stýribreytunnar á virði gæðanna sem metin eru með aðhvarfslíkaninu endurspegla þá greiðsluvilja neytenda fyrir tiltekin umhverfisgæði. Einnig er unnt að meta velferðaráhrif vegna breytinga á umhverfisgæðum með þessari aðferð. Þegar aðferð ánægjuverðs er beitt til þess að meta verðgildi umhverfisgæða þarf að safna gögnum um viðkomandi markaðsgæði og alla þá þætti sem kunna að hafa áhrif á verðgildi þeirra. Með því að safna einnig gögnum um tekjur neytenda og aðrar félagshagfræðilegar (e. *socio-economic*) stærðir er unnt að meta eftirspurn neytenda eftir viðkomandi umhverfisgæðum.

Líkt og ferðakostnaðaraðferðin er þessi aðferð ekki gallalaus. Fyrir það fyrsta metur hún ekki tilverugildi til verðs heldur eingöngu virði sem fæst af notkun umhverfisgæðanna. Auk þess er gengið út frá því að markaður fyrir viðkomandi gæði, sem verið er að meta, sé fullkominn í þeim skilningi að jaðargreiðsluvilji samsvari jaðarkostnaði.

1.1.5 Útgjöld til að forðast kostnað

Mögulegt er að draga ályktanir um raunverulegan greiðsluvilja neytenda fyrir tiltekin umhverfisgæði út frá því hvað þeir eru tilbúnir að borga til að forðast annan og meiri kostnað. Í þessu samhengi er oft um að ræða kaup á einhvers konar öryggistækjum til þess að lágmarka þann kostnað sem hlýst af heilsufarslegu tjóni. Sem dæmi um þetta má meðal annars nefna kaup neytenda á öndunargrímum í stórborgum með mikla loftmengun. Upphæðin sem varið er til kaupa á öryggistæki í því skyni að draga úr neikvæðum áhrifum tiltekinna umhverfisgæða samsvarar því greiðsluvilja neytenda fyrir bætt umhverfi.

Þessi aðferð er alls ekki gallalaus. Fyrir það fyrsta er ekkert sem segir að neytendum takist að eyða skaðanum sem mengun eða önnur birtingarmynd slæms umhverfis veldur með þeim útgjöldum sem þeir leggja í til að forðast þau. Auk þess geta kaupin á öryggistækjum haft önnur jákvæð áhrif en þau að leiðrétta það ástand sem skapast af slæmum umhverfisgæðum. Einnig er vert að athuga það að neytendur aðhafast ýmislegt til þess að forðast slæmar niðurstöður vegna umhverfisgæða en það er ekki þar með sagt að allar þær athafnir séu verðlagðar á markaði. Það er því óhætt að fullyrða að mat á greiðsluvilja með þessari aðferð mun alltaf leiða til bjagaðs mats.

c. Skilyrt verðmætamat

Skilyrt verðmætamat er ein af aðferðum yfirlýsts vals[46] og gengur hún út á að grafast fyrir um greiðsluvilja og/eða bótavilja neytenda fyrir tilteknum gæðum með því leggja fyrir þá spurningakönnun af einhverju tagi. Neytendur eru látnir ímynda sér breytingar á aðstæðum á þann veg að annað hvort neysla þeirra á tilteknum gæðum eða gæðastaðall þessara gæða breytist. Á einn eða annan hátt eru þeir síðan látnir gefa upp hvers virði þessar breyttu aðstæður eru þeim. Mikilvægt er fyrir gæði könnunarinnar að úrtakið endurspegli

[46] Ekki verður farið í fleiri aðferðir yfirlýsts vals hér.

undirliggjandi þýði á sem bestan hátt. Í undirliggjandi þýði kannananna byggða á skilyrtu verðmætamati eru allir þeir sem hafa verulegra hagsmuna[47] að gæta af tilteknu verkefni.

Vanda þarf framkvæmd skilyrts verðmætamats til þess að könnunin gefi sem óbjagaðast mat á undirliggjandi greiðslu- og/eða bótavilja þátttakenda. Grundvallaratriði er að útskýra vandlega fyrir þátttakendum út á hvað könnunin gengur og nákvæmlega um hvaða breytingu á hvaða gæðum er að ræða áður en farið er út í það að inna þá eftir greiðslu- og/eða bótavilja þeirra. Einnig þarf að koma því til skila hvernig verði greitt fyrir verkefnið. Koma þarf þátttakendum í skilning um það að þeir hafi takmarkað ráðstöfunarfé sem verkefnið muni með einum eða öðrum hætti hafa áhrif á. Eigi að nota opinbera skatta til þess að greiða fyrir verkefnið þarf að tiltaka hvernig skattbyrði vegna verkefnisins dreifist á þegna samfélagsins og á hverju ákvörðun um hvort farið verði út í tiltekið verkefni grundvallast. Einnig er vert að hafa í huga að ákvörðun um að fara út í tiltekið verkefni getur breytt forgangsröðun annarra verkefna í samfélaginu.

Könnunin sjálf er framkvæmd með einni af eftirfarandi aðferðum: beinum viðtölum, símaviðtölum, póstkönnun eða netkönnun. Allar hafa þessar aðferðir sína kosti og galla en almennt séð er sú aðferð að taka bein viðtöl talin einna ákjósanlegust við kannanir byggðar á skilyrtu verðmætamati (Hagfræðistofnun 2003). Með henni er auðveldast að skýra út aðstæður fyrir þátttakendum en helsti galli hennar, ásamt því að hún er gífurlega kostnaðarsöm, er sá að spyrjendur geta haft óþarflega mikil áhrif á svör þátttakenda. Þátttakendur eru inntir eftir greiðsluvilja sínum í könnuninni en auk þess eru þeir spurðir almennra spurninga um hagi sína, s.s. menntun, hjúskaparstöðu, fjölda barna á heimilinu og samanlagðar tekjur heimilisins. Er þetta meðal annars gert til þess að grafast fyrir um samband tekna og greiðsluvilja, eða tekjuteygnina, og til þess að kanna skilning þátttakenda.

Mögulegt er að spyrja þátttakendur um greiðsluvilja þeirra með ýmsum hætti og hér verður fjallað lítillega um þrjár aðferðir. Í fyrsta lagi er hægt að setja tölur á ákveðnu bili fyrirfram niður á blað og þátttakendur eru síðan látnir velja þá tölu sem kemst næst greiðsluvilja þeirra. Gallinn við þessa aðferð er sá að þátttakendur eru þvingaðir inn á ákveðið bil greiðsluvilja sem þarf ekki endilega að endurspegla þeirra eigin greiðsluvilja. Í öðru lagi má spyrja þátttakendur um þá hámarksupphæð sem þeir eru reiðubúnir til þess að greiða til þess að ná fram tilteknum breyttum aðstæðum án þess að þeim sé gefið í skyn neitt ákveðið gildi. Þessi

[47] Með hagsmunum er hér átt við ábata.

aðferð reynist þátttakendum oft erfið þar sem þeir hafa sjaldnast reynslu af viðskiptum með undirliggjandi gæði. Í þriðja lagi má spyrja þátttakendur hvort þeir samþykki tiltekna upphæð sem greiðsluvilja sinn eða ekki. Samþykki þátttakendur ekki upphæðina eru þeir spurðir aftur og þá um lægri upphæð þar til þeir svara játandi.[48] Samþykki þátttakendur hins vegar strax upphæðina eru þeir spurðir aftur og þá um hærri upphæð þar til þeir svara neitandi.[49] Kosturinn við þessa aðferð er sá að þátttakendur eru stöðugt að gefa vísbendingar um raunverulegan greiðsluvilja sinn. Gallinn er hins vegar sá að þátttakendur miða greiðsluvilja sinn ómeðvitað út frá upphafsupphæðinni sem myndar ákveðið akkeri[50] í hugum þeirra.

Þegar lokið hefur verið við að safna upplýsingum um greiðsluvilja þátttakenda þarf að meta greiðsluvilja úrtaksins þannig að hann endurspegli sem best greiðsluvilja undirliggjandi þýðis. Nauðsynlegt er að taka tillit til öfgagilda sem gefin hafa verið í mótþróa- eða í hagsmunaskyni og endurspegla því ekki raunverulegan greiðsluvilja þátttakenda. Í þessum skilningi er miðgildi ekki eins næmt fyrir öfgagildum og meðaltal.

Helsti gallinn við aðferð skilyrts verðmætamats er sá að þátttakendur í úrtakinu eru látnir ímynda sér breytingar á aðstæðum sem oft getur reynst þeim erfitt. Jafnframt er matið sem könnunin leiðir af sér háð því hverning könnunin er framkvæmd og því er nauðsynlegt að hún sé eins skýr og notendavæn og unnt er. Vel uppbyggð könnun ætti því að geta gefið áreiðanlegt mat á undirliggjandi verðmæti gæða.

[48] Á þetta við þegar upphafsupphæðin er hærri en sem nemur greiðsluvilja þátttakandans. Hér er því í raun um að ræða svokallað hollenskt uppboð.
[49] Á þetta við þegar upphafsupphæðin er lægri en sem nemur greiðsluvilja þátttakandans. Hér er því um að ræða svokallað enskt uppboð.
[50] Hugmyndafræðin um akkerið er vel þekkt í samningatækni.

10. Viðauki IV: Hicks efndabót

Fræðilega rétt mat á greiðsluvilja fæst með því finna svokallaða Hicks efndabót (e. *Hicksian compensating variation*). Hicks efndabót er í raun og veru sá neytandaábati sem afmarkast af Hicks eftirspurnarfalli sérhvers neytanda. Hicks eftirspurnarföll eru frábrugðin hinum hefðbundnu Marshall eftirspurnarföllum á þann veg að þau eru skilyrt á notagildi, þ.e. þau sýna eftirspurn eftir tilteknum gæðum við sérhverju verði að gefnu föstu notagildi en ekki að gefnum föstum tekjum. Notagildi neytenda er raðrækinn (e. *ordinal*) mælikvarði á smekk eða vildir þeirra og endurspegla notagildisföll minnkandi jaðarnytjar neyslu. Notagildisfall er unnt að skilgreina fyrir sérhvern neytanda á eftirfarandi hátt:

$$U = U(x, \mathbf{y})$$

þar sem x stendur fyrir neyslu á tilteknum umhverfisgæðum x og **y** er neysluvektor allra annarra gæða. Neysla afmarkast af tekjum, I, neytandans og verði, p_x, á gæðum x og verðvektor, $\mathbf{p_y}$, allra annarra gæða.[51] Við útleiðslu á Hicks eftirspurnarferli og Hicks efndabót er gengið út frá því að neytandinn standi frammi fyrir þeim vanda að hámarka nyt sín með tilliti til neyslu að gefnu tekjubandinu. Formleg framsetning á hámörkunarvandamáli neytandans er því eftirfarandi:

$$\max_{x,\mathbf{y}} \; U(x, \mathbf{y})$$

$$\text{s.t.} \;\; I \geq p_x x + \mathbf{p_y y}$$

þar sem halli tekjubandsins er $-\frac{p_x}{\mathbf{p_y}}$. Að því gefnu að notagildisferill neytandans uppfylli þau skilyrði sem honum eru sett er hægt að finna lausn á vandamálinu. Mynd 8. 1 sýnir útleiðslu á Hicks eftirspurnarferli fyrir vöru x og Hicks efndabót fyrir verðlækkun á sömu sömu vöru.[52] Upphaflegt notagildi og neyslu neytandans á vöru x má sjá þar sem tekjubandið I_0 myndar snertil við jafnnotagildisferilinn U_0. Þar er neysla neytandans á vöru x x_0. Undirliggjandi verð á vöru x í tekjubandinu I_0 er p_0. Sé verð á vöru x lækkað í p_1 en verði á vöru y haldið óbreyttu minnkar hallinn á tekjubandinu og það snýst í I_1. Neysla á vöru x eykst því úr x_0 í x_1, þar sem nýtt tekjuband myndar nú snertil við hærri jafnnotagildisferil U_1 í þeirri stöðu. Væri notagildi

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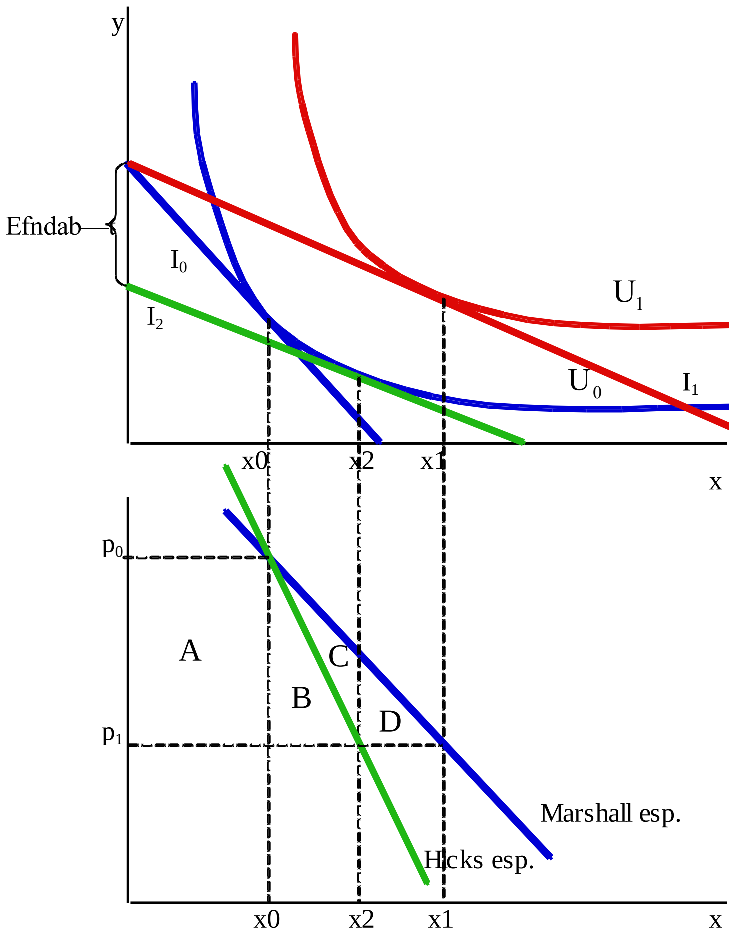
[51] Hér eru forsendurnar þær að neytandinn geti ekki aukið neyslu sína með því að taka lán.

[52] Hér er einnig hægt að hugsa sér að gæði vörunnar séu að aukast en að verð haldist óbreytt og því sé um raunlækkun verðs að ræða.

neytandans hins vegar haldið föstu þrátt fyrir verðlækkun á vöru x myndi hann neyta magnsins x_2 af vöru x. Sú staða fæst með því að finna snertil tekjubands I_2 sem hefur sama halla og tekjuband I_1 við upphaflega jafnnotagildisferilinn U_0. Út frá jafnnotagildisföllunum er hægt að leiða út hvort tveggja Marshall eftirspurnarferil og Hicks eftirspurnarferil fyrir vöru x, og er það gert á neðri helmingi myndarinnar. Marshall eftirspurn er fall af verðum í hagkerfinu og tekjum neytandans og Hicks eftirspurn er fall af verðum í hagkerfinu og notagildi neytandans. Á Marshall eftirspurnarferli hefur neytandinn eftirspurnina x_0 eftir vöru x þegar verðið er p_0 en eftirspurnina x_1 þegar verðið er p_1. Á Marshall eftirspurnarferli eykst því í raun notagildi neytandans þegar verð á vörunni lækkar vegna staðkvæmdar- og tekjuáhrifa. Á Hicks eftirspurnarferli hefur neytandinn eftirspurnina x_0 eftir vöru x þegar verð hennar er p_0 en eftirspurnina x_2 þegar verðið lækkar í p_1. Hicks eftirspurnarferill er alltaf brattari en Marshall eftirspurnarferill og því einnig óteygnari. Neytandanum er haldið á sama jafnnotagildisferli og fyrir verðbreytinguna með því að lækka tekjur hans sem þýðir í raun að einu áhrif verðbreytinga eru staðkvæmdaráhrif. Á efri helmingi myndarinnar má því lesa út efndabótina eða greiðsluvilja neytandans fyrir því að verð á vöru x lækki sem bilið á milli tekjubands I_1 og I_2. Á neðri helmingi myndarinnar afmarkar svæði A+B greiðsluvilja neytandans fyrir því að verð á vöru x lækki. Þetta svæði samsvarar því að finna neytendaábata með Hicks eftirspurnarferlinum. Væri greiðsluviljinn hins vegar fundinn með Marshall eftirspurnarferlinum endurspeglaði hann svæðið A+B+C+D, og væri hann því í raun ofmetinn um svæðið C+D. Ástæðan fyrir þessu er sú að neytandinn er jafnvel settur fyrir og eftir verðlækkunin á Hicks eftirspurnarferlinum en betur settur á Marshall eftirspurnarferlinum eftir verðlækkunina þar sem hann kemst á hærri jafnnotagildisferil.



Mynd V-1 Hicks efndabót

Hicks og Marshall eftirspurnarföll gefa sama eftirspurt magn í ákveðnum punkti ef tekjurnar eru þannig að þær nægi til þess að ná fasta notagildisstiginu sem er undirliggjandi í Hicks eftirspurnarfallinu. Því er augljóst að í gegnum sérhvern punkt á Marshall eftirspurnarferli liggur eitthver tiltekinn Hicks eftirspurnarferill og öfugt. Í þeim tilvikum þar sem tekjuáhrif verðbreytinga eru hverfandi dugir að styðjast við neytendaábata afmarkaðan af Marshall eftirspurn sem greiðsluvilja.