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Costs and Benefits of a mining project in Rönnbäck

– A CBA on the social and environmental impacts of mining

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Abstract

This study aims to give an overview of the costs and benefits from establishing a nickel mine in Rönnbäck, in the municipality of Storuman, Sweden. The mining industry is known to have both positive and negative effects on the society. The costs associated with the business include environmental disturbance and interest conflicts from local inhabitants and minority groups. The benefits from a mining project take its expression in terms of profit for the mining company, tax revenue and the creation of job opportunities. By using the transfer method and other CBA studies some of the impacts are examined. The result is a positive net social benefit with a value between 947 125 MSEK and 1 477 032 MSEK for the mining project which indicates that the project would have a beneficial impact on the society. It should be noted that only a few aspects are covered in this essay and that the case need further research.

Tack till Amanda & Vidar

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1 Introduction

The Swedish mining industry exists to provide raw material for a wide range of sectors, both within the country and for export. The activity has implications for the local society, the surrounding nature and wildlife. When planning and evaluating mining projects, the impacts on national and regional economy and labor markets are often in focus. This is reflected in the existing literature considering the effect mining activities pose on the environment and local society, where the studies are often written from a management perspective. Previously there have been two economic studies conducted specifically on the mining site that will be discussed in this essay, neither of which consider the external effects on nature. Furthermore, the reports are conducted on request from the local municipality and the company owning the rights to the mining site respectively, and thus there should be reason to consider whether the studies have a potential bias. The fact that many of the externalities that can be expected from a mine are excluded and the lack of non-partial research makes it interesting to look into the case and gather information from a wider range of literature.

This study handles the conflicting interests in the Swedish mining industry. More specifically the cost-benefit analysis (CBA) methodology with benefit-transfer. The study is limited to a planned mining project in Rönnbäck in the municipality of Storuman, but could be of value when evaluating other mining projects in Sweden. The study aims to give a general understanding of the external effects of a mining business but is limited to mainly focus on some of the environmental effects, the effect on the reindeer industry and the local labor market. The specific research question that the essay will address is:

Is it socioeconomically optimal to approve the establishment of mining in Rönnbäck?

The study is organized as follows, a presentation of the method used, followed by the presentation of the case and data used. This is followed by result, discussion and conclusion.

2 The CBA method

2.1 Theory

Cost-benefit analysis is basically about decision making. The validity of a project can be evaluated by systematically listing impacts as either benefits or costs, turning them into comparable values and determine the net benefits of the proposed project relative to the present situation. As opposed to the individual's decision making, CBA attempts to evaluate a project's consequences for a society as whole. By trying to grasp how a project will affect the society, the expectation is to find more a more efficient allocation of the society's resources than the individual actors would make separately.

Mining projects in Sweden are usually initiated by companies, however, it is the state authorities that decide whether or not exploitation permit is given to the company. This is where an CBA could play a role for the state's decision making, by using a so called *ex ante* CBA, where the project is evaluated before it is started.

It could be argued that a CBA is an unnecessary measure to take. In addition to scientific analysis of the environmental consequences of the project, the company has the liability to restore the environment stated by Swedish law. However, to do a ex ante CBA has several benefits. One advantage of CBA is that it covers a wider range of benefits and costs, both social and environmental. The fact that all effects are valued makes it easier to have financial obligations on a company, as oppose to if the damage is only described in physical evaluation. Furthermore, the effect on social and natural environment can be expected to be more far-reaching than the life-time of the mining project with irretrievable damage, and therefore should be considered carefully on beforehand.

2.2 Outline of CBA

Regardless of what kind of project that is explored using a CBA, the following nine steps should be used, in order to ensure that all aspects and possible impacts are taken into account in a systematic way. Below follows an overview, followed by a more detailed description, of the general steps that forms the basis of an successful CBA, divided into four different categories (Boardman *et al.*, 2005).

Identification

1. Specify alternative projects
2. Decide whose benefits and costs count (standing)
3. Identify all impacts

Quantification

4. Predict all impacts quantitatively over the life of the project

Valuation

5. Monetize all impacts
6. Discount to obtain present values

Assessment

7. Compute the net present value of each alternative
8. Perform sensitivity analysis
9. Make a recommendation

Identification
Step 1 is the starting point where the analyst identifies and explores a number of alternative projects that would lead to the same results as the project examined in the CBA. The projects should be clearly described in space, time and procedure. Furthermore, the net benefits of the alternative projects are compared with the net benefits of a project that would be displaced if the evaluated project where to proceed. This alternative project is what is commonly called the counterfactual. If the counterfactual is applied it will mean that no policy is undertaken.

Step 2 requires the analyst to decide whose benefits and cost that should be included in the analysis. Should the project be seen in a global context, or should it only take national costs and benefits into account? Is it perhaps a project that is mainly relevant to discuss on a local scale? Most projects are possible to see from different perspective in this sense, and it can therefore always be discussed what is the best approach.

In **step 3** the analyst identifies the physical impact categories that can affect the actors on the level chosen in step two. The proposed impacts are then to be organized as benefits or costs and how these benefits or cost are measured should also be specified. It is important to note that the CBA should be focused on the way a project is affecting the utility of individuals, if an impact is not affecting humans it should not be taken into account. This also means that different groups might view a physical outcome of a project differently depending on their interest. A mine establishment can for instance be seen as beneficial for someone that is applying for jobs within the sector, but as a cost for someone who enjoys the nature at the planned mining site. To take both aspects into account, the analysist normally put the impact into two categories, one positive and one negative.

Quantification
Step 4 is where the cost and benefits identified should be quantified within each time period. Since most projects have impacts that extends over time, the analysist needs to make prediction for each category. This is often a complex task, since the projects can have long timeframes and many complex variables. As far as possible the analyst should base its predictions on available data. However, relevant data can be hard to find which makes policy research and a good knowledge of the project useful for the analyst in order to make informed guesses. The uncertainty in finding the correct net benefits is what makes it necessary to include a sensitivity analysis in the CBA (see step eight).

Valuation
Step 5; when the impacts have been quantified the next step is to monetize them. In the ideal case these estimates should be specific to the place and time that the project is conducted. However, to obtain these values is a very time consuming task and it is common practice that the analysists uses estimates from previous studies. To fit them into the CBA of the specific project, the values can be adjusted by taking sociological and geographical variables into account. Regulating the estimate to inflation, exchange rates and taking the purchasing power parity into account is also necessary. In a

CBA study, it is usually the willingness to pay that is used as the measure for the value of the outcome. If there is an existing well-working market for the good, willingness to pay can be determined from the market demand curve. But if such a market does not exist or is not functioning, problems arises making the monetization more time consuming.

In **step 6** the values obtained in step five are adjusted to get the present value (PV). This is done by discounting the present cost and benefits obtaining the future benefits and costs. The values are already adjusted for inflation in step five, but by discounting them, the analysts can account for the fact that most people prefer to consume today rather than later as well as the fact that there is an opportunity cost to all resources used in a project. Since there is not one indisputable discount rate, it is common to include it in the sensitivity analysis.

Reaching step six, the different benefits and costs are discounted and summarised to obtain the net present value (NPV) using equation (1)

$$\sum\left(\frac{\quad}{SDR)}\right) + \sum\left(\frac{\quad}{DR)}\right.$$

The variables in the equation stands for:

- Ft - the annual net financial cost or benefit
- N_0 - the annual net environmental cost or benefit as assessed by the current generation in year 0
- SDR - Social Discount Rate, used for the economic effects
- EDR - environmental discount rate for the environmental effects, lower than SDR

When attempting to settle the net social benefit, the focus is to obtain what will generate the most utility to the greatest number of people (Perman *et al.*, 2011). That concept springs from the theory of utilitarianism. According to utilitarianism consumers have positive time preferences and require a payment of interest to postpone consumption, and hence utility, for later. A positive discount rate is therefore commonly used to compare the value of consumption at different time periods. The expectation is that the marginal utility for any normal good is diminishing.
In this sense, environmental goods are considered to be normal. On the other hand, it is argued that a positive discount rate discriminates the future generations and is not suitable for environmental goods, being limited and expected to be scarcer in the future. One way to deal with this problem is to use the common Social Discount Rate for market goods and a lower - environmental - discount rate for non-market goods simultaneously in the CBA (Sáez & Requena, 2007).

Assessment
Step 7 is where the cost and benefits are finally calculated into their NPV. If there are several alternatives to the counterfactualthe project with the highest NPV is preferred.

Step 8 is the section where the sensitive analysis is conducted. As mentioned in step six, the discount rate is often suitable to analyse. However, it is also a good idea to try to handle the uncertainty of the actual value of the impacts that are monetized. This can be done by testing alternatives to each element in the CBA one by one, and see how the result varies.

In **Step 9** the analyst reaches a conclusion and gives the final recommendation of whether to proceed or not proceed with the project. There are of course also other aspects of the project, that goes beyond the CBA, hence the recommendation is not sure to be the same as the final decision about the project.

2.3 Benefit transfer

Benefit transfer is a method to collect data to a CBA that is time and resource saving (Desvousges *et al.*, 1999*)*. By taking advantage of previous CBA studies, data on social and environmental costs and benefits can be applied to the project of interest. Most commonly a study of the same kind of project but in a different location is used for the benefit transfer. In this study a wider perspective will be adopted, where cost and benefits from different contexts will be applied to the one of a mining project. This is motivated by the fact that there are few accessible studies on mining projects that contains suitable data.

The first step of the benefit transfer is to gather studies that can be used for the benefit transfer (Desvousges *et al.*, 1999).

Secondly the specific values that can be transferred needs to be identified and the demographic of the study should be examined. The more similar the original projects' impact on its surrounding and the preferences of the people participation is to the project in focus is, the easier the transfer is. There are different survey methods used for quantification and valuation (step 4-5) but the two main categories are direct and indirect valuation method (Perman *et al.*, 2011). The studies used for the benefit transfer study in this essay are all conducted with direct valuation. The benefit of direct valuation is that non-use values can be taken into account, which is important since the non-use value often make up a significant part of the total value (Perman *et al.*, 2011). The demographic of the studies used are similar to each other in the sense the collection of data is conducted on a local level. Studies from countries with similar demographic structure was chosen since this makes the valuation results more viable.

Thirdly, a study where the benefit transfer is used can never provide a result with better quality than the quality of the original study. This empathizes the importance of choosing reference material with care.

3 The Rönnbäck case

3.1 Background

The mining project explored in the present study is located in Rönnbäck, a mountain area in the municipality of Storuman in the north of Sweden. Rönnbäck is sparsely populated, with 25 km to the closest village but is with its biodiversity and wildlife of importance for recreation in different forms (Storuman, 2017). The area is also used for reindeer herding, an activity that is expected to be heavily affected by the establishment of mine (Wikland & Larsson, 2014).

Nickel Mountain Resources AB is a Swedish company that received the right of exploratory concessions in Rönnbäck in the year of 2005 and has since then been working towards the establishment of a mine in the area (*Tillståndsprocess | Nickelmountain*, 2017). Since 2015 Archelon AB is a parental company to Nickel Mountain R. Some studies on how the mining can be expected to affect the surroundings has been conducted on behalf of the company, where the general conclusion is that the damage on nature will be limited and that the conflicting interests of the site can be solved through dialogue (Miljö |*Nickelmountain*, 2017)

The plans of exploiting minerals in Rönnbäck is an example that pinpoints the kind of conflicting opinions associated with mining projects (*SGU: Gruvor och miljöpåverkan*, 2017). Even though Sweden has a relatively extensive system of environmental regulations it is often inevitable that there will occur negative impact on the surroundings of the mine (*Naturvårdsverket: Gruvor*, 2017). Another problem with mining projects is that they tend to affect the local society negatively (Hellmark, 2016). In the Swedish context, there is an indigenous population that often gets affected by the projects. In Rönnbäck, there are local interest groups claiming the rights of the local population to have their environment sustained (*Samer | Nätverket Stoppa gruvan i Rönnbäck*, 2017). The interest groups are critical to the effects on landscape, water areas and contamination owing to leakage from mining waste.

There have been some studies made on Rönnbäck, specifically different types of environmental impacts and effect on reindeer industry is evaluated in technical reports conducted by Nickel Mountain. A summary of the mining is expected to affect the local and regional economy, mainly in terms of changes in the labor market is put together on behalf of Nickel Mountain, but are based on a study for Luleå Technical University (*Samhällsekonomisk effekt* | Nickel Mountain, 2017). None of these studies will be part of the CBA in this study, mainly because of the fact none is suitable for a valuation study.

3.2 Assessment of costs and benefits

In the following section part 1-3 of the outline of CBA (2.2) are two alternatives discussed. In this study there is only two alternatives for point 1 since there is no alternative project, only the decision of whether to approve the mining project or not.

In this study it is the local community that is in focus when looking on the external effects of the mining project. The studies used for valuing non-environmental goods are therefore based on the responses from the inhabitants of the project regions. However, the national perspective is also looked upon when taking the tax revenue and company's return into account. Since a mining project will result in cost and benefits both on the local and national level the study attempts to cover the two perspectives.

When determining what costs and benefits that should be included in the CBA of Rönnbäck, there were two main aspects that were considered. Firstly, the relevance of the cost or benefit based on site specific information about the mining project, in particular information about the local society and on technical reports about the external effects of mining. Secondly, the availability of relevant data has been a limiting factor, since only aspects from studies that can be transposed to Rönnbäck can included in the analysis.

Positive consequences of a mining project are the revenue of mining, tax revenue and local job opportunities (Ericsson & Söderholm, 2012). Mining projects are likely to have an effect on the local job market (Tano *et al.,* 2016). To the local society, the allocation of jobs a nearby mining site has a high value (Ek & Matti, 2015).

Positive impacts

- revenue from mining
- tax revenue
- job opportunities within the sector

Most negative effects associated with a mine are the environmental impact that the activity impose on its surroundings. Mining projects often lead to contamination, where the pollution of groundwater and streams in the mining area are one of the most significant (Jordan & Project, 2009). Air quality, health effects, noise, disturbance of the landscape and impact on the biodiversity and wildlife are other negative external effects that could be relevant for the study (Abelson, 2015). From this aspects, two studies have been used to evaluate the impact on degradation of streams, dust, noise and impact on landscape. Furthermore, the negative effect on the reindeer herding sector in the area is also one of the consequences of mining establishment (Larsen *et al.,* 2017). This aspect is regarded as important since the reindeer sector is important for the indigenous population in

Sweden and is associated with legal rights (Wikland & Larsson, 2014)

Negative impacts

- Reduced environmental quality due to noise dust and visual impact
- Degradation of streams
- Degradation of water quality
- Degradation of wildlife
- Disturbance of the reindeer sector

3.3 Data & Application

In this section step 4-6 described in 2.2 will follow. The quantification and valuation will be performed through benefit transfer method presented in 2.3. Furthermore, the values will be discounted as described in 2.2.

The CBA benefit-transfer is conducted by using several sources of data that are applied to the settings of Rönnbäck. There are three different studies that together cover environmental costs and social cost and benefits for the society. The three studies that are used for data, are selected on the basis of how well the external effects that they explore resembles external effects of the case of Rönnbäck. In the following section these studies with relevant data will be presented.

Valuing the Non-Market Impacts of Underground Coal Mining (Gillespie & Kragt, 2010) is a study that explores the external effects from a coal mine in New South Wales, Australia. The study is using Contingent Evaluation to estimate the benefits and costs of the mining operation. One of the most interesting aspects discussed is how the mine establishment can be expected to affect the water of the area. The authors have divided the mining operations impact on the local water in to two categories: degradation of streams and degradation of upland swamp. The variable "stream" includes effects as cracking of stream beds, draining of pools, reduced water flow in streams, iron staining and local ecological impact. Several of the effects are similar to those predicted from the mining operation in Rönnbäck, such as reduced water flow, changed water levels and ecological impact. Even though the conditions from New South Wales differ to those of Rönnbäck in terms of different climate, different ecosystems and coal mining differ from nickel mining, the study is the best evaluation of environmental impacts from underground mining conducted. Values for the degradation of streams will therefore be used in this study. The values for degraded upland swamp are found to be too different from the conditions in Rönnbäck to be of use.

To adapt the data to the location of Rönnbäck, the value is adjusted using the length of the lake "Storuman". The length of the lake is estimated using the map *Rönnbäck* (2017), found in appendix I. Multiplying the length by environmental impact per kilometre, a cost for the external effect is obtained. Gillespie & Kragt (2010) do not present any information regarding the width or depth of the streams, why only the length is taken into consideration. Estimated values for the impact on water in connection to the coal mine in New South Wales, Australia, are shown in Table 1. In the calculations of this essay, the mean value is used.

Table 1: Mean estimated implicit prices (A$/household/year)

Attribute	**Mean**	**95% Confidence Interval**
Streams (km)	3,74	(2,48 – 5,41)

Source: (Gillespie & Kragt, 2010)

For the estimation of the cost of external effects like dust, noise and impact on the landscape, data from a study concerning quarries in the UK is used (Willis & Garrod, 1999). Many of the externalities from quarries are the same as those resulting from mining; in both cases rock is processed. For the quarry the magnitude of the externalities vary with the type of rock. “Hard rock” is found to be the type of rock most similar to the mountain in Rönnbäck. In the British study, values for the externalities are presented both for willingness to accept (WTA) and willingness to pay (WTP). The WTA is, as can be expected, higher than WTP, being £2.62 and £0.47 per ton respectively. According to Swedish environmental law (*Miljöbalk (1998:808)*, 1998), the polluter pays principle is used. The value for WTA is therefore regarded as most appropriate, incorporating the full cost the mine must compensate the local inhabitants with for them to be as well of as before. To calculate the external cost of dust, noise and impact on the landscape in Rönnbäck, the value for WTA for the quarry is multiplied by the number of tons of minerals expected to be extracted from the mine. The environmental costs caused by a hard rock quarry in the UK are presented in Table 2.

Table 2: Values of environmental costs of quarries, £ per tonne per annum

Quarry type	**Average environmental cost, WTA 1998**	**Average environmental cost, WTP 1999**
Hard rock	2,62	0,47

Source: (Willis & Garrod, 1999).

To estimate the value of job opportunities created by the mine and the mining operations impact on reindeer herding, a study concerning a wind power plant in Markbygden, Piteå municipality and located in the north of Sweden, is used (Ek & Matti, 2015). Similar to Rönnbäck, the area of Markbygden is sparsely populated and has shown a decline during last decades. Job opportunities are therefore assumed to have a similar value in Markbygden and Rönnbäck. The study uses a Choice Experiment to investigate WTP for a reduced impact on birds and reindeer herding as well as an increased number of permanent jobs. Three different values for the attributes are estimated: a *private sample* where the respondents are asked to choose the personally best option, a *public sample* where the respondents are asked to choose the option best for society at large and finally a *pooled sample* of the two former. In this essay, values from the public sample are used since the local society is regarded as the most interesting stakeholder. The average respondents WTP for more job opportunities is first divided to calculate the value per job and then multiplied by the number of households in Storuman municipality. Finally, the value is multiplied by the predicted number of jobs created by the mining operation.

The area of Markbygden wind power park is used as winter grazing for reindeer herding. In the study, WTP for a reduced negative impact on reindeer herding from "significant impact" to "limited impact" is estimated. The impacts are both direct - limiting the area of winter grazing - as well as indirect - increasing the grazing pressure in other areas possibly leading to conflicts with other Sami villages. As the negative impact on reindeer herding in the Rönnbäck area is expected to be affected in a similar way (Storuman, 2017) values are only adjusted to the number of households in Storuman municipality.

Values taken from Ek & Matti (2015) are presented in Table 3. The values from the Public sample are used for calculating the value of created job opportunities and the monetary loss of negatively affected reindeer herding.

Table 3: Estimated implicit prices of job opportunities and reduced negative impact on reindeer herding, SEK

Attribute	**Pooled sample**	**Private sample**	**Public sample**
Reindeer herding	389	480	295
Job opportunity	562	388	725

Source: (Ek & Matti, 2015).

Since the transferred data is from different years all data from the three studies are converted to a monetary value of 2017. This is done with the help of a converter programmed by Edvinsson & Söderberg (2011). Both the external cost of impact on water and the external cost for noise, dust, and visual impact are converted to SEK using exchange rates from Forex. The exchange rates used presented in Table 4.

Table 4: Exchange rates

SEK/USA$	**SEK/A$**	**SEK/£**
9,3030	6,9671	12,0112

Source: (*Valutakurser*, 2017)

There have been several predictions made regarding the produced quantity of nickel, number of jobs generated by the mine, investment costs and expected lifetime of the mine. The most recent estimates are presented in Table 5. These values are used to adapt the data from the other studies to the case of Rönnbäck, as well as calculating costs of investments, profit and tax revenue. The tax rate used for the calculation is 49,4 % of the profit which is what the company is the expected level of taxation that the company would have (Ericsson & Söderholm, 2012)

Table 5: Data regarding Rönnbäck

Number of households in Storuman municipality 2016[1]	2 884
Initial investment in mine (SEK)[2]	10 000 000 000
Investment during remaining lifetime (SEK)[2]	3 000 000 000
Time of construction (years)[2]	3
Lifetime of mine, including time of construction (years)[2]	22
Annual Production (tonnes)[3]	573 000
Processed rock (tonnes/year)[4]	30 000 000

Source: 1) (*Antal och andel hushåll samt personer efter region och hushållsstorlek. År 2011 - 2016*, 2017), 2) (*Socioekonomisk analys - Rönnbäcken*, 2011), 3) (Bradley *et al.*, 2012), 4) (Bradley *et al.*, 2011).

Essential to the profit of a nickel mine, is the price of nickel. The U.S. Geological Survey makes every year a summary of mineral markets. In Table 6, the highest and lowest nickel prices for 2008-2017 are presented. The Mineral Commodity Summaries are published in January each year, why only the value for the first month of 2017 is included. Since prices in January 2017 have been exceptionally low, no maximum value is reported. Minimum values for 2010 and 2016 are not presented in the reports. Averages of the lowest and highest prices of nickel for the period 2008-2017, are used to calculate two different scenarios of annual revenue for the mine in Rönnbäck. The values are converted to SEK using the exchange rate presented in table 4.

Table 6: Prices of nickel

Nickel Prices	**$USD/tonnes**	
Year	**Min**	**Max**
2017	8 480	
2016		10 262
2015	9 895	14 767
2014	15 765	19 434
2013	13 725	17 729
2012	15 654	20 762
2011	17 879	28 249
2010		22 905
2009	9 693	18 520
2008		27 680
Average	13 013	20 034

Source: (Kuck, 2010, 2011, 2012, 2013, 2014, 2015, 2016; Schnebele, 2017).

The company tax is based on the profit. There are therefore two different tax revenue scenarios as well. The initial investment of 10 billion SEK is assumed to be equally divided during the three years of construction. Similarly, the investments of 3 billion SEK during the lifetime of the project is assumed to be equally divided over remaining 22 years.

As described in 2.2 step 6 all data collected are discounted to account for the fact that the value of the goods is expected to vary over time. The discount rates used are collected from Almansa & Martínez-Paz (2011). To note is that different discount rates are used for different kinds of goods: 3.5% for the normal goods and 2.5% for the environmental. Since the discount rates chosen can have a significant effect on the final result of the CBA a sensitivity analysis with alternative discount rates is presented in section 5.

Equation (1)

$$NPV = \sum_{t=0}^{t=n}(\frac{F_t}{(1+SDR)^t}) + \sum_{t=0}^{t=n}(\frac{N_0}{(1+EDR)^t}$$

The variables in the equation stands for:

- Ft:the annual net financial cost or benefit
- N_0: the annual net environmental cost or benefit as assessed by the current generation in year 0
- SDR: 2,5 %
- EDR:3,5 %

In this study, where only one project is discussed, it is enough to conclude whether the net present value is positive or negative. If the benefits are outweighing the cost, the project should proceed. There is of course no guarantee that the suggested project or the impacts considered are the only option; even if the NPV is shown to be positive, there might be better solutions.

4. Results

Here is where the value for Rönnbäck are calculated and NVP is determined in line with step 7 described in section 2.2.

The values used in the CBA are summarised in Table 7. Two different values for revenue from nickel and tax are given, using both the high and the low estimate for nickel prices. The years, the different costs and benefits occur are presented, as is the discount rate applied to the different values. Table 8 presents the NPV of the mining project, calculated using both low and high nickel prices. In Table 9 compares the NPV of tax revenue and externalities (environmental costs and impact on reindeer herding) to see whether the tax revenue can cover the costs imposed by the negative externalities. Full calculations are shown in appendix II – VI.

Table 7: Values used in the CBA

Benefits	**Value/year High nickel prices**	**Value/year Low nickel prices**	**Years**	**Discount rate**
Revenue Nickel, except firm tax	54 104 935 885,64	35 167 240 230,15	3-24	3,50%
Tax revenue	52 688 685 160,36	34 200 104 816,85	3-24	3,50%
Job opportunities, construction	14 913 333,33	14 913 333,33	0-2	3,50%
Job opportunities, operation period	12 325 870,00	12 325 870,00	3-24	3,50%
Costs				
Initial investment	3 333 333 333,33	3 333 333 333,33	0-2	3,50%
Investment during projects lifetime	136 363 636,36	136 363 636,36	3-24	3,50%
Environmental Costs: noise, dust, visual impact	1 247 804 128,00	1 247 804 128,00	0-24	2,50%
Environmental Costs: water	3 363 682,00	3 363 682,00	0-24	2,50%
Reindeer herding	910 229,00	910 229,00	0-24	2,50%

Table 8: Net Present Value of CBA

NPV	
High nickel prices	1 477 031 904 161,12
Low nickel prices	947 125 488 416,30

Table 9: NPV comparing tax revenue and externalities

NPV	
High nickel prices	722 356 405 227,49
Low nickel prices	460 582 635 849,55

Both Table 4.2 and Table 4.3 show positive NPV. The results indicate that the mine Rönnbäck would be a positive investment for society at large. The results will be discussed thoroughly in the following section.

The net present value of the mining project in Rönnbäck was found to be between 947 125 MSEK and 1 477 032 MSEK. The range depending on the predicted price of nickel. The positive result remains when using alternative discount rates to calculate the benefits and costs which indicates that the net benefit value is robust. When considering if the income of tax revenue can cover the negative external effects on the environment and the reindeer industry, the result is also positive. This could indicate that there are resources to cover the external costs that will arise from a mine establishment.

5 Sensitivity Analysis

Since there is a several uncertainties in the quantities and values used in the CBA, step 8, a sensitivity analysis, is important. One of the central parts to consider in a sensitivity analysis for this study is the price of nickel. Nickel prices is a factor that affects the result considerably as it varies. By using two values, a minimum level and a minimum value of the nickel price in section 5 and 6 this uncertainty is taken into account. The different results are shown in table 6.10.

Furthermore, the level of the discount rate has a great impact on all costs and benefits calculated. At the same time, what discount rate that is the appropriate to use is not self-evident. In this study, a discount rate of 3,5 % is used for the normal goods, while the discount rate for environmental goods are 2,5 %. To give some perspective on how the result can vary depending on the discount rate, a higher and a lower discount rate is applied on the costs and benefits to generate two alternative net present values. As shown below in table 10, the result is still positive. The full calculations are shown in appendix VI and VII.

Table 10: Sensitivity Analysis

	NPV (1% discount rate)	***NVP (2,5 % respectively 3,5 % discount rate)***	*NPV (4% discount rate)*
High Nickel prices	2 018 134 571 275,51	**1 477 031 904 161,12**	1 395 278 531 572,21
Low nickel prices	1 296 818 245 934,62	**947 125 488 416,30**	8950 980 745,89

6. Discussion

The main focus of the study has been to investigate what the net benefit of a mining project would be, when taking external effects caused by mining activities into account. There are a wide variety of effects on the natural surroundings that typically occur, but in this study only the impact on water, landscape scenery, noise and dust were included as environmental costs. These aspects are very central, but it would of course have been beneficial to have a more complete review of the impact on the natural environment. If additional impacts would have been considered, e.g. the impact on wildlife, the environmental costs would likely have been greater.

It is also reasonable to believe that the effect on the local region in terms of job opportunities and regional development is more complex than what the analysis in this study comprises. The CBA is based on a previous study by Ericsson & Söderholm (2012) when accounting for the benefit for the local labour market, but only uses data for direct and indirect job opportunities created, and does not consider any extended scope of the effect on the labour market due to regional investments. Basing the benefit transfer on a single study also makes the analysis questionable, just like in any other case where there is lack of data. If more aspects of the mine's impact on the job opportunities in the area would be included in the CBA, the expected benefit would most likely differ. In this CBA, the aim was rather to account for a wide range of cost and benefit, which is why a more detailed analysis of the labour market was not prioritized.

The fact that the CBA conducted in the study is based on benefit-transfer as its survey method is what affects the outcome of the net benefit the most. Even though the planned mining project in Rönnbäck was a specific case study, the transfer of data from other studies has made the study more hypothetical than if the data had been collected from the site. The transfer method is a time efficient way to explore the impact of a project, but the fact that the study is dependent on the quality of the previous analyses is a deficiency. The study of Rönnbäck was also obstructed by the fact that no accessible CBA seem to have been made on mines in similar conditions to Sweden. This made it necessary to use other studies on projects that could be assumed to have similar impacts on the society and the environment. It can of course be questioned if the impacts are comparable. Even if many of the impacts made when extracting natural resources resemble the ones made by a mine establishment, more time could be allocated to look closer at how comparable the external effects of a mine are to the studies used in for the benefit transfer.

In the ideal case, data should be collected at the prospective site for the mine in Rönnbäck in order to ensure that all site-specific conditions are taken into account and that the impacts are quantified in a reasonable way. For this study, some important measures could also be taken to improve the exactness and reliability of the analysis. If more information regarding the project's magnitude and impact on the natural surroundings, more information about groups affected by the mining would be gathered, it would contribute positively to the validity of the results. Something also worth noting is that a considerable amount of data for the CBA was accessed through the mining company Nickel Mountain Resources. This could be an issue in relation to impartiality, but it has also been a good way to get information on how the company is planning to conduct their project.

In the study, the life time of the mining project is assumed to be about 24 years including the construction period. This is however a time period that is likely to change depending on mineral prices, authority's trial and the general economy of the company initiating the mining project. The calculations that together make up the CBA are all depending on the assumption of the mentioned operation time, which means that the result can change considerably if the time frame of the project extends or shortens. A crucial factor for the profitability of the mining project, both for the private company and for the socioeconomic state in the society, is the level of the nickel price. The mineral prices are fluctuating and it can be hard to estimate how the world market of nickel will develop over time. The mining projects require large investments, and if there are uncertainties of how the mineral price will act in the near future, a company will want to wait before establishing a mine at all. It is therefore hard to estimate the benefits from extracting nickel in this respect, and the attempts might be misleading depending on the market behaviour.

Another perspective related to the life time of the mine, is that the benefit accounted for are likely to occur only during the lifetime of the mine, while the costs are likely to be present for a longer time period. In this study, it is assumed that both costs and benefit shares the same time frame, but that is most likely not the case. This is certainly an issue since the positive net benefit are based upon the assumption that the surrounding area will go back to the way it was before when the mine ends its production. Furthermore, even if the reindeer industry can go back to use the area after the mine is closed, several actors in the reindeer business state that they are likely to close down their business after having limited access to the area after such a long time (Wikland & Larsson, 2016). These potentially far-reaching effects would affect the outcome of the net social benefit but are not included in CBA, since the survey method and time span was only accounting for the expected life-time of the project.

The valuation of the reindeer sector is difficult due to other reasons as well. The value of the Sami people's traditional activity takes its expression in both economic profit from the companies that operates in the area, but also in cultural value since they are performing a traditional practice that are deeply rooted in the identity of the Samis. However, the WTP is a good method to use in this case, since it takes the accounts for people's opinions about the activity. It could also be said that apart from the WTP for the reindeer sector, the Sami perspective is in some senses handled by taking the natural environment into account, since the reindeer industry are based on an undisturbed nature in the area. The same argument could be applied for the recreational values of the planned mining site.

As a final remark to the discussion it is clear that there are plenty of variables that need to be taken into consideration when evaluating a project as in the present study. It is important to make site specific adjustments and evaluations and to use as much information about the project as possible. With this in mind, a transfer study is however a good way to get a better understanding of an issue and a point of departure for future studies.

7. Conclusions

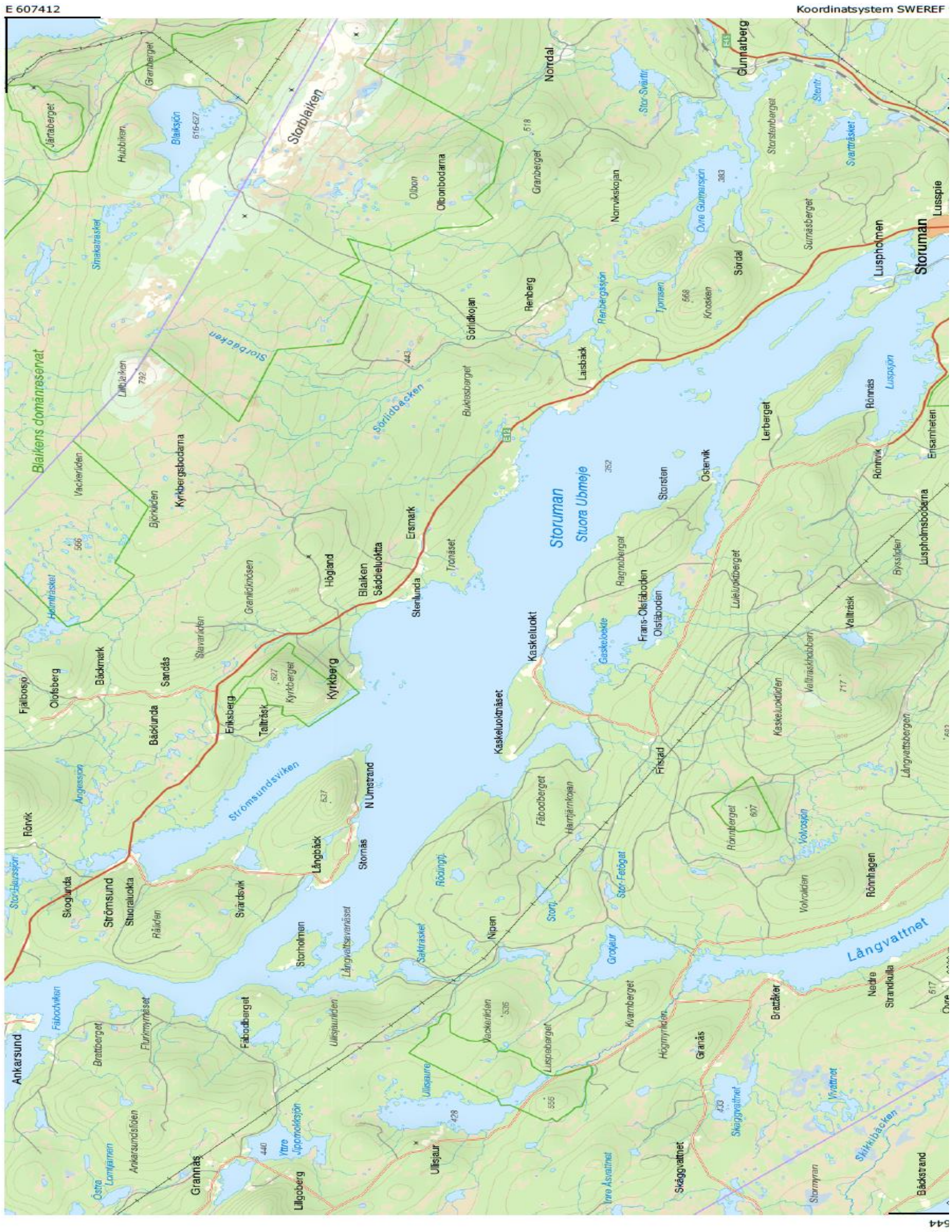
This study has showed that a mine establishment in Rönnbäck will be beneficial for the society, thus answering the research question; *Is it socioeconomically optimal to approve the establishment of mining in Rönnbäck?*

However, since the study is hypothetical and only partly based on site specific data of the mining project, more research is necessary to enable any satisfactory foundation of a policy for Rönnbäck.

Appendix

Appendix I

Map of the area of Rönnbäck. Source: (Karta Rönnbäck, © Lantmäteriet)



Lake Storuman, by the planed mine Rönnbäcken.

Appendix Ⅱ

This appendix contains the calculations of benefits and costs using the data presented in section 3.2. Table 11 shows the calculated revenue from the mine and Table 12 the tax revenue of the Swedish government. Calculations are made using bout a high and a low average price of nickel.

Table 11: Revenue Nickel

	Nickel Price (USA$/tonne)	Annual Production (tonnes)	Annual Revenue (USA$)	Annual Revenue (SEK)
Low nickel price	13 013	573 000	7 456 449 000	69 367 345 047
High nickel price	20 034	573 000	11 479 482 000	106 793 621 046

Table 12: Government's tax revenue from company tax, 49,4% of profit

	Price of nickel (USA$/tonne)	Profit (SEK/year)	Tax Revenue
Low nickel price	13 013	66 367 345,05	32 785 468,45
High nickel price	20 034	103 793 621,05	51 274 048,80

Table 13 and 14 show the environmental costs. The externalities are transferred to the case of Rönnbäck, converted to SEK and adjusted for inflation.

Table 13: Environmental cost - noise, dust and visual impact

Environmental cost (£/tonne/year)	Processed rock (tonnes/year)	Total cost (£/year)	Total cost (SEK/year)	Total cost (SEK/year, monetary value 2017)
2.62	30 000 000	78 600 000	944 080 320	1 247 804 128

Table 14: Environmental cost - water

Environmental cost (A$/km/household/year)	Length of affected water (km)	Total cost (A$/household/year)	Total cost (SEK/household/year)	Total cost (SEK/year)	Total cost (SEK/year, monetary value 2017)
3,74	40,0	149,60	1 042,28	3 005 930,21	3 363 682,0

In table 15 a value for a reduced impact on reindeer herding is presented. The value is multiplied by the number of households in Storuman municipality.

Table 15: Reindeer herding, reduced impact from significant to limited

Value reduced impact on reindeer herding (SEK/household/year)	Value reduced impact on reindeer herding (SEK/year)	Value reduced impact on reindeer herding/year (SEK, monetary value 2017)
295	850 780	910 229

The value of one job for all the households in Storuman municipality is calculated in table 16. Table 17 shows the value for all job opportunities created by the mining operation.

Table 16: Value of job opportunities

Value 100 jobs (SEK/household/year)	Value per job (SEK/household/year)	Value per job Storuman (SEK/year)	Value per job Storuman (SEK/year, monetary value 2017)
725	7,25	20 909,0	22 370,0

Table 17: Value of job opportunities created by the mining operation

	Number of jobs/year	Value jobs/year (SEK)
Construction period	667	14 913 333,3
Operation period	551	12 325 870,0

Appendix Ⅲ

Table 18: CBA using high estimates for nickel prices

Year	Benefits			Costs						
	Revenue Nickel, high price	Tax Revenue	Job opportunities	Investments	Environmental costs: noise, dust, visual impact	Environmental cost: water	Reindeer herding	Net Benefit, normal goods	Net Benefit, environmental goods	Net Precent Value
0			14 913 333,33	3 333 333 333,33	1 247 804 128,00	3 363 682,00	910 229,00	-3 318 420 000,00	-1 252 078 039,00	-4 570 498 039,00
1			14 913 333,33	3 333 333 333,33	1 247 804 128,00	3 363 682,00	910 229,00	-3 318 420 000,00	-1 252 078 039,00	-4 427 742 448,79
2			14 913 333,33	3 333 333 333,33	1 247 804 128,00	3 363 682,00	910 229,00	-3 318 420 000,00	-1 252 078 039,00	-4 289 526 480,99
3	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	95 047 173 626,27
4	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	91 822 058 374,11
5	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	88 706 272 298,24
6	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	85 696 111 757,06
7	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	82 787 998 511,88
8	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	79 978 475 482,43
9	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	77 264 202 645,85
10	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	74 641 953 074,61
11	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	72 108 609 108,38
12	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	69 661 158 655,49
13	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	67 296 691 619,59

			0							
14	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	65 012 396 447,15
15	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	62 805 556 791,83
16	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	60 673 548 291,76
17	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	58 613 835 455,82
18	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	56 623 968 655,34
19	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	54 701 581 217,56
20	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	52 844 386 617,49
21	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	51 050 175 764,80
22	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	49 316 814 382,45
23	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	47 642 240 474,19
24	54 104 935 885,64	52 688 685 160,36	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	106 669 583 279,64	-1 252 078 039,00	46 024 461 877,58
Total										1 477 031 904 161,12

Table 19: CBA using low estimates of nickel prices

Year	Benefit			Costs						
	Revenue Nickel, low price	Tax Revenue	Job opportunities	Investments	Environmental costs: noise, dust, visual impact	Environmental cost: water	Reindeer herding	Net Benefit, normal goods	Net Benefit, environmental goods	Net Precent Value
0			14 913 333,33	3 333 333 333,33	1 247 804 128,00	3 363 682,00	910 229,00	-3 318 420 000,00	-1 252 078 039,00	-4 570 498 039,00
1			14 913 333,33	3 333 333 333,33	1 247 804 128,00	3 363 682,00	910 229,00	-3 318 420 000,00	-1 252 078 039,00	-4 427 742 448,79
2			14 913 333,33	3 333 333 333,33	1 247 804 128,00	3 363 682,00	910 229,00	-3 318 420 000,00	-1 252 078 039,00	-4 289 526 480,99
3	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	61 290 816 988,66
4	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	59 207 221 043,08
5	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	57 194 352 171,64
6	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	55 249 812 117,83
7	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	53 371 283 884,61
8	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	51 556 528 982,65
9	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	49 803 384 771,67
10	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	48 109 761 891,83
11	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	46 473 641 782,01
12	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	44 893 074 282,19
13	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	43 366 175 316,89
1	35 167	34 200	12	136	1 247	3 363	910	69 243	-1 252	41 891

4	240 230,15	104 816,85	325 870,00	363 636,36	804 128,00	682,00	229,00	307 280,64	078 039,00	124 657,10
15	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	40 466 163 757,96
16	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	39 089 593 669,67
17	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	37 759 773 019,02
18	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	36 475 116 059,39
19	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	35 234 090 786,70
20	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	34 035 217 119,07
21	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	32 877 065 138,30
22	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	31 758 253 390,67
23	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	30 677 447 245,42
24	35 167 240 230,15	34 200 104 816,85	12 325 870,00	136 363 636,36	1 247 804 128,00	3 363 682,00	910 229,00	69 243 307 280,64	-1 252 078 039,00	29 633 357 308,72
Total										947 125 488 416,30

Appendix IV

Table 20: CBA externalities and tax using high estimates for nickel prices

Year	Benefit	Costs				
	Tax Revenue	Environmental costs: noise, dust, visual impact	Environmental cost: water	Reindeer herding	Net Benefit, environmental goods	Net Percent Value
0		1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	-1 252 078 039,00
1		1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	-1 221 539 550,24
2		1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	-1 191 745 902,68
3	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	46 359 496 322,19
4	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	44 780 824 263,88
5	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	43 255 804 558,89
6	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	41 782 616 356,71
7	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	40 359 500 540,54
8	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	38 984 757 635,72
9	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	37 656 745 789,13
10	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	36 373 878 816,91
11	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	35 134 624 318,32
12	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	33 937 501 853,51
13	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	32 781 081 182,89
14	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	31 663 980 566,28
15	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	30 584 865 119,49
16	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	29 542 445 226,70
17	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	28 535 475 006,49
18	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	27 562 750 829,90
19	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	26 623 109 888,63
20	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	25 715 428 811,77
21	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	24 838 622 329,31
22	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	23 991 641 981,02
23	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	23 173 474 868,94
24	52 688 685 160,36	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	22 383 142 452,22
Total						**722 356 405 227,49**

Table 21: CBA externalities and tax using low estimates for nickel prices

Year	Benefit Tax Revenue	Costs Environmental costs: noise, dust, visual impact	Environmental cost: water	Reindeer herding	Net Benefit, environmental goods	Net Percent Value
0		1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	-1 252 078 039,00
1		1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	-1 221 539 550,24
2		1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	-1 191 745 902,68
3	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	29 683 856 143,20
4	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	28 669 094 622,35
5	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	27 688 916 016,35
6	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	26 742 144 334,94
7	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	25 827 643 514,66
8	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	24 944 316 064,83
9	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	24 091 101 759,28
10	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	23 266 976 372,61
11	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	22 470 950 459,10
12	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	21 702 068 173,10
13	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	20 959 406 129,36
14	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	20 242 072 301,99
15	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	19 549 204 960,76
16	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	18 879 971 643,39
17	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	18 233 568 162,71
18	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	17 609 217 647,50
19	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	17 006 169 615,78
20	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	16 423 699 079,54
21	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	15 861 105 679,82
22	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	15 317 712 851,08
23	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	14 792 867 013,92
24	34 200 104 816,85	1 247 804 128,00	3 363 682,00	910 229,00	-1 252 078 039,00	14 285 936 795,20
Total						**460 582 635 849,55**

Appendix VI

Table 22: Sensitivity Analysis using 1% and 4% discount rates, using high estimates for nickel prices

Net Benefit (Normal and environmental good)	Discount Factor (1%)	NPV (1% discount rate)	Discount Factor (4%)	NPV (4% discount rate)
-4 570 498 039,00	1,00	-4 570 498 039,00	1,00	-4 570 498 039,00
-4 570 498 039,00	0,99	-4 525 245 583,17	0,96	-4 394 709 652,88
-4 570 498 039,00	0,98	-4 480 441 171,45	0,92	-4 225 682 358,54
105 417 505 240,64	0,97	102 317 192 005,67	0,89	93 715 778 299,10
105 417 505 240,64	0,96	101 304 150 500,67	0,85	90 111 325 287,59
105 417 505 240,64	0,95	100 301 139 109,57	0,82	86 645 505 084,23
105 417 505 240,64	0,94	99 308 058 524,33	0,79	83 312 985 657,91
105 417 505 240,64	0,93	98 324 810 420,13	0,76	80 108 640 055,68
105 417 505 240,64	0,92	97 351 297 445,67	0,73	77 027 538 515,08
105 417 505 240,64	0,91	96 387 423 213,53	0,70	74 064 940 879,88
105 417 505 240,64	0,91	95 433 092 290,63	0,68	71 216 289 307,58
105 417 505 240,64	0,90	94 488 210 188,74	0,65	68 477 201 257,29
105 417 505 240,64	0,89	93 552 683 355,19	0,62	65 843 462 747,39
105 417 505 240,64	0,88	92 626 419 163,55	0,60	63 311 021 872,49
105 417 505 240,64	0,87	91 709 325 904,51	0,58	60 875 982 569,70
105 417 505 240,64	0,86	90 801 312 776,74	0,56	58 534 598 624,72
105 417 505 240,64	0,85	89 902 289 877,96	0,53	56 283 267 908,38
105 417 505 240,64	0,84	89 012 168 196,00	0,51	54 118 526 834,98
105 417 505 240,64	0,84	88 130 859 600,00	0,49	52 037 045 033,64
105 417 505 240,64	0,83	87 258 276 831,68	0,47	50 035 620 224,65
105 417 505 240,64	0,82	86 394 333 496,72	0,46	48 111 173 292,93
105 417 505 240,64	0,81	85 538 944 056,15	0,44	46 260 743 550,90
105 417 505 240,64	0,80	84 692 023 817,98	0,42	44 481 484 183,55
105 417 505 240,64	0,80	83 853 488 928,69	0,41	42 770 657 868,80
105 417 505 240,64	0,79	83 023 256 365,04	0,39	41 125 632 566,16
		2 018 134 571 275,51		1 395 278 531 572,21

Table 23: Sensitivity Analysis using 1% and 4% discount rates, using low estimates for nickel prices

Net Benefit (Normal and environmental good)	Discount Factor (1%)	NPV (1% discount rate)	Discount Factor (4%)	NPV (4% discount rate)
-4 570 498 039,00	1,00	-4 570 498 039,00	1,00	-4 570 498 039,00
-4 570 498 039,00	0,99	-4 525 245 583,17	0,96	-4 394 709 652,88
-4 570 498 039,00	0,98	-4 480 441 171,45	0,92	-4 225 682 358,54
67 991 229 241,64	0,97	65 991 617 247,42	0,89	60 443 955 217,37
67 991 229 241,64	0,96	65 338 234 898,44	0,85	58 119 187 709,01
67 991 229 241,64	0,95	64 691 321 681,62	0,82	55 883 834 335,59
67 991 229 241,64	0,94	64 050 813 546,16	0,79	53 734 456 091,91
67 991 229 241,64	0,93	63 416 647 075,41	0,76	51 667 746 242,22
67 991 229 241,64	0,92	62 788 759 480,60	0,73	49 680 525 232,91
67 991 229 241,64	0,91	62 167 088 594,65	0,70	47 769 735 800,87
67 991 229 241,64	0,91	61 551 572 865,99	0,68	45 932 438 270,07
67 991 229 241,64	0,90	60 942 151 352,47	0,65	44 165 806 028,91
67 991 229 241,64	0,89	60 338 763 715,32	0,62	42 467 121 181,65
67 991 229 241,64	0,88	59 741 350 213,18	0,60	40 833 770 366,97
67 991 229 241,64	0,87	59 149 851 696,22	0,58	39 263 240 737,47
67 991 229 241,64	0,86	58 564 209 600,22	0,56	37 753 116 093,72
67 991 229 241,64	0,85	57 984 365 940,81	0,53	36 301 073 167,04
67 991 229 241,64	0,84	57 410 263 307,73	0,51	34 904 878 045,23
67 991 229 241,64	0,84	56 841 844 859,14	0,49	33 562 382 735,80
67 991 229 241,64	0,83	56 279 054 315,98	0,47	32 271 521 861,34
67 991 229 241,64	0,82	55 721 835 956,42	0,46	31 030 309 482,06
67 991 229 241,64	0,81	55 170 134 610,32	0,44	29 836 836 040,44
67 991 229 241,64	0,80	54 623 895 653,78	0,42	28 689 265 423,50
67 991 229 241,64	0,80	54 083 065 003,74	0,41	27 585 832 137,99
67 991 229 241,64	0,79	53 547 589 112,61	0,39	26 524 838 594,22
		1 296 818 245 934,62		895 230 980 745,89

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