Master's Thesis
Nijmegen School of Management

Economics, Behaviour & Policy

A Social Cost-Benefit Analysis of Dutch natural gas extraction

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27th August 2018

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Abstract

This thesis describes the contribution of natural gas extraction in the Netherlands to social welfare. Natural gas extraction in the Netherlands has encountered backlash from inhabitants of the extraction region, while it is an industry from which the Dutch society seems to benefit enormously due to the government obtaining a large part of the revenues. Reports that evaluate natural gas extraction focus only on the direct costs and benefits. An ex post Social Cost Benefit Analysis is conducted to gain insights on the contribution of natural gas extraction to the society, of the direct and indirect effects caused by extracting natural gas. This overview makes it possible to answer questions that are left open with ordinary cost benefit analysis, with special concerns for the redistributive effects of the Dutch natural gas extraction.

Contents

Chapter 1

Introduction

The Netherlands is going to fully stop its natural gas extraction in the Groningen gas field (Wiebes, 2018) due to societal costs becoming larger than the gains from extraction. A major driver for this decision is the regional unrest, stirred by damage and feelings of unsafety from the nearly depleted gas field's earthquakes (Wiebes, 2018, pp. 2-3). This ends a period of almost sixty years, starting in 1959 with the discovery of multiple small gas fields and the large Groningen[1] gas field – an important milestone in the modern economic history of the Netherlands. Before these discoveries, natural gas was merely seen as a cheap by-product of oil extraction. Especially the Groningen gas field changed this idea, as it was at that moment the world's largest gas reserve ever found.

After several years of negotiations, the Dutch government in 1963 reached an agreement with the Nederlandse Aardolie Maatschappij (NAM) for exploiting the gas reserves. The NAM, a joint venture between the firms nowadays known as Shell and ExxonMobil, and the Dutch government (through the state agency Dutch State Mines (DSM)) created a new legal entity, the *Maatschap* (Society) [2]. NAM became owner of the Groningen concession and was responsible for the gas extraction. The *Maatschap* subsequently took care of the accounting, selling the gas to the infrastructural company, Gasunie, and dividing the revenues to the partners and the Dutch

[1] Also referred to as the Slochteren gas field, to the place it was first discovered.

[2] This method was chosen to cover the involvement of the Dutch government, which was a solution for the *sheikh-effect*(Van Gastel, Van Maanen & Kuijken, 2014, p. 12). In line with this, the second section of the foundation article of the *Maatschap* clearly states that is does not act publicy (Staatsmijnen, B.P.M., Standard Oil Company New Jersey & NAM, 1963). This is due to the oil companies being afraid to weaken their international position, as it was the period of especially Organization of Oil Exporting Countries (OPEC) who were pushing for State participation (Correljé, Van der Linde & Westerwoudt, 2003; Standard Oil Company New Jersey & B.P.M., 1963).

government (Staatsmijnen et al., 1963). The creation of Gasunie was also part of the agreement. It was founded to buy, transport and sell natural gas extracted in the Netherlands (Staatsmijnen et al., 1963).

This agreement started an era of large scale gas extraction in the Netherlands. Gas extraction increased from 2173 million m^3 in the period 1953-1962 with 8375% to 184 167 million m^3 in the next decade (1963-1972). For the entire period of 1963-2016 an amount of 3 600 414 m^3 natural gas has been extracted in the Netherlands (Statistics Netherlands, 2018d), with a total revenue for the Dutch goverment of approximately 265 billion Euros (Verhulst, Van Bloemendaal, Blokdijk, Pothof & Schouren, 2014, p. 5).

Correljé et al. (2003, p. 16) argue that these revenues have had multiple positive effects. Firstly, it opened luxuries like gas fueled central heating to Dutch households. It brought comfort to them. Second, it gave the Dutch the possibility to close the coal mines earlier than neighbouring countries. Third, the revenues allowed the Dutch government to uphold the welfare state and to invest in flooding protection. Fourth, it gave the Netherlands the possibility to decrease oil imports long before similar countries were able to do this. Next to these effects, the natural gas sector is a major employer in the region of Groningen. Estimates are that it generates around 60 000 jobs directly and indirectly (Van Den Berg, Denys & Bos, 2012).

On the other hand, economic debate has been going on about negative effects on the Dutch economy, especially considering the ‘Dutch disease’. This hypothesis argues that due to the abundance of money coming in the Netherlands as a consquence of this prospering new industry, the competitive position worsens – leading to a shrinking tradable sector (Corden & Neary, 1982). This would be the mechanism behind the relatively bad economic performance of the Netherlands in the early 1980s. Another explanation for this focuses on presumed ‘burning’ money, keeping the social welfare state at a level that is not maintainable.

Verhulst et al. (2014) have examined the effects of the natural gas revenues in an audit for the Dutch Court of Audit. The report compares three scenarios for the usage of gas revenues in the Netherlands. Their first scenario described the current practice. All revenues are spent in the General Budget. In the second scenario an allocation fund is described, which would be a fund comparable to the formerly present Economic Structure Enhancing Fund (FES). Revenues solely flow to the earmarked budget. In the last scenario a State capital fund (also referred to as Sovereign Wealth Fund) is created, the direction followed by the Norwegian government. The revenues are accrued and a fixed percentage is deducted from the fund and added to the government budget each year. A downside of this approach is that the potential of revenues for the use of alleviating the sovereign debt is lost.

The main difference between the alternatives is the period during which the revenues can be used for the government budget. The first and second scenario instantly provide a high contribution, as all revenues are directly spent. As the natural gas resource depletes, in the future periods there are no direct contributions as natural gas revenues disappear. With using a State capital fund, the contribution to the general budget is smaller in the first periods. Norway uses this method. It deduces a yearly amount of 4% of the funds' capital, which is offset by an average return of 5.6%. (Verhulst et al., 2014). In the calculations of Verhulst et al. (2014), the Dutch capital fund would have generated more revenue from the withdrawal of the capital fund than revenue from natural gas from 1988 onwards. Considering these scenarios, the conclusion could be made that from a generational perspective the decision has been made in the 1970s to use a high discount factor and shift consumption to the present. This conclusion is supported by Correljé et al. (2003, p. 64), the volume of natural gas extraction was increased due to the expectation that nuclear energy would take over the market – rendering natural gas worthless.

The Dutch Ministry of Economic Affairs criticizes the results from Verhulst et al. (2014). The seemingly most compelling caveat addressed by the Ministry is the lack of inclusion of social returns in the analysis. This argument states that the natural gas revenues that were spent through the general budget might create a permanent income through social returns, instead of capital returns that are generated with the capital fund. Their reasoning is valid in the first periods, during which the revenues that are directly spent in the general government budget will generate higher social returns than the withdrawal of the sovereign fund would. However, after a certain amount of time the sovereign fund will benefit more from the yearly withdrawal than it could gain from natural gas extraction. At that point, the social returns in the third scenario will start to eclipse the social returns of the first scenario if capital returns are higher than social returns.

1.1 Research question and objective

The critique by the Ministry of Economic Affairs might hardly be relevant in the comparison between the different policy alternatives. However, it is still relevant to study the effects of natural gas revenues and to find out whether it resulted in causing negative effects. Next to that, it is of great relevance to find out why a profitable industry that generates revenues for society encounters such a backlash as is happening with natural gas extraction. Hence, this thesis examines the social costs and benefits of natural gas extraction. Whereas studies like (Verhulst et al., 2014) are limited to only use costs and benefits directly related to the business case, this thesis studies the costs and benefits for the society. This set-up improves upon previous research as it give policy makers a better overview of the total effects of this policy on society. Therefore, central question is:

What are the social costs and benefits of natural gas extraction?

To answer this question, the method of the Social Cost-Benefit Analysis is used. This analysis includes both direct and indirect effects of a policy measure and values these effects on their contribution to the social welfare function. Welfare economics is used as theoretical background for conducting this analysis.

1.2 Outline

The theoretical chapter consists of two parts. First the environment that was created for natural gas extraction is outlined to create a common understanding of this complex setting. Second, the theory behind social returns is examined. It is shown why studying the social return can be important and how this is embedded in economics.

The methodological chapter will first give an introduction to Social Cost Benefit Analysis. Then, further in the chapter methodological decisions for this analysis are explained.

In the analysis, the Social Cost Benefit Analysis will be conducted based on the parameters chosen in the methodology. The forthcoming results are discussed in the final chapter.

Chapter 2

Theory

The theory first gives a historical background of the institutional environment of the natural gas extraction in the Netherlands. Furthermore, the natural gas extraction policies are outlined.

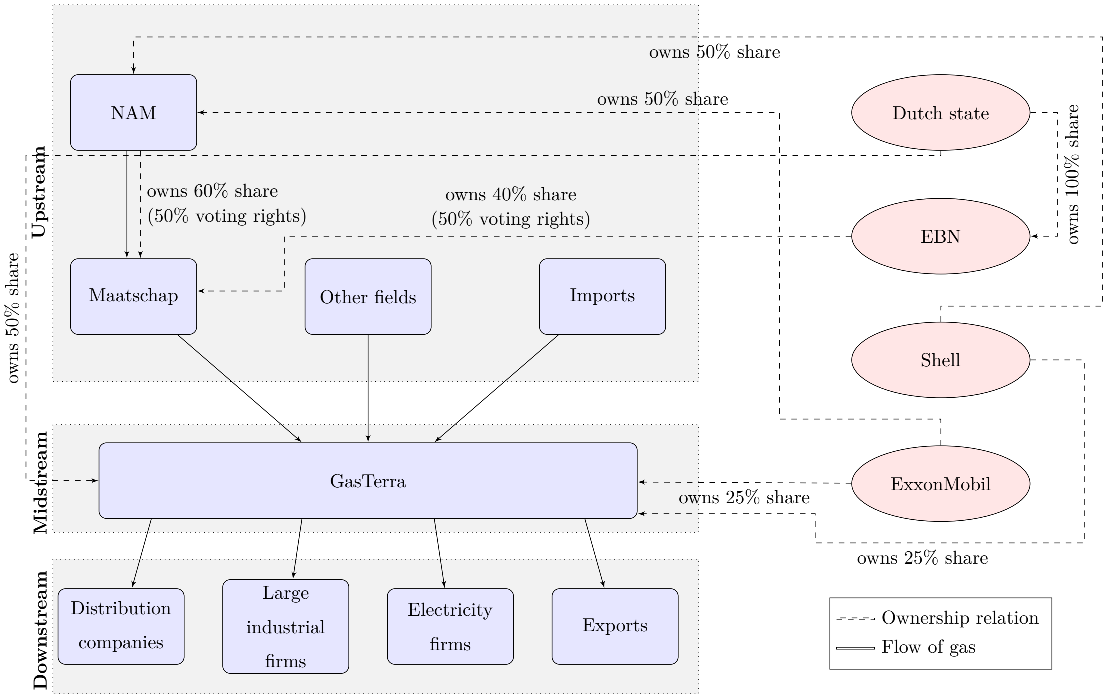
2.1 Institutional environment

The market for natural gas can be divided in three segments: Upstream, midstream and downstream (Correljé, 2016, p. 29). Figure 2.1 gives an overview of the three segments in the Dutch natural gas market. This section will outline the relationships in this figure, as well as the historical context behind them in order to give an understanding in the institutional processes underlying the natural gas market.

The upstream segment creates the supply in the natural gas market, with gas extraction and exploring new fields. As mentioned in the introduction, in 1963 a public-private cooperation was created between the Dutch state, Shell and ExxonMobil. They created the joint venture NAM in 1947 for the extraction of the Schoonebeek oil field. NAM received the concession rights to extract the Groningen gas field until it is depleted. Therefore, NAM has the main responsibility in the upstream sector in the Groningen area.

After the natural gas is extracted the Maatschap accounts for costs and sells the gas to GasTerra, who sells the natural gas to the market as a wholesaler. The Dutch State does not participate directly in the Maatschap. DSM, which was fully owned by the Dutch state until 1989, represented the Dutch state. After the Dutch state started to privatize DSM, their activities regarding natural gas extraction were split from the rest of the company to form Energiebeheer Nederland B.V. (EBN), which remained fully owned by the Dutch state (Van Gastel et al., 2014, p. 13), whose interests are managed by the Ministry of Economic Affairs (Algemene Rekenkamer,

Figure 2.1: Institutional environment. Adapted from Correljé, Van der Linde and Westerwoudt (2003, p. 36)



2015, p. 42).

With the sale to GasTerra the midstream section is entered, gas is transported to distribution companies or large industrial firms. In the 1963 agreement this task was given to the newly formed Gasunie, which also had the task to maintain gas transmission in the Netherlands. The market for gas infrastructure was seen as a natural monopoly due to the increasing returns to scale, the undesirability of having multiple pipeline systems in the nation and the need for secure energy supply (Correljé, 2016, p. 29). Therefore, Gasunie became monopolist in gas transmission as the owner of the natural gas transportation network in the Netherlands, the Transmission System Operator (TSO).

However, due to the European energy market liberalization of 1999 the Gasunie was in 2005 forced to split both tasks, upon which GasTerra was founded (Van Gastel et al., 2014, p. 12).

Whereas Gasunie was formerly owned for 25% by both Shell and ExxonMobil and 50% by the Dutch state, after the split both oil companies were bought out by the Dutch state – becoming full owner. This division was part of the energy market liberalization to stimulate competition in the wholesale market, which would not be possible without access to the *essential facilities* of the gas transportation network Correljé (2016, p. 30).

The final segment of the gas market, the downstream, consists of the supply from distribution companies – retailers – to households and businesses that do not have an exceptional energy demand.

With outlining the set-up of the market it already becomes clear that the natural gas market has been reformed during the end of the past century. Therefore, the next subsections show the transition from a coordinated energy market towards the liberalized energy market.

2.1.1 Coordinated energy market

The Groningen natural gas field is by far the largest reserve in the Netherlands and has a major role in providing a stable supply of natural gas. To prevent this field from a steady depletion, the *small field policy* was created. This policy prioritized Non-Groningen natural gas fields over the Groningen field. Natural gas from the latter is used to provide a stable and reliable supply of natural gas (Correljé et al., 2003, p. 50), e.g. in harsh winters the Groningen field is used more.

Correljé et al. (2003, p. 51) argue that the Dutch state clearly revealed that their priorities were to provide a sufficient supply instead of maximizing revenues with implementing this policy in the mid-1970s. Due to economies of scale it is cheaper to extract gas from larger fields. Therefore, prioritizing the smaller fields leads to a decrease of the profit margin. However, due to a rapid increase in both real and nominal natural gas prices from 1974 onwards (Krichene, 2002, p. 559) and the use of the *market-value principle* this did not have an effect on the revenues.

The market-value principle entails that the natural gas price is pegged to the substitutes (mainly oil) for the different kind of consumers (Van Damme & Ruys, 1999, p. 17; Aalbers & Langenhuyzen, 2000, p. 1; Correljé et al., 2003, p. 34). It was introduced to make natural gas an alternative for Dutch consumers, while on the other hand the revenue is maximized as the consumer price of the substitutes was much higher than the production costs of natural gas (Correljé et al., 2003, p. 34).

An important prerequisite for this principle to work is that no other sources of natural gas had the ability to enter the Dutch market as competition would decrease the government and concession holders' revenues, they would not be able to maintain a price above the market level (Aalbers & Langenhuyzen, 2000).

2.1.2 Liberalized energy market

Changing attitudes towards the role of the public sector in the energy market in the 1980s and the European Commission expressing the objective to adopt the Single Market strategy in 1985 (Council of European Communities, 1988, p. 2) resulted in restructuring the energy market on European Union level in the 1990s. The aim was to create competition in either the upstream segment between gas suppliers and in the downstream segment between trading wholesalers and retailers (Correljé, 2016) in order to reduce energy costs to the benefit of consumers and industries (Council of European Communities, 1988, p. 5). From the perspective of the Dutch energy market, the market-value principle had need to be abolished.

Correljé (2016) distinguishes three regulatory principles that were adopted to transform the divided markets into a Single Market. The first principle, the 'unbundling' of production and trading activities was implemented to prevent asymmetric information and conflicts of interests. Without embracing this principle, the firm operating in both activities could use prior knowledge about either activity to manipulate the other. In the Netherlands, this was implemented by the split between Gasunie and GasTerra.

Secondly, 'undiscriminatory access' to the *essential facilities* for trading means. This corresponds with the first principle, as this is a prerequisite to guarantee that the unbundled activities are not only *de jure* unbundled. Gasunie has implemented this principle by operating the Title Transfer Facility (TTF), a virtual marketplace for the trade of natural gas. TTF has emerged as one of three most important trading hubs in the natural gas market in Europe (De Jong & Schneider, 2011, p. 3).

As third, it was noted that the characteristics of the gas infrastructure as natural monopolies cannot be neglected with the liberalization of the energy market. Due to the market form, the infrastructural firms will not be able to find market efficiency while it does have the ability to abuse their market power. To manage these aspects, each Member State was required to create an independent regulatory authority for the infrastructural monopolists. This regulatory role is fulfilled by Netherlands Authority for Consumers and Markets (ACM) in the Netherlands (Netherlands Authority for Consumers and Markets, 2017). As a result of this regulation, Gasunie has moreover been forced to reduce their usage fees (the payment for using their gas transportation network) due to worse performance compared to other TSOs. The impact of the third principle can be found in the natural gas market regulatory goals as maintained by ACM (Netherlands Authority for Consumers and Markets, 2017, p. 5):

- Provide network operators with an incentive to operate in an efficient manner
- Prevent network operators from charging tariffs above the (efficient) cost level
- Allow network operators an appropriate return on investments

This overview brings forward that due to shifting attitudes towards the role of the state in the market the natural gas market in the Netherlands has been reformed from a coordinated market towards a liberalized market. It is debatable whether the effects of this reform to the general welfare of the Netherlands have been positive or negative[1], however, this goes beyond the scope of this thesis.

This section surveyed the institutional environment of the natural gas market. The next section will go deeper into how it is possible that there are effects that are not directly included in this market, as this would normally be the case.

2.2 Social returns

The critique from the Ministry of Economic Affairs implies that social returns were missing in the analysis of Verhulst et al. (2014). In the economic literature, a disparity between market returns and social returns can be contributed to market failures. A major cause of market failure are externalities. This section brings forward what externalities are and how they could cause the disparity between market returns and social returns.

Externalities were first introduced by Marshall as *external effects*, defined as 'economies external to the firm, but internal to the industry' (Mishan, 1971, p. 1). However, most well-known is the contribution of Pigou in the field of externalities, who defined externalities as the divergence between 'private net product' and 'social net product' (Mishan, 1971, p. 1). Externalities exist in two types, positive and negative externalities. Most literature covering externalities discusses

[1] Aalbers and Langenhuyzen (2000) argues the liberalization of the European energy market will have negative net welfare effects for the Dutch society due to multiple effects. Lower natural gas prices might decrease the societal welfare in Europe due to negative environmental effects. Increased competition will generate higher demand for energy, which increases greenhouse gas emissions with negative external effects to the environment as consequence.

However, their main argument is that it is not likely that the increased demand will outweigh the loss of revenue due to lower pricing, as there already was a cap on the production capacity in the Netherlands. Next to that, increasing the production cap would only speed the depletion of the natural gas fields. The decrease in natural gas revenues would have to be substituted by higher taxation to balance effect on the government budget. This is negative for the societal welfare as the authors argue that higher taxation on production factors has more distortionary effects than revenue gained through a higher natural gas price.

negative externalities. These exist when marginal private costs of an action are lower than marginal social costs. An example of this is a scenario in which there is a factory and there is a fisherman. The factory pollutes the nearby river as side-product of their operations. The fisherman operates downstream of this river and has decreased benefits due to the polluted river he is fishing in. This decreased benefit is a negative externality according to Pigou's theory. On the other hand, with positive externalities private net benefit is lower than the social net benefit. An example is this is education, generating knowledge spillovers. An investment is made by an individual in education from which he or she makes a benefit in a higher future salary. However, the acquired competencies can be valuable more to society than the increased salary does as the person could inspire other individuals or spread ideas that benefit third parties.

A major problem in economics regarding externalities is whether they are internalized by the market or not and the subsequent question whether the government should intervene. Actually, one of the main arguments behind market failure is the existence of Pareto-relevant externalities, which are negative externalities that would increase and positive externalities that would increase social welfare if removed. Dahlman (1979) illustrates this by the use of two different general equilibrium models. The first model exists of a system with standard production functions and standard utility functions that result in unique general equilibrium price vectors with each different endowments. The second model exists of the same system with the introduction of externalities. The author argues that in general the equilibrium resource allocation will be different in the second model. This difference can only exist if the market does not fully internalize externalities and fail to reach Pareto-optimality in the first model. If they would have, there would be no difference in equilibrium price vectors with the introduction of externalities, as a perfect market would already have internalized externalities.

However, critics have arised on the methodology of taking a world without frictions as reference point and to argue that this leads to market failure, it is therefore called a zero transaction cost model (Dahlman, 1979). Transaction costs should be included in the first model, making it a positive transaction cost model. These are costs that mainly arise due to uncertainty as a result of information asymmetries. This includes a variety of costs like search costs, monitoring costs, bargaining costs, etc. With the inclusion of these, the first model would describe an attainable optimum instead of a solely theoretical idea as first mentioned. With the introduction of transaction costs, the introduction of externalities in the second model does not alter the equilibrium resource allocation. In this new situation, the Pareto-relevant externalities are internalized by the market as actors observe the potential costs or benefits of internalization with the inclusion of transaction costs. As Pareto-irrelevant externalities do not increase social welfare if they are removed, these were already absorbed by the market. This adaptation results in an outcome in which there is no role for government intervention on externalities.

Returning to the example of the fisherman, it would mean that market equilibrium can be reached even if the fisherman receives less income due to pollution, if the factory's marginal income due to the damage is larger than the loss of income from the damage for the fisherman. The other way around, if the marginal income of the factory due to the damage is lower than the marginal income of the fisherman, the fisherman would bargain and pay the factory to lower its production – or buy the factory to internalize the problem.

With the assumption that the world reaches its Pareto equilibrium with the inclusion of transaction costs, government action on externalities is only Pareto efficient if the government has a higher efficiency than the market. Thus, the transaction costs should be lower as a result of government action. This assertion is striking with the earlier mentioned attainable optimum, as there would be no attainable market optimum if the government is more efficient than the market. Dahlman (1979) concludes that the result of this assumption is:

> In the presence of side effects, markets fail.

Going further on this quotation he argues that the persistence of Pareto-relevant externalities as deviations from the attainable optimum cannot be justified on transaction costs, the judgment on the internalization of Pareto-relevant externalities determines whether one believes in the existence of these. Therefore, according to Dahlman (1979) the justification is based on personal value judgments more than on positive economics. It depends on the observants' judgment on government efficiency relative to market efficiency and forthcoming, the existence of market failures. Demsetz (1996) refers to this judgment as the comparison between the *idealized state* and the *idealized market*, only resulting in an outcome in which no action ought to be undertaken by the state.

This does not per se contravene with the works of Pigou (and welfare economists in general), as he does not prove – only *assumes* – that there are Pareto-relevant externalities left in the market and points his literature on policy issues involving these assumed externalities. On the policy issue, the analysis of Coase (1960) differs less from Pigou. Coase (1960) argues that the government should intervene when the transaction costs of internalization by the private firm is too high. Extending on his earlier work, the government – seen as supra-firm – should internalize the problem and move the market transaction towards an administrative (internal) transaction.

An important note by Demsetz (1996), however, is that this discussion should be regarded as a discussion sprung from the historical treatment of the externality problem. Although being more difficult than using idealized conditions due to a lack of empirical data on phenomena such as public choice, he prefers the comparison between the actual government and the actual market. Coase (1960) can also mainly be seen as a critique on the economic history of externalities. The author discards the idea of an ideal world, instead he proposes to take the real world as a reference point and to analyze the departure from this situation. Coase (1960) advocates an analysis of the total effect of policy changes, of which transaction costs is an example. In analogy with this idea, Demsetz (1996) argues that the zero transaction model is mainly used to characterize the existing economic ideas (the assumption of perfect competition) at the time of Coase (1960).

The critique of the Dutch Ministry of Economic Affairs seems plausible in the limelight of Coase his remarks. They seem to correctly point out at a gap in the analysis of (Verhulst et al., 2014) by arguing that government spending is preferred to saving money in a fund due to social returns, positive externalities created by these expenditures. In the limelight of the theoretical discussion it is interesting to see whether government action internalizes transactions not occurring due to too large transaction costs and thereby solving market failures?

Individuals who have negative judgments on the persistence of Pareto-relevant externalities would argue that the government expenditures are less efficient than the market and could therefore have positive social returns, but not at the attainable optimum. Individuals who hold positive judgments will not agree on reaching the attainable optimum. The complexity of this issue is that these positions remain theoretical. They cannot empirically be tested due to the impossibility of determining the attainable optimum.

Therefore, this thesis does not examine the question of the persistence of externalities. The Pigouvian tradition of *postulating* that Pareto-relevant externalities persist is used. To put the focus not on comparing government and market efficiency, but rather to examine the side effects of the policies that have been adopted. The definition of externality that is used in this perspective is the definition as stated by Pigou; externalities are a divergence between private and social costs and benefits. However, externalities are not the direct equivalent of social returns. In an endogenous growth model that examines the effect of R&D expenditures on aggregate output Jones and Williams (1998) define social returns as the effect on consumption in the second period of a reallocation of resources from consumption towards R&D investment in the first period. The reallocation towards R&D results in multiple dividends to society that accumulate in the social return. In the case of R&D this dividend consists of a dividend of new ideas, increasing the future productivity path of capital and labour and a dividend to productivity of future R&D investment. The latter might increase due to a 'standing on the shoulders of giants' effect (knowledge spillovers), but also decrease as result of a 'stepping on toes' effect. This study is a contribution in a major strand of studies on effects of R&D investment on economic growth, as the effect of R&D is related to total factor productivity growth (B. H. Hall, Mairesse & Mohnen, 2010). This study is an example of how positive externalities can lead to multiplier effects, which is an application that is also going to be included in the analysis of this thesis.

2.3 Conclusion

This chapter first examined the institutional environment of natural gas extraction and developments within this environment. The second part consisted of examining the theoretical basis on 'social returns'. These social returns can be reaped by solving market failures, of which it is assumed that externalities are most important with the natural gas extraction. The welfare economic approach of assuming that the market is not efficient and that there are externalities left will be used to examine the social returns of gas extraction. This assumption is consistent with the foundations of Social Cost-Benefit Analysis, which is elaborated upon in the next, methodological, chapter.

Chapter 3

Methodology

To analyze the costs and benefits of natural gas extraction in a systematical manner, a Social Cost Benefit Analysis (SCBA) will be conducted. This method is commonly used as ex ante decision rule for publicly financed projects. It assesses the costs and benefits in a *money metric* measure of utility by applying analyses from welfare economics. This means that factors that are not directly expressed in monetary value (e.g. noise pollution, clean air) are valuated with a so-called *shadow price* (Boadway, 2006). Shadow pricing estimates the willingness-to-pay in terms of units of current consumption. The application of welfare economics indicates that the costs and benefits are regarded on their effect on a social welfare function. The scale of this social welfare function is important as it determines the scope on which effects are weighed, e.g. taking a municipal scale would neglect substitution effects of a project on the social welfare of neighbouring municipalities. This project studies the effects on a national scale, as the national government was the level at which the decision of starting with natural gas extraction was made. An important factor behind this social welfare function is the weighting of different citizens and the effect of unequal distribution of utility among citizens. The most common approach is to ignore redistributive concerns in the utility weighting, as proposed by Harberger (1971) in order to give a positivist outcome. The redistributive effects can be given as information apart from the net present value, so it can be taken into account by the policy maker or politician who has the ability to make normative judgments on these issues. (Boadway, 2006; Romijn & Renes, 2013, p. 112).

With SCBA, one or multiple projects are compared to a zero point measurement. The criterion that best fits this comparison mostly is the net present value, due to its intertemporal characteristics. It does not only include the current period, but future periods are included with a discount factor. A project is socially profitable with a positive net present value, which indicates that it leads to a higher social welfare optimum than the zero point measurement.

A systematic process for the SCBA is provided by Romijn and Renes (2013), who drafted SCBA guidelines for Dutch government usage. The process in their model consists of eight subsequent steps:

1. Problem analysis
2. Determine zero point measurement
3. Define policy alternatives
4. Determine effects and benefits
5. Determine costs
6. Scenario and risk analysis
7. Draft overview of costs and benefits
8. Present the results

These guidelines will be used in the analysis with several adaptations. A major difference between the projected procedure and this analysis is the moment of analysis. One of the important tenants of SCBA is that it ought to be performed *ex ante*. This has not happened for the Dutch natural gas extraction, the method was hardly documented at the moment the project started. Therefore, whereas the method is primarily defined for deciding between alternatives before starting a project, in this setting it will be used for policy evaluation *ex post*. Ex post use of SCBA is common to evaluate implemented policies, to learn from past experiences (Blom, De Bruyn, Warringa & Schep, 2017). A problematic aspect of an ex post SCBA is to define a zero point measurement, as a scenario has to be created of the would without the policy measure.

3.1 Net Present Value

The SCBA is used to calculate a Net Present Value (NPV). This indicator aggregates the sum of costs and benefits into a single figure that can be used to determine the impact of a policy measure. Two choices have to be made regarding the NPV; what is the base year of prices and what is the size of the discount rate. First, the base year. This is important as all estimates should be using inflation corrected figures that are set to one base year. This analysis will present all estimates in the price level of 2015, as these are the levels given in most of the used data sets and can be easily cognitively processed and put within a reference framework by the the reader. Second, the discount factor. As this analysis evaluates the effects of a decision made in 1963, the NPV assesses the weighting of costs and benefits as it should happen in that year. The discount factor corrects for the time preference. The basic assumption behind this is human impatience: One euro in one year is valued less than one euro today, we demand a return for impatience. This effect can also be applied to the NPV, a cost in 2000 is valued less than a cost in 1965 for the decision maker in 1963. The height of this factor is mostly equated to the marginal productivity of capital (Feldstein, 1964), the returns that can be obtained by investing in alternative projects. Only a project with returns higher than the discount factor increases social welfare, as it otherwise is an inefficient allocation of means. Therefore, it is applied to SCBA, where it functions as policy rule for the minimum returns that should be obtained. Due to the equation with the marginal productivity, the discount factor should be an easy representation of the market interest rate. This is applicable for investments with a maximum span of ten years, looking at the market rate of ten year bonds. However, for projects with a longer time span there is no such market that can be trusted upon, leaving the height of the discount factor open for discussion.

A method that is also applicable for determining long term discount rates is the Ramsey (1928) rule:

$$r_f = \delta + \gamma g$$

In the Ramsey rule, the risk free discount rate, r_f, consists of the social time preference, δ, and the product of the preference for consumption smoothing, γ, and consumption growth, g. The social time preference can, in addition to the theory on time preferences given earlier, be regarded as a preference for generational equality if used on the long run. In this formula, zero time preference indicates that society prefers total generational equity – future periods should have the same weighting as current periods. The preference for consumption smoothing uses the assumption of diminishing marginal utility, leading to a preference for more equal consumption over time. In the Ramsey rule, increasing consumption smoothing leads to a higher discount rate as a higher return is asked for saving for the future instead of consuming now (saving leads to increased consumption in the future and thus more unequal consumption). Due to conducting the SCBA in an ex post situation, the uncertainties coming with an ex ante analysis are not an issue, there is no uncertainty with future costs or benefits. Therefore, the risk free discount rate will be used for determining discount factor in this thesis.

To determine the rate, the factors in the Ramsey rule should be estimated. Werkgroep Discontovoet (2015) discussed what the discount factor for SCBA's in the Netherlands ought to. Summarizing academic discussion on all factors, they calculated that the risk free rate ranges from 1% to 6%, with a rate of 3% as center value. This thesis will use a discount rate of 3 %, while also calculating the NPVs at the upper and lower bound of the discount rate.

For discounting environmental effects, another discount factor is estimated. Environmental effects are not bound by the national border and therefore use a discount factor based on European standards (Aalbers, Renes & Romijn, 2016). Due to higher average economic growth in Southern and Eastern European countries than in the Netherlands, a percentage of 3.5% is used as central value. Aalbers et al. (2016) argues that the main reason behind this is catch-up growth, GDPs per capita within Europe are expected to be decreasingly converging until 2050. With the scope of the period 1963-2017 this does not seem to hold, as catch-up growth started for a large part of accession to the European Union by Eastern European countries at the beginning of this milennium (Baldwin, Wyplosz & Wyplosz, 2006). Accordingly, no different social discount factor will be used for environmental effects.

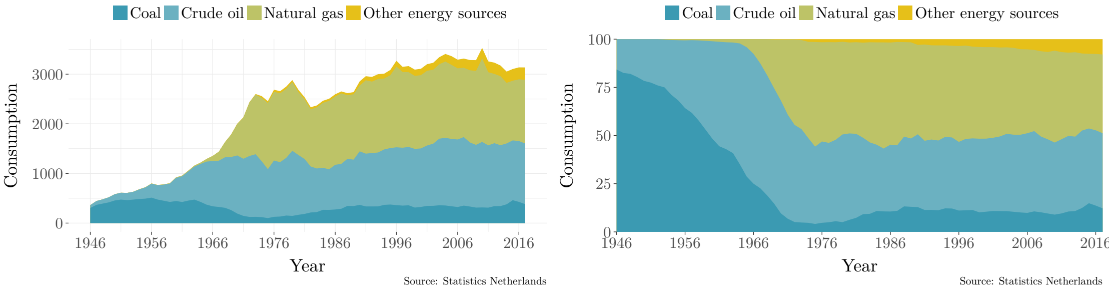
As the ex post SCBA is dependent on the alternative scenario of the world without this policy measure, in the next section the choices that are made for the zero point measurement are outlined. Then the indirect and direct effects are identified and benefits are determined, followed by the determination of the costs. This set-up will be used in the analysis to give an overview of the costs and benefits, with an examination of the redistributive effects. The implications of this analysis are summarized and discussed in the final chapter of this thesis.

3.2 Zero point measurement

In zero point measurement a scenario is determined as if the policy measure would not have been implemented, this functions as reference point in the analysis. This raises some difficulties, due to the ex-post character of this SCBA since the question 'What would have happened without natural gas extraction in the Netherlands' has to be answered.

Figure 3.1 shows the development of sources of energy consumption in the Netherlands. After the introduction of natural gas for consumption means, the share of coal consumption rapidly decrease while the share of natural gas consumption increases. Without natural gas extraction in the Netherlands it is very likely that the share of coal would not have declined with this pace,

Figure 3.1: Energy consumption in the Netherlands



(a) Relative (b) Total

while oil retained its position due to applications like transport. Natural gas extraction was one of the reasons for closing coal mines in the Netherlands since 1963. The industry already suffered from increased competition from cheaper foreign markets. It mainly survived due to having a foothold in Dutch households (Correljé et al., 2003, p. 57), which has been completely overtaken by natural gas after a major increase in energy usage in the 1960s. This transition was primarily fueled by natural gas, which for strategic reasons was first introduced to small users (Verbong & Geels, 2007, p. 1027), resulting in 96% of the households using natural gas in 2009 (Van Der Sar, 2014, p. 12).

Coal was mined in the province of Limburg, in the South of the Netherlands. East of this province, the Belgian province of Limburg is located, which is also a mining region. The comparison between both regions might give an idea of what would be the situation in the Netherlands without natural gas resources, as Belgium does not have access to comparable ones. The vast majority of the mines in Belgian Limburg closed between 1987 and 1992, nearly twenty years later than the mines in Dutch Limburg (Veldhoven, 2015, pp. 334-336). Therefore, it is assumed that coal would keep its foothold in the Netherlands if it would not be substituted by natural gas in the Total Primary Energy Supply (TPES)[1]. Nevertheless, it would have taken twenty years longer for the coal mines to be closed as was the case with neighbouring Belgian coal mining. This would have resulted in a lower trade balance, as more coal would have to be imported and oil imports were also affected negatively by the introduction of natural gas (Correljé et al., 2003, p. 15).

[1]This is a measure of available energy for consumption or conversion means in a country, solely counting the primary energy commodities (e.g. crude oil, natural gas) (OECD, IEA & Eurostat, 2004, p. 18).

As a result of lobbying from the fossil energy sector (Oteman, Wiering & Helderman, 2014), the Netherlands nowadays has a relatively small share of renewable energy compared to neighbouring countries. In the absence of natural gas extraction this lobby would probably be less powerful, leading to a higher share of renewable resources. To capture the effect of this less powerful lobby, additional scenario's with a shift towards renewable energy usage in a size that is double and triple the current renewable energy usage are created.

Natural gas extraction has resulted in a direct benefit for the Dutch state of 286 billion euros (Statistics Netherlands, 2014; Statistics Netherlands, 2018c)[2]between 1969 and 2017. Of these benefits, most has not been earmarked within the general government budget and as such is not directly traceable. The FES is an exception on this, with a total allocation from natural gas revenues of 25 691 million euros between 1994 and 2010 [3]. For the remaining 91% of the gas revenues flowing into the general government budget it is difficult to state how these are allocated and how this additional funding altered the overall budget. Without natural gas revenues the budget could have been cut or financed by increasing sovereign debt. However, some intuitions have been shared in the literature. One idea is that under political pressure the revenues have been used to keep up the welfare state, while these were at unsustainable levels. (Van Der Ploeg, 2011, p. 392; Corden, 1984, p. 359). This idea indicates that fiscal spending would have contracted under the absence of the natural gas revenues. Taking these observations into consideration it is assumed that without the natural gas revenues the Dutch government budget would decrease proportionally.

3.3 Identification of effects

Romijn and Renes (2013) distinguish effects over two types: Direct and indirect effects. In this case, direct effects are interventions on the market that is directly intervened on, whereas indirect effects are interventions on other markets. In the following subsections, first the direct effects are identified and subsequently the indirect effects.

3.3.1 Direct effects

The extraction of natural gas is an intervention in the energy market. First and foremost, it has had the effect of converting natural gas resources into value added, thus economic growth.

[2]Data from before and after the 1995 revision have been combined with 1995 as convergence point. See Figure B.1 for a graphical display of this adjustment.

[3]This amount is a sum based on the yearly statements of the FES as reported to the Dutch parliament.

Next to that, Correljé et al. (2003) mention multiple direct effects. The first effect on this market is the transitioning of households towards natural gas. A large portion of Dutch housing was built after the Second World War, during a period of economic hardship for the Netherlands. They were built with cheap materials and without access to (central) space heating. The transition from coal to natural gas gave the Dutch households access to (central) space heating through natural gas, a luxury that was not present before. The value of this luxury equals the expenditures from Dutch citizens to obtain this service. The availability of this luxury caused an improvement in the quality of the consumption good heating. It attributes to an increase in economic welfare for the consumer through an increased real income as a more valuable bundle of goods became available without a change in income (otherwise the consumer would not choose to obtain the more luxurious form of heating).

Secondly, the coal mines were closed earlier (Correljé et al., 2003). Although this had some redistributive effects from mining regions to other regions in the Netherlands, under the assumption of an efficient labour market the closing of the coal mines has had no net welfare effects. Apart from that, the closing of the coal mines cannot be attributed towards the natural gas extraction. The rise of gas as commodity only made it easier for the Dutch government to make the decision of closing the coal mines from 1965 onwards. This lead to one cost, the depreciation of obsolete coal reserves. Without the coal extraction being replaced by natural gas extraction, these would have had economic use.

Third, it lead to decreasing oil imports and increasing natural gas exports due to having indigenous natural gas (Correljé et al., 2003). This resulted in a more positive trade balance for the Netherlands. However, Verbong and Geels (2007) highlight that the Dutch energy strategy deviated from other European nations on the oil dependency. The other countries aimed at decreasing oil dependency, while the Dutch government coupled a program of energy usage reductions with restrictions on the use and exports of natural gas and enforced usage of oil, which finally should be replaced by coal and nuclear energy (Correljé et al., 2003, p. 82; Verbong & Geels, 2007, p. 1027). This was a major policy shift after the first oil crisis, as before natural gas was valued lowly due to its abundance and the expectation that it would quickly be rendered obsolete as a result of the introduction of nuclear energy (Correljé et al., 2003, p. 82). It was now seen as a strategic resource that should not be used for electricity production, it ought to be preserved for a longer period. Thus, its natural gas gave the Dutch government the possibility to improve the trade balance with respect to natural resources, limited by restrictions after the oil crises.

3.3.2 Indirect effects

The most clear indirect effect is that the revenues have been used for government spending. In the zero point measurement this is already elaborated upon, a part is spent on infrastructure projects. Most, however, was directly spent in the general government government budget.

Finally, the Dutch method of handling natural gas extraction caused the 'Dutch disease'. The revenues that were gained with the boom in the natural gas sector were spent in the on non-traded goods, e.g. services. This caused the relative price of non-traded goods to rise compared to the price of traded goods. At the same moment the currency appreciated, as there was higher demand for the own currency relative to foreign currencies, which had a negative effect on exports as they became relatively expensive. Therefore, resources shifted away from tradable goods (except the natural resource) towards non-traded sectors. Thus, the effects were that the country becomes less diversified in traded goods and has become less competitive (Corden & Neary, 1982; Van Wijnbergen, 1984)[4].

The natural gas extraction also has had environmental effects. Natural gas is seen as a transition fuel towards renewable energy due to generating lower emissions than coal (Hayhoe, Kheshgi, Jain & Wuebbles, 2002; Rodhe, 1990) and oil (Rodhe, 1990). The Netherlands has had lower CO_2 emissions due the usage of natural gas.

The region of Groningen was affected in two different ways. Firstly, negative externalities from natural gas extraction have arisen in the region in which extraction takes place in the form of earthquakes (Boelhouwer & Van der Heijden, 2018). These earthquakes have made the Ministry of Economic Affairs decide to quit natural gas extraction in 2030, after multiple years during which the production volume was decreased by the Minister. This decision was influenced by pressure from local action groups. These were founded due to the fear and anxiety felt as a result of a high (although non-life threatening) risk of a strong earthquake (Van der Voort & Vanclay, 2015, p. 2). Earthquakes are not only having a negative social impact on the inhabitants, damaged homes in the region have to be repaired or replaced for safety reasons (Staatstoezicht op de Mijnen, 2018).

Secondly, natural gas extraction in the region creates jobs. It is doubtful whether this job creation has had any additional welfare effects apart from the value gained from natural gas

[4] Another explanation for this decreased competitiveness is the argument that under political pressure the revenue have been used to keep up the welfare state, while these were at unsustainable levels. (Van Der Ploeg, 2011, p. 392; Corden, 1984, p. 359).

extraction. Assuming that the overall energy level is not affected by natural gas usage[5] (in this way it is regarded as substitute for coal and oil), jobs have only shifted from the South (where the coal mining took place) to the North (the main natural gas extraction region). Natural gas extraction increased the amount of energy produced in the Netherlands as was argued before, decreasing oil imports and increasing natural gas exports. Consequently, the amount of domestic jobs could increase due to substituting products from foreign labor to products from domestic labor. This effect can also be neglected in the welfare analysis, as it is already accounted for with the increased trade balance. On the one hand, shifts in employment will have no additional effect on net social welfare. On the other hand, shifts in employment will have redistributive effects between regions within the nation.

Table 3.1: Identified effects in the SCBA

Effect	Type	Cost or benefit
Added value to the economy	Direct effect	Benefit
Transitioning of households towards natural gas	Direct effect	Benefit
Earlier closing of coal mines	Direct effect	Cost
Surplus on the trade balance	Direct effect	Benefit
Increased government spending	Indirect effect	Benefit
'Dutch disease'	Indirect effect	Cost
Lower greenhouse gas emissions	Indirect effect	Benefit
Earthquakes in the Groningen region	Indirect effect	Cost
Job creation	Indirect effect	Neither

3.4 Data

A wide variety of data sources is employed as a consequence of the wide range of identified effects. Nearly all data comes from Statistics Netherlands, as this agency is responsible for gathering all official statistics in the Netherlands. The exact data sources are provided in the analysis.

One issue arises with the data from Statistics Netherlands. The gathering of most statistics started in 1969, hence there is missing data for the period 1963-1969 for several statistics. This

[5]Which is a realistic assumption, as energy prices were hardly affected due to the 'market-value principle' explained in the previous chapter, therefore not changing the marginal rate of substitution of energy to all other products.

does not seem to be a major issue due to the lower extraction volumes obtained in these years and the dependence of nearly all the statistics on the extraction volume.

3.5 Conclusion

The identified effects (summarized in Table 3.1) will be analyzed in the next chapter in order to calculate the Net Present Value as argued in this chapter by using the methodological choices made in this section.

Chapter 4

Analysis

As brought forward in the methodological chapter, the analysis will consist of an SCBA. First the benefits will be estimated, then the costs and finally an qualitative overview of redistributive effects is given.

4.1 Benefits

4.1.1 Value added to the economy

The value added of natural gas represents its contribution to the Gross Domestic Product (GDP) of the Netherlands. Notten (2015, p. 12) uses the sum of value added from the mineral extraction industry, the price a product is sold for minus the production cost. According to Notten (2015, p. 12), 88% of the value added in the mineral extraction industry can be contributed towards natural gas extraction. Natural gas extraction does not seem to have a high economic multiplier from natural gas extraction, as it has very low intermediary usage compared to production (Notten, 2015, p. 12). Due to the difficulties arising with estimating the multiplier and the fact that it is very likely to have only a small amplitude, it is assumed that there are no multiplier effects from natural gas extraction.

With the use of this distribution between natural gas extraction and other extraction industries, and the discount factor as described in the methodology, the net present value of natural gas extraction is 328 billion Euros[1][2]. The discounted yearly figures and the price index can be found in Table A.1.

[1] Prices of mineral extraction price index of 2015

[2] 552 billion Euros with a discount factor of 1%, 170 billion Euros with a discount factor of 6%

4.1.2 Transitioning of households towards natural gas

In the identification of the effects it was described that welfare increased due to the increased availability of natural gas for means like cooking and qualitatively higher heating.

The utility that is gained from this luxury can be determined by the costs that have been taken to gain it. The increased availability of natural gas was foremost made possible due to innovations in heating on itself, investments in the transport network of natural gas made it possible. The increased social welfare of this luxury therefore can be expressed as the cost of transitioning towards natural gas by creating this network of pipelines throughout the Netherlands, as this investment shows the revealed preference for this kind of luxury from society.

Unfortunately, there are no statistics on the book value of the natural gas network since for a period before 2010. Therefore, it is not possible to give a quantitative estimate of this effects.

4.1.3 Surplus on the trade balance

The natural gas extraction has caused a surplus on the natural resource component of the trade balance of the Netherlands due to exports on natural gas and decreased imports on oil (Correljé et al., 2003, p. 16). Questionable is whether this leads to increased welfare effects on top of the value added from natural gas production. One might consider the GDP formula using the expenditure approach, $Y = C + I + G + (EX - IM)$. In this equation, extracting natural gas will result in decreased imports and increased exports, which increases output. However, the increase of the trade surplus on itself does not seem to have any additional positive effects on economic growth. It is no more than another approach of showing how natural gas extraction contributes to economic growth, essentially the same as the calculation of value added − which is a production approach to GDP − made earlier in this section.

Positive effects of decreased fuel imports and increased exports can be found in the value of possessing a strategic good. This bears impact that can be considered in a geopolitical context, but this economic power cannot be expressed in economic value as it is only one of the many components in global politics.

4.1.4 Additional government funding

The 286 billion Euros earned by the government as result of natural gas extraction could have created additional output (the revenue itself is already included in the output through the value added of natural gas extraction) due to being spent in the general government budget, generating more benefits due to the fiscal multiplier effect. The fiscal multiplier is the ratio of change of the output to the change of government expenditures. A multiplier of one suggests that one additional euro spent by the government increases output by one euro, indicating that it is efficient to stimulate output by means of fiscal expansion. To analyze this effect, two issues have to be coped with.

The first issue is that although the government multiplier effect is subject of a broad discussion within economics, there is hardly any consensus regarding the size of this multiplier effect. The effect of government spending on output is mostly examined by studying the effect of defense expenditure shocks, the most exogenous shock in the government budget, on output (R. E. Hall, 2009). This literature merely focuses on government purchases, consumption by the government, instead of transfers and interest payments. With these methods, the estimates of the multiplier in most studies roughly vary from 0.8 to 1.5 (Ramey, 2011, p. 37), depending on conditions as have an short-term interest rate at the zero lower bound, the openness of the economy and the source of income. Especially the latter is a major difference between the Dutch situation and outcomes from most studies in which the government finances its spending by borrowing or running a budget deficit. When spending is financed by borrowing or creating a budget deficit, the Ricardian equivalence states that citizens will foresee that the increased spending will have to be compensated by future repayments or budget surpluses. Therefore, they will not increase their consumption, but start saving to smooth the expected future economic hardship (De Grauwe, 1996, p. 164). This decreases the marginal propensity to consume, thereby decreasing the output and subsequently the multiplier effect. Due to the absence of any future obligations when government spending increases are financed with natural gas revenues, the Ricardian equivalence does not hold.

Studies of subnational government levels have a comparable situation of increased spending without having to anticipate on future liabilities. With instrumental variable approaches these have measured multipliers above the 0.8-1.5 range.

Serrato and Wingender (2016) used a budget revision as a result of a difference between Census counts and estimated population as instrumental variable,. Shoag (2010) used a 'windfall gain' on state pension plans as instrumental variable, as these excess returns could be used for increased government spending. Chodorow-Reich, Feiveson, Liscow and Woolston (2012) performed a state level analysis on the multipliers from increased federal funding issued as anti-cyclical policy from the Obama government in 2009, identifying the effects with exogenous factors concerning the variation in Medicare programmes prior to the recession. These and other studies using this kind of approach measure spending multipliers of 2.0, with only small deviations. Due to the common characteristics, this spending multiplier seems clearly suitable for the assessment of spending funded by natural gas returns.

The second problem is that, as mentioned in the zero point measurement, the benefits from this additional source of government income cannot be estimated without the use of assumptions with respect to the allocation of funds in the absence of this revenue. This problematic aspect will be handled with the assumption that, as elaborated on in the zero point measurement, all indirectly allocated natural gas revenues have been used for increased government spending.

With both of these assumptions a benefit of government expenditures from government expenditures can be calculated. Using the discount factor of 3%, this results in a net present value of €392 B[3]. However, the value added from natural gas revenues have already been accounted for. The added benefit from increased government funding therefore is estimated at €196 B[4].

4.1.5 Lower greenhouse gas emissions

Due to households transitioning from coal to gas, total greenhouse gas emissions have lowered compared to the scenario in which households would have used coal. In the SCBA, this unpriced effect is monetized by giving it a shadow price. Bein and Rintoul (1999) define a shadow price as 'the present value of possible future stream of monetary costs and benefits of impacts'. The shadow price to be used for greenhouse gas emissions is subject of a wide debate. Main elements are the choice of *discount factor* and *benchmark damage* (impact of CO_2 on the present economy) (Bein & Rintoul, 1999).

The benchmark damage can be regarded as the translation from environmental effects to economic effects. The problematic aspect of benchmark damage is that it values environmental hazards against a market that does not exist, estimating a price for clean air or clean soil.

To monetize carbon dioxide (CO_2) impact, first the amount of CO_2 gasses that has not been emitted due to the transition towards natural gas must be determined. Four scenarios are created, differing in the replacement of natural gas usage by coal and oil (see table 4.1). Energy usage is based on the Energy Balance of the Netherlands Statistics Netherlands, 2018b. Yearly data is taken from the period 1963-2017, the era in which natural gas was extracted in the Netherlands. These four scenarios are also regarded with a shift towards renewable energy, which gives a small diminishing effect on the total benefit A.4.

[3] Data from Statistics Netherlands (2014), Statistics Netherlands (2018c)
[4] Prices of government production price index of 2015

Table 4.1: Environmental costs of alternative energy usage (Net Present Value in 1963, prices of 2015 in billions)

	Low (0.0142 €/kgCO_2)	High (0.0566 €/kgCO_2)
100% coal, no oil	€15.8 B	€63.1 B
75% coal, 25% oil	€13.6 B	€54.3 B
50% coal, 50% oil	€11.4 B	€45.6 B
25% coal, 75% oil	€9.2 B	€36.8 B
no coal, 100% oil	€7.0 B	€28.1 B

Source: Statistics Netherlands (2018b)

The environmental impact of this energy usage was calculated with the use of CO_2 emission factors from Zijlema (2017). These figures are chosen out of a wide range of emission factors due to them being directly applied to the situation in the Netherlands. Alternatives like Hayhoe et al. (2002, p. 113) give emission factors that are based on a global average, giving a deviation due to mainly regional differences. In the emission factors this leads to deviations, in for instance the emissions of natural gas, for which Hayhoe et al. (2002) has a large margin due to uncertainties about methane (CH_4) leakages during extraction and transportation. The Netherlands is highly efficient in this aspect (Kamp, 2017), leading to lower emissions than the global average. In the reporting, a difference is Hayhoe et al. (2002) reporting emissions in not only CO_2, but also in CH_4, sulfur dioxide (SO_2) and black carbon (BC). In the Zijlema (2017) figures, CH_4 and BC are included, but expressed in terms of CO_2 (Heslinga & Harmelen, 2006). However, SO_2 is not included in their figures, as it does not directly contribute to the greenhouse effect and is emitted in a rather negligible quantity compared to CO_2 (Statistics Netherlands, 2018a).

The emissions were monetized (or the benchmark damage is determined) with the estimated environmental prices from De Bruyn et al. (2017). The valuations in table 4.1 are expressed with a lower and upper bound to show the uncertainties of pricing environmental effects. These estimates are made with the central discount factor. The values for the upper and lower bound discount factor are included in the appendix. De Bruyn et al. (2017, p. 39) measure these prices by estimating the effect of emissions on 'midpoints' (e.g. the climate, ozone layer and acidification) and subsequently from midpoint to 'endpoint' (e.g. health, buildings and well-being) to estimate the costs from emissions.

Due to high uncertainties regarding the energy usage in the Netherlands if there would have been no natural gas extraction and uncertainties in the debate of pricing environmental effects, this benefit is estimated to be in the range of €6.3 and €55.9 billion Euros.

4.2 Costs

4.2.1 Earlier closing of coal mines

At the moment of closing the coal mines due to aforementioned reasons, economic value was 'left in the ground'. The residual stock of coal lost its economic value, leading to a depreciation of it. Dutch historical government statistics contain no information on the value of the coal stock, neither are there sources that mention this depreciation. This lack of data, combined with the uncertainty on the causality of the mine closure and the start of natural gas extraction makes it unfeasible to estimate the capital loss that can be attributed to natural gas extraction.

Due to the inevitability of the mine closing, as argued in the methodology, it is very hard to attribute further costs to natural gas extraction. Redistributive effects, elaborated on in the last section of this chapter, could cause friction costs due to market imperfections. Due to the uncertain indirect relation between natural gas extraction and friction costs, these are not included in this analysis.

4.2.2 'Dutch disease'

The Corden and Neary (1982) hypothesis that a natural resource boom hurts the competitiveness of the domestic economy due to increased relative prices of the non-tradable sector compared to the prices tradable sector as a result of increased domestic spending due to income generated from natural resource imports has been widely tested empirically.

In their extensive literature review Magud and Sosa (2010) found that there is little theoretical and empirical support for a reduction of economic growth due to Dutch disease in recent literature. The literature states that the intuition of harmed economic growth comes from assumptions surrounding special characteristics of the declining tradable sector that makes it more profitable than the non-tradable sector, an idea that has been mostly unproven in the literature. Apart from this supposed shift, the Dutch disease models merely describe economic development due to increased wealth.

With lack of support for this hypothesis there are no costs estimated as a result of the Dutch disease. The literature does though describe interesting redistributive effects. These are considered in the final section of this chapter.

4.2.3 Earthquakes in the Groningen region

Natural gas extraction have increasingly caused earthquakes to damage the nine municipalities of the Northern part of the province of Groningen: Appingedam, Bedum, Delfzijl, the Marne, Eemsmond, Loppersum, Slochteren, Ten Boer and Winsum. These earthquakes have a clear negative impact on the region for multiple reasons (Boelhouwer et al., 2016; Van der Voort & Vanclay, 2015). First, the risk of earthquakes and potential damage cause feelings of insecurity and psychological damage. Second, satisfaction with the living area has dropped. Since 2015, it is the least satisfied area of the Netherlands. Third, it has harmed the already weakly performing housing market in the area. Much more often than in an normally functioning housing market, inhabitants have the wishing to leave the area – even though they have a strong connection with it (Boelhouwer et al., 2016, pp. 5-6).

These negative feelings are economically mainly expressed through the housing market, the low demand and high supply of houses in this region. This is not a symptom that directly comes from having an earthquake hazards. Contrary to areas well known for earthquake hazards due to geophysical reasons, the earthquake hazard in Groningen is a relatively new factor in the local housing market, it is not yet fully anticipated on it. In these anticipated markets, housing prices do not fall after earthquakes (Fenn & Elizabeth, 2010). The housing market is transforming towards one in which the earthquake hazard is anticipated upon.

De Kam (2016) used results from Koster and Van Ommeren (2015) to estimate a cost of 954 million Euros for 180.000 houses for this transition. 715 million Euros of this total amount comes from decreased home values in the nine Northern municipalities, leading to an average decrease between 4 and 10% in this specific area. This research analyzed the difference between estimated home values by the government in 2011 and the transaction value in 2012 and 2013, including only transactions within province. This estimate is a rather conservative one. It is only based on data from housing market transactions, leading to a downward bias due to the likeliness that the most severely damaged homes are not included in this figure as they will be more difficult to sell. Next to that, as the author brings forward, the government estimations of home values are mostly lower than their market value as it functions as a tax base.

Boelhouwer and Van der Heijden (2018, p. 432) criticized the approach taken by Koster and Van Ommeren (2015) in the identification of measuring the severity of earthquakes. Boelhouwer and Van der Heijden (2018) argue that not the strength of the earthquake is vital, but the actual damage it has on dwellings. The type of soil the house was built on and the construction year and type are more important determinants according to them. Boelhouwer et al. (2016) estimate a decrease of 2% in housing prices. However, they argue that the decline in prices is less problematic than the decline in marketability of houses and the amount of transactions. Idiomatic of this aspect is that for every house bought in the region, 54 houses were for sale in 2013, nearly double as high as the Dutch average.

This damage on dwellings does not only affect the housing market, these homes also have to be repaired or rebuilt. Staatstoezicht op de Mijnen (2018) advised to strengthen at least 7200 dwelling in the region as prevention measure against an expected future earthquake with a Richter magnitude higher than 4. The costs of this strengthening operation are not yet made public. Apart from that, it is not possible to reach a conclusion on the economic impact of these operations yet. The repair and strengthening operations merely function as redistribution from NAM and the Dutch government towards construction firms, which can easily assumed to be domestic. Next to that, these investments could also decrease the costs from decreased housing values. This aspect is especially difficult to forecast with strengthening the dwellings, becoming superfluous when the earthquake danger diminishes due to decreased natural gas extraction volumes.

Valuing the negative impact of the earthquakes is not complete with solely including the loss of value on the housing market, as it partly neglects the inhabitants' psychological damage. This effect could be priced with the increased costs of psychological aid and subsequent eventual trading in of working hours. This leads to several methodological issues that go beyond the scope of this thesis.

A valuation based on opportunity costs could be made by using the rest value of the gas reserves, 70 billion Euros (Trouw, 2018), that is not going to be extracted as a result of recent measures from the Minister of Economic Affairs. These opportunity costs do not function as alternative for the effects described by Boelhouwer et al. (2016), as it is a decision that has its effect on future earthquakes. Therefore, this valuation does not fit within the methodology of this analysis, due to its ex ante character.

However, a lower bound estimation can be made with the figures from De Kam (2016). As his decreased estimations have occurred in 2012 and 2013, the costs will be divided evenly over these years. This results in an estimated cost of 221 million Euros [5].

[5] 582 million Euros with a discount factor of 1% and 53 million Euros with a discount factor of 6%

4.3 Redistributive effects

The effects in this analysis have been assessed on the social impact for the Netherlands as an entirety. Redistributive effects within the Netherlands do not affect the outcomes, as they do not have an influence on the total welfare of the country. They might not weigh in the final outcome of the SCBA, redistributive effects are important to acknowledge as they might stack upon certain groups within the society. While this does not influence the outcome, it might be of importance for decision makers if this strikes with their preferences. Therefore, this section will give an overview and discuss the possible redistributive effects.

First, the earlier transition from coal to natural gas has redistributed production factors from labour to capital. Coal was a relatively labour intensive industry, while only 4% of the value added from the gas industry is produced by labour (Notten, 2015, p. 13). Due to this difference, the transition from coal to natural gas has caused a relative distribution from labor to capital.

More problematic than the redistribution of factors was the regional redistribution. The Southern part of the province of Limburg had became highly dependent on the coal mining industry. Due to the absence of alternative industries, the closing of the mines resulted in high unemployment and socioeconomic problems. With both of these effects it is difficult to argue whether a delayed closing as in Belgium would have alleviated the

On the other hand, in the Northern part of the province of Groningen new job opportunities emerged which aided an economically struggling part of the country.

Not only did natural gas extraction decrease the labour-capital ratio, due to the mechanisms mentioned in the Dutch disease hypothesis, factors shifted from tradable to non-tradable sectors as an effect of wealth increase. While it is not empirically proven that this has had negative effects for the output, the redistribution towards tradable shifted resources away from the relatively low-skilled manufacturing industry as these were outsourced to lower countries. This development cannot be solely attributed towards increasing wealth in the Netherlands, it occurred in a decade during which world markets became more open and the world started to globalize. In the U.S., job losses due to this transition have had structural negative effects on the labourers, who for a large part were not fit to adapt to new more highly skilled sectors, and regions in which these industries were concentrated (Autor, Dorn & Hanson, 2013; Autor, Dorn & Hanson, 2016; Stiglitz, 2017).

Finally, natural gas extraction to some extent redistributes welfare from the inhabitants of the nine municipalities in the Northern part of the Groningen province to the rest of the Netherlands.

The Netherlands has gained economic welfare from natural gas extraction as can be reasoned from the costs and benefits that are analyzed in this chapter. However, there is a disparity between the location where the benefits are reaped and the costs are made. The benefits have attributed to the national economy, some budgets from the national government considering infrastructure have even been spent disproportionate on projects in the economically strong regions of the country. On the other hand, jobs have moved towards the province as mentioned earlier. The major point is that these regional differences and possible regional welfare loss as a result of distributional effects could be of importance.

4.4 Conclusion

The effects that were identified in the methodological chapter have been analyzed, leading to results that are summarized in Table 4.2. Interesting, and in some aspects problematic, is that the costs are less quantifiable than the benefits of natural gas extraction. This is not only due to missing data as witch the mine closing, but also due to the more subjective negative aspects that come with the earthquakes. These findings will be discussed and put in context in the next chapter.

Table 4.2: Results per identified effect in the SCBA

Effect	NPV in €B
Added value to the economy	328.0
Transitioning of households towards natural gas	.
Surplus on the trade balance	-
Increased government spending	196.4
Lower greenhouse gas emissions	5.6 - 63.1
Earlier closing of coal mines	.
‘Dutch disease’	-
Earthquakes in the Groningen region	0.2

. Effect could not be quantified

- Effect not found to be significant

Chapter 5

Discussion

This thesis had the aim to describe the effects of natural gas extraction on society. In order to do this, a social cost-benefit analysis was used. This instrument was foremost chosen for its treatment of indirect effect and including effects for which there is no market to determine its value. In this chapter first the results of this analysis will be discussed, then the shortcomings of this research are outlined and finally ideas for new further research are given.

Looking at the results, it is clear that the Net Present Value of the benefits is disproportionate for an economy like the Dutch with a sum in euro at the price level of 2017 that is nearly equal to the entire GDP of 2017. It is not possible to calculate a NPV compared the zero measurement point due to missing data and the difficulties arising with phenomena like psychological damage. Though the scale of benefits is to such an extent larger than the height of costs reasonably can be, that there is no doubt that the Dutch government would start extracting natural gas in 1963 with having the information from today. This is not an issue, as it was not the purpose of this thesis to find out whether natural gas extraction has been worthwhile or not. More interesting are the qualitative insights and the aspects that could have been responsible for backlash against government policies that economically might seem very efficient.

Natural gas extraction has contributed for more than 500 billion euros to the Dutch economy is the estimate from the analysis. Still there is the paradox that with an industry with such benefits to society there are discontents due to its negative effects on the extraction region, the Northern part of the province of Groningen. Van der Voort and Vanclay (2015) refers to this discontent as the NAM losing its 'social license to operate' due to psychological damage, decreased satisfaction and plummeting property values in the region. Analyzing the redistributive effects shows how this paradox is possible, costs are made in the region of Groningen and the benefits are spread over the entire country – leading to a possible regional welfare loss from serving a thriving industry.

Stating that there are such redistributive effects is not new, however it is interesting to see how a method like the SCBA can help policy makers to ignore these problematic aspect. First, as the SCBA is used as a policy rule due to its quality of showing a single number that indicates whether a policy alternative contributes to social welfare or not, it is vulnerable for issues that are very known with other policy tools based on providing simple outcomes. An example that lies very close to the SCBA and therefore shows the same pitfalls is analysis with the use of neoclassical economics. With their tension to give clear results, they tend to neglect effects that can be quantified less easily. Effects that are harder to quantify, like the psychological effects in this study or institutions within neoclassical economics, are maybe mentioned, but not included in the final result and therefore neglected too easily. This is not only the case with the earthquake damage, but also with redistributive effects. Neoclassical economics described redistributive effects on topics like opening for trade. However, as Stiglitz (2017) shows, these are for different reasons neglected, leading to the idea that everyone is better off with a certain policy – while there are groups that might be worse off, though they lose less than the winners gain. This is identical with SCBAs, where redistributive issues are not left out of the analysis for positivist reasons and only mentioned afterwards.

Second, the discussion around the height of the discount factor gives a lot of room to discount possible negative future effects to become very small, simply by selecting a high discount factor. This seems obvious, but it interesting that with a discount factor of 3% a costs of a billion euros in 2013, only results in a cost of 250 million euros for the NPV and even only 50 million if the upper bound discount rate of 6% is chosen. As the height of the discount factor is rather arbitrary, it gives policy makers the possibility to diminish future costs and to magnify short term gains. National government try to prevent the abuse of this possibility by setting standards for discount rates (Werkgroep Discontovoet, 2015).

The analysis of this thesis on itself has several issues that are debatable or could be improved. A problematic issue with conducting an ex post SCBA is defining the scenario to compare with, the zero point measurement. The zero point measurement created for this analysis had two aspects with special difficulty: Energy usage and government spending. Better insights on both issues could be gained by conducting qualitative studies on the motives of the decision makers at that moment.

Another issue, that also arises with this suggestion, is the historical time span that makes it very difficult to obtain empirical evidence for the entire period. As Statistics Netherlands for a lot of statistics only started gathering from 1969 onwards, the period between 1963 and 1969 is missing in the estimates. This is assumed not to be a problem due to the low production volume in these years. On the other hand, the costs that are made due to earthquakes are difficult to estimate due to the topicality of it, a lot of developments occurred during writing this thesis and in the coming years new developments will possibly change the costs.

Further research could as stated before, try to find more empirical evidence on the path the Netherlands would have taken concerning energy usage and government spending without natural gas extraction. With respect to SCBA, it is interesting to examine the influence of the presentation of results on policy makers. It would be worthwhile to study how policy makers could be influenced to take notice of effects that are difficult to quantify or redistributive effects. Finally, it would be very interesting to monitor the development of the Groningen region after natural gas extraction will stop in 2030. Especially the question whether a temporary negative influence can have lasting effects would be of great relevance.

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Appendix A

Tables

Table A.1: Value added of natural gas extraction (prices of 2015 in million Euros), 1969-2017.

Year	Value added	Price index	Real Value added	3% Discount	1% Discount	6% Discount
1969	435	7	6072	5085	5720	4280
1970	597	8	7782	6328	7259	5176
1971	801	8	9723	7675	8979	6100
1972	952	8	11971	9174	10945	7085
1973	1177	9	12755	9491	11547	7122
1974	1791	12	15289	11045	13704	8054
1975	3109	20	15814	11091	14034	7859
1976	4215	25	17065	11621	14995	8001
1977	4765	26	18292	12093	15913	8090
1978	4642	28	16515	10600	14225	6891
1979	5396	31	17316	10791	14767	6816
1980	7241	41	17498	10587	14775	6498
1981	9568	56	17107	10049	14302	5993
1982	9910	63	15687	8946	12985	5185
1983	10462	63	16673	9232	13665	5199
1984	11795	67	17678	9503	14345	5200
1985	13456	73	18495	9652	14859	5132
1986	8777	54	16228	8223	12908	4248
1987	5552	37	14984	7371	11801	3701

Year	Value added	Price index	Real Value added	3% Discount	1% Discount	6% Discount
1988	4990	34	14708	7025	11469	3427
1989	5244	35	15139	7020	11688	3328
1990	6308	40	15927	7170	12174	3303
1991	7621	43	17572	7680	13299	3438
1992	6498	38	17017	7221	12752	3141
1993	6200	35	17469	7197	12960	3041
1994	6088	35	17612	7044	12937	2893
1995	6288	36	17369	6745	12633	2691
1996	7488	38	19757	7449	14227	2888
1997	7241	41	17660	6464	12591	2436
1998	6583	39	17011	6045	12008	2213
1999	5685	35	16150	5572	11288	1982
2000	8073	54	15062	5045	10423	1744
2001	10153	65	15525	5049	10637	1696
2002	9307	59	15668	4947	10629	1615
2003	9730	63	15519	4757	10423	1509
2004	10314	61	16881	5024	11226	1548
2005	11337	81	14031	4054	9238	1214
2006	14389	105	13730	3852	8950	1121
2007	13889	105	13278	3617	8570	1023
2008	19416	133	14643	3872	9358	1064
2009	14100	105	13403	3441	8481	919
2010	15399	100	15477	3858	9695	1001
2011	16621	117	14243	3447	8834	869
2012	18837	134	14026	3295	8614	807
2013	19625	129	15178	3462	9229	824
2014	14732	113	13037	2887	7849	668
2015	11061	100	11061	2378	6593	534
2016	6972	69	10134	2115	5981	462
2017	6635	76	8708	1765	5088	374

Source: Statistics Netherlands (2018e), Statistics Netherlands (2018f)

Table A.2: Environmental costs of alternative energy usage with Discount factor of 1% (Net Present Value in 1963, prices of 2015 in billions)

	Low (0.0142 €/kgCO_2)	High (0.0566 €/kgCO_2)
100% coal, no oil	€27.0 B	€107.6 B
75% coal, 25% oil	€23.3 B	€92.7 B
50% coal, 50% oil	€19.5 B	€77.8 B
25% coal, 75% oil	€15.8 B	€62.9 B
no coal, 100% oil	€12.0 B	€48.0 B

Source: Statistics Netherlands (2018b)

Table A.3: Environmental costs of alternative energy usage with Discount factor of 6% (Net Present Value in 1963, prices of 2015 in billions)

	Low (0.0142 €/kgCO_2)	High (0.0566 €/kgCO_2)
100% coal, no oil	€8.2 B	€32.5 B
75% coal, 25% oil	€7.0 B	€28.0 B
50% coal, 50% oil	€5.9 B	€23.5 B
25% coal, 75% oil	€4.8 B	€19.0 B
no coal, 100% oil	€3.6 B	€14.5 B

Source: Statistics Netherlands (2018b)

Table A.4: Environmental costs of alternative energy usage with Discount factor of 3% and a doubling of renewable energy (total energy usage ceteris paribus) (Net Present Value in 1963, prices of 2015 in billions)

	Low (EUR0.0142/kgCO_2)	High (EUR0.0566/kgCO_2)
100% coal, no oil	€14.9 B	€59.4 B
75% coal, 25% oil	€12.8 B	€50.9 B
50% coal, 50% oil	€10.6 B	€42.3 B
25% coal, 75% oil	€8.5 B	€33.8 B
no coal, 100% oil	€6.3 B	€25.3 B

Source: Statistics Netherlands (2018b)

Table A.5: Environmental costs of alternative energy usage with Discount factor of 3% and a tripling of renewable energy (total energy usage ceteris paribus)

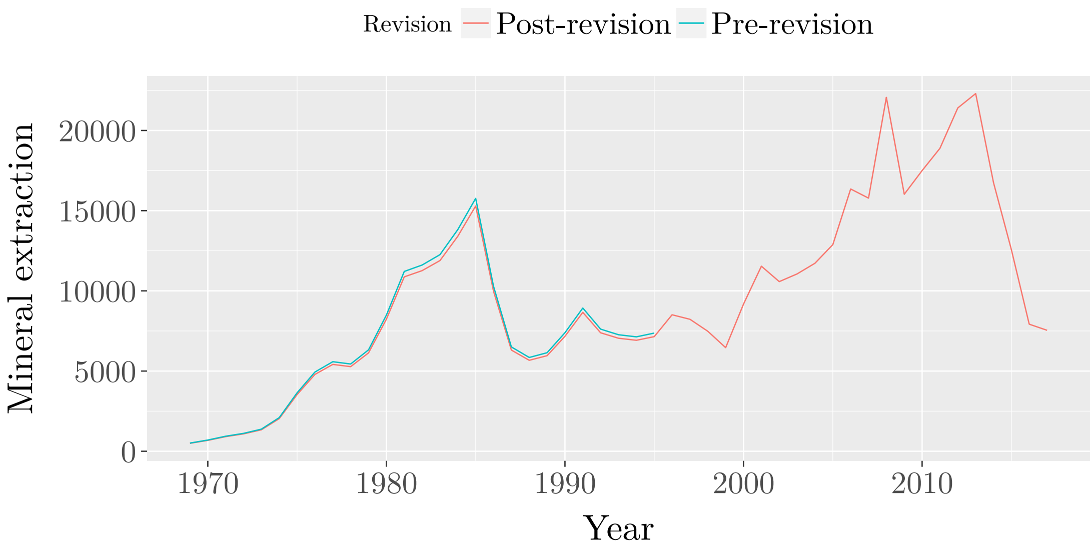
	Low (EUR0.0142/kgCO_2)	High (EUR0.0566/kgCO_2)
100% coal, no oil	€14.0 billion	€55.8 billion
75% coal, 25% oil	€11.9 billion	€47.4 billion
50% coal, 50% oil	€9.8 billion	€39.1 billion
25% coal, 75% oil	€7.7 billion	€30.8 billion
no coal, 100% oil	€5.6 billion	€22.5 billion

Source: Statistics Netherlands (2018b)

Appendix B

Figures

Figure B.1: Revision of mineral extraction in national accounts



Source: Statistics Netherlands

Appendix C

Acronyms

ACM Netherlands Authority for Consumers and Markets

DSM Dutch State Mines

EBN Energiebeheer Nederland B.V.

FES Economic Structure Enhancing Fund

NAM Nederlandse Aardolie Maatschappij

OPEC Organization of Oil Exporting Countries

SCBA Social Cost Benefit Analysis

TPES Total Primary Energy Supply

TSO Transmission System Operator

TTF Title Transfer Facility