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Is Norway's Resource Wealth Management Sustainable in the Long Run?

A Comparative Study of the Scandinavian Countries

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Abstract

The discovery of natural resources can turn out to be a curse rather than a blessing, as resource-rich countries tend to grow at a slower pace. However, Norway is considered an exception. This article conducts a structural break analysis in GDP growth to test for the presence of a curse by comparing Norway to Denmark and Sweden. We find that there are no signs of a deceleration in Norway by looking at GDP growth. This perspective is very limited as GDP does not provide a clear interpretation of economic growth. As such, we broaden the analysis by studying variables of sustainability and wealth management, using the same empirical framework. The findings for sustainability suggest a decline in early 2010s, even if GDP growth is on a positive trajectory. This seem to coincide with movements in the oil price. On the other hand, our tests indicate that the wealth management in Norway might be unpredictable, thus violating principles of consumption smoothing. By going beyond the limitations of GDP, Norway seem to develop towards an unsustainable path, and opening the possibility of a resource curse.

1. Introduction

Natural resources have since the days of Adam Smith and David Ricardo been recognized as a blessing and central for sustained economic growth. However, in recent decades, economists have observed that resource abundant countries tend to grow at a slower rate than countries with fewer natural resources. Auty (1993) referred to this as a *"resource curse*". The curse illustrates that there is an inverse relationship between natural resource dependence and growth. Consequently, an abundance of literature studying how resource-rich countries can fall victim to the resource curse emerged after the 1980s, which challenged the traditional view on natural resources. Studies such as Sachs & Warner (2001), Gylfason (2001), and Mehlum et al. (2006) confirm the inverse relationship between resource dependence and economic growth, but they further suggest that certain countries have escaped the resource curse through other channels that drive economic growth. A clear limitation with the existing literature is that it focuses narrowly on Gross Domestic Product (GDP). GDP does not consider the well-being of future generations because it ignores changes in climate, depletion of natural resources and human capital. This has led to an emerging literature on sustainability and how this affects economic growth. This is both an interesting, and important topic in economics because it provides another interpretation of economic progress.

Torvik (2009) shows that Norway is one of the countries that have escaped the resource curse. This makes it an interesting country to study in comparison to other resource-rich countries. Larsen (2005) tried to explain the phenomenon by looking for deceleration in Norwegian growth relative to its Scandinavian neighbors. However, his paper is limited to acceleration or deceleration in growth. This paper proposes a different approach to questioning the existence of a resource curse by challenging the classical way of handling cross-country studies on economic growth. The alternative approach identifies whether a country is sustainable/unsustainable in the management of natural capital. This is different from measuring economic activity, as this paper studies whether changes in the present value of future welfare can question the existence of a resource curse. This motivates the following research question:

"Is there evidence of a decline in the sustainability of Norway's wealth management?"

The aim is to answer the research question through the same methodology as Larsen (2005). We find this approach interesting because it has not been done before in this context (to our knowledge). It is also relevant in broadening the discussion on the resource curse. This paper will, therefore, search for structural breaks in time series, which consists of the relative difference between Norway and Denmark, but also Norway and Sweden. The time series consist of gross domestic product (GDP) per capita, adjusted net savings (ANS) and its components, and finally, government consumption. These variables are relevant in the discussion of a potential resource curse, as the aim is to broaden and illustrate alternative paths to answer the research question. The results indicate a deceleration in the early 2010s in ANS compared to Denmark and Sweden, but no structural change in GDP per capita after oil discovery. We also find a break in government consumption, which suggests a higher rate of consumption over time. This leads to the question of whether Norway has escaped the curse, because our results indicate a relative slowdown in the sustainability of the Norwegian economy.

In the remainder, this paper is structured first to give an overall impression on why sustainability and resource wealth management is essential in the discussion of the resource curse. In addition, this also provides insight into why the variables of interest become relevant. In section 3, the purpose is to illustrate the empirical techniques used in the collection of data, but also the empirical framework used to conduct the structural break analysis. Section 4 provides the empirical results from the structural break test, which sets the stage for a broad discussion in the following section. The discussion section will, therefore, take into account different perspectives on how sustainable Norwegian wealth management is based on the literature review and empirical findings. Furthermore, this section also includes insight into the current fiscal rule with future predictions, environmental issues with the current approach to wealth management, and finally avenues for future research. In section 6, the conclusion is based on the presence of a possible resource curse, and if this is connected to how Norway sustains their natural capital.

2. Literature Review

In this part, we are going to go through the literature regarding sustainability and resource wealth management. This sets the ground for the choice of variables and the discussion in section 3 and 5.

2.1. Sustainability

During the 1970s, the oil crisis caused an increasing interest in the link between business cycles and oil prices. The scarcity of natural resources became acknowledged as a possible hinder to economic growth. This became important due to commodities described as *exhaustible resources.*[1] According to Dasgupta and Heal (1979); *"A resource is exhaustible if it is possible to find a pattern of use which makes its supply dwindle to zero".* This makes resources such as oil, coal, and ores exhaustible resources because there is a finite limit, and thus leads to the problem of depletion. This is a very interesting topic because, on all feasible consumption paths, the exhaustible resources must decline to zero (Meadows & Randers, 2006). It must decrease to zero because using positive or constant amounts of finite resources will eventually lead to depletion.

The concept of sustainability is defined by economists as a sustainable state in which utility/consumption is non-declining through time (Perman et al., 2003). If consumption is non-declining through time, then intergenerational well-being is also non-declining over time. This means that the current generation has allocated its resources in such a way that it will consume the same amount as future generations. This is only possible if the criteria of non-declining consumption paths are fulfilled. In figure 2.1, we find five alternative paths of consumption. We can easily see that in C (1), C (3), and C (5), this criterion is satisfied, that is consumption growth is positive or zero.

[1] Also known as natural resources, non-renewable resources, finite resources

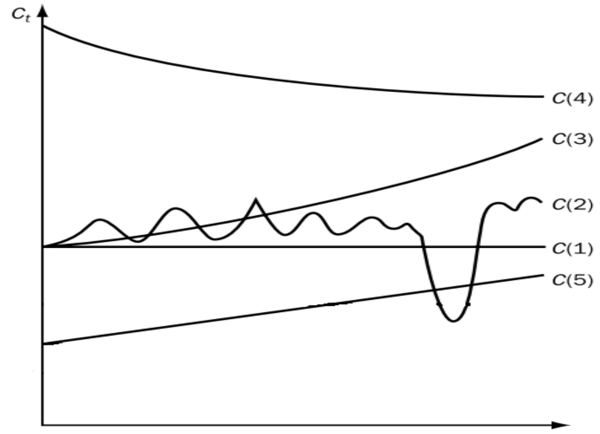

Figure 2.1: Consumption Paths Over Time

(Source: Perman et al. (2003))

On the other hand, how feasible is this concept of sustainability? In the basic neoclassical growth models created by Robert Solow (1974), economic growth was driven by *capital accumulation*. In short, this meant that output from current production was not used for current consumption, but saved for future production and consumption (Perman et al., 2003). Inputs for production are physical capital (buildings, machinery, and equipment) and human capital. However, in a "cake-eating" economy, both production and consumption depend on exhaustible resources. The main concern in this economy will, therefore, be that this cake is eventually eaten up.

To avoid this problem, Stiglitz (1974) mentions that there are three main economic forces that can remove the limitations on natural resources. These are technical changes, the substitution of capital in production for resources, and returns to scale. He shows that technical changes and *capital accumulation* can lead to non-declining consumption paths. If the share of capital is higher than that of the natural resources, or if the technological change is large enough over time, then we have constant consumption over time. Norgaard (1991) described this as being similar to a society dependent on harvesting the forest. If the current generation invested in planting trees rather than sawing them down, the next generation would gain more.

To measure if natural resources can be substituted by capital, the literature suggests that the asset's *degree of substitutability* determines whether we get non-declining consumption paths. The elasticity of substitution can be explained by how a decline in one input can be compensated by an increase in another, while the output is held constant (Markandya & Pedroso-Galinato, 2007). If elasticity is high (high substitution effect), then it is easier to make up for the loss of one input by substitution with another.

2.1.1. Weak- versus Strong Sustainability

Norton & Toman (1997), Everett & Wilks (1999), Thiry & Cassiers (2010) explains the assumption that natural capital can be fully substituted by produced-, human- and financial capital is based on the theories of *“weak” sustainability.* Weak sustainability assumes that sustainable development is achieved if total wealth is non-declining. This is also in line with Hartwick’s rule, which we will look further into in section 2.1.3. On the other hand, weak sustainability is not necessarily realistic as it does not take into account that once natural capital has been completely exhausted. It cannot be substituted anymore. Manufactured capital is dependent on the flow of materials and energy that comes from natural resources. In other words; “We cannot construct the same house with half the lumber no matter how many extra powers saws or carpenters we try to substitute” (Daly, 1991). This raises the question of whether to conserve natural capital for future generations. The reason is that a decline in natural resources cannot be offset by an increase in other assets due to not being perfectly substitutable. In this perspective, *strong sustainability* assumes that “sustainable development requires non-declining natural wealth” (Hanley et al. 2014). This restricts the substitutability of natural capital because it is not considered substitutes, but compliments to reproducible capital. In other words, the assumption of weak sustainability does not hold for sustainable development, but is required as the first step towards sustainability. Strong sustainability is achieved if there is an absolute decoupling from the use of natural resources. This means that natural capital should not be reduced to critical or irreversible levels beyond which can render substitutability no longer possible. The challenge for oil exporters will, therefore, be to decouple from the very use of natural resources over time, as a sudden stop in oil extraction would be infeasible in the current economic state. Intuitively, the focus should be pointed towards how long-term sustainable development is possible in terms of reduced dependency on natural resources, and maintenance of current national wealth.

2.1.2. Pace of Extraction/Hotelling Rule

The rate at which non-renewable resources are depleted is essential in the discussion of sustainability. It is essential because the rate of extraction is connected to whether industrializing countries can transform their wealth in the ground into other assets that provide social welfare and economic growth. In contrast to renewable resources, it is often not clear what the optimal rate of depletion is because the very use of resources depletes the resource (Hunter, 2014). It is, therefore, important that the government develops a framework for the extraction of non-renewable resources to maximize the net present value (NPV) of economic rent in the petroleum sector.[2]

Aarrestad (1979) explains that some extraction policies will always be non-optimal due to lending/borrowing restrictions. However, the most interesting part of his article is bound to the discussion of the value of oil in the ground versus the value of oil in financial assets. He mentions that *"when the rate of growth in the price of the resource is greater than the rate of interest on financial claims, it pays to keep the resource in the earth as long as possible".*[3] However, *"when the rate of growth in the price of the resource is less than the rate of return on financial assets, it pays to shift the resource into financial assets as fast as possible".*

Aarrestad's discussion can also be illustrated in the *Hotelling Rule.* This rule is often mentioned by economists as a guideline for the extraction of non-renewable resources. Harold Hotelling (1931) argues that under a perfectly competitive market, there was an equilibrium price path, in which the price of oil would rise with the rate of interest (Moses & Letnes, 2017).

(1) $\frac{\dot{P}_t}{P_t} = \rho$, where $\frac{\dot{P}_t}{P_t}$ is the price growth and ρ = discount rate

This equation is also known as the Hotelling's Rule and is an *intertemporal efficiency condition*.[4] The intuition behind this condition is that when the price of

[2] The Net Present Value (NPV) is the total of the present values of all project cash flows (Berk & Demarzo (2007)

[3] Financial claims are seen as borrowing restrictions in this case

[4] A condition that takes into account benefits for future generations

natural resources increases, the country should slow down its pace of extraction. The value of the resource in the ground will increase with its market price; thus it is expected that the owners will extract less when the price goes up, and rather let value in the ground increase while investing the resource rent in reproducible capital. A higher price will also lessen the demand, but as the demand falls, the price will eventually fall as well. When the price for resources fall below the rate of interest, the owners will invest in increasing production, as mentioned above by Aarrestad (1974).

2.1.3. Hartwick's Rule

In 1977, John Hartwick introduced a rule that fulfilled the condition of non-declining consumption. This rule is known as *Hartwick's rule,* and states that we should *"Invest all profits or rents from exhaustible resources in reproducible capital such as machines"* (Hartwick, 1977). [5] By following his advice, a sustainable path is possible because the capital is held intact through investments in other forms of wealth. This makes Hartwick's rule a rule of thumb for intergenerational allocation of resources, but also a way for resource-rich countries to avoid long-term dependency on a single source of income. In other words, natural capital is substituted for other forms of capital. Hartwick's rule is also quite similar to Hicks (1946) *concept of income* where he suggests that an individual's income is defined as "*the maximum amount the individual can spend during a week, and still expect to be able to spend the same amount in each ensuing week"*. This can be seen in the perspective of national wealth because the wealth is sustained through time, but consumption is equal in each period. It is equal in each period because if the resource rents are efficiently invested in reproducible assets, then this will generate income and jobs in the long run even after depletion.

On the other hand, if a country is not on a sustainable path, then following Hartwick's rule will not be enough to point an economy towards a non-declining consumption path. This means that the rule is necessary, but not sufficient to ensure sustainability. It is not sufficient because if the country is not on a sustainable path, the prices for natural capital will not reflect their true *shadow value* (UIO, 2012). The shadow value is a measurement of scarcity and reflects the shadow price of

[5] Hartwick's Rule is also known as the investment/saving rule

natural capital. [6] If the shadow price is high, then resources have a high social worth, but also indicates a low supply. In other words, when natural capital does not reflect its true shadow value, the scarcity measurements can be suboptimal, and this leads to unsustainable paths because it is hard to estimate the value of the resources. This is closely related to the *Hotelling rule* mentioned in section 2.1.2

2.1.4. Adjusted Net Savings

In the literature about sustainability both savings and investments matter in whether an economy is on a sustainable path. Corden (1984), Gylfason (2001), Gylfason & Zoega (2006) states that resource wealth can under certain conditions reduce the need for savings and investments because there is a continuous stream of royalty that is not dependent on transfers from the manufacturing sector. This means that there is a correlation between resource abundant countries and low saving. Sachs and Warner (2001) have confirmed in the traditional Dutch disease literature that resource abundance has an inverse long-run relationship with economic growth. Torvik (2009) finds several explanations for the resource curse, but a key mechanism is linked to the overspending of resource revenues. Van der Ploeg and Poelheke (2009) states that *"Natural resources can be a blessing for countries with the institutional means to spend the proceeds wisely"*. In other words, countries that spend their proceeds wisely is also more likely to have positive *Adjusted Net Savings.*

Adjusted Net Savings (ANS), also known as Genuine Saving (GS) is an indicator for sustainable development, but is defined as the true level of saving in a country after accounting for depreciation of produced capital (Hamilton, 2006). [7] The intuition is that if ANS is negative, then total wealth is declining, and the country is consuming more than it saves. [8] According to Van der Ploeg (2007), a negative ANS in resource abundant countries can hurt their growth prospects and harm

[6] Shadow Price is not the same as market price. Shadow prices are defined as the contribution an additional unit of an asset would make to human well-being (Dasgupta, 2010)

[7] Produced capital refers to investments in human capital, depletion of natural resources and pollution.

[8] Total Wealth takes into account natural capital, produced capital, human capital and net foreign assets

welfare, which is in line with the literature regarding *the resource curse*. The World Bank (2018) uses the following equation to calculate the level of ANS:

(1) ANS = Gross National Saving (GNS) - Consumption of Fixed Capital (CFC) + Investment in Human Capital (HC) - Depletion of Natural Capital (ED) - Pollution Damage - Carbon Dioxide Damage
(Source: World Bank, 2018)

This equation takes into account several variables of interest in the discussion of sustainability. It also shows that there is a mix of both consumption and savings indicators because this illustrates the relationship between the variables. The first variable is GNS, and this is calculated as:

(2) GNS = Gross National Income (GNI) - Private and Public Consumption
(Source: Acar, 2017)

The GNS variable consists of the necessary items for a country's saving because it deducts what is left of GNI (Boos, 2015). Afterward, net *national saving (NNS)*, also known as *adjusted savings* is calculated by deducting for CFC. The third variable in equation (1) is investments in HC. Hamilton (1994) argues that HC is seen as a positive contribution to ANS because education expenditure is not seen as consumption, but a way to increase or maintain current and future national wealth. This should, therefore, be included in the calculation of ANS. The three final variables in equation (1) takes into account the depletion of natural capital, but also damage to natural capital due to pollution and carbon dioxide. This is deducted from NNS plus HC because total wealth is reduced through depletion and damage to total wealth.[9] This finally leaves us with the ANS, which shows that there is a relationship between these variables. This process can also be observed in figure 2.2, as it shows the calculation of ANS in 2011 for Norway; see Lange et al. (2018) for more information.

[9] Depletion of natural capital takes into account changes in fossil energy (coal, crude oil, and natural gas), metals and minerals (bauxite, copper, gold, iron ore, lead, nickel. phosphate rock, silver, tin and zinc), and forest depletion (Acar, 2017)

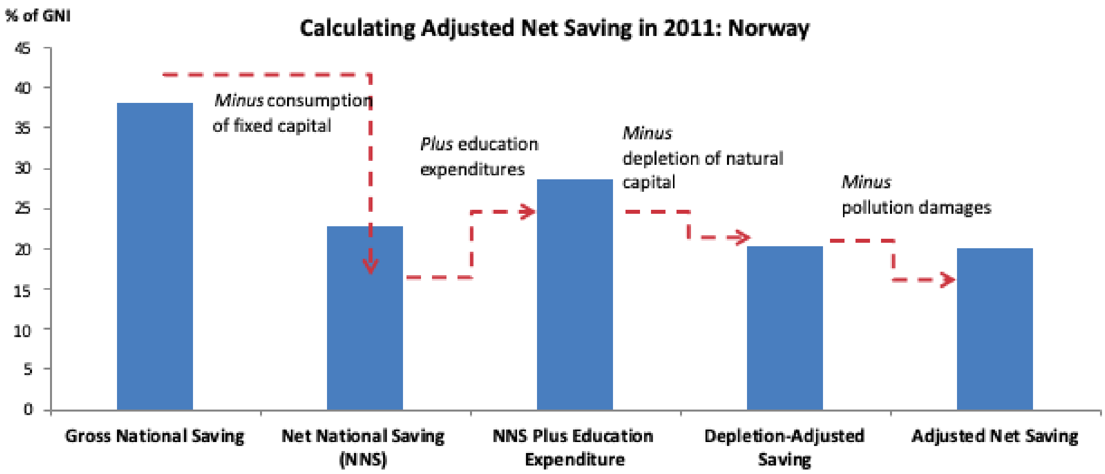

Figure 2.2: Calculation of ANS in 2011: Norway

(Source: Lange et al., 2018)

Dietz and Neumayer (2006) describe the ANS equation as a modification to the Hartwick rule, where "the aim of the sustainability planner is to keep ANS above or equal to zero". Furthermore, the ANS is based on wealth accounting because it illustrates a nation's total capital stock changes on a year to year basis. This concept is, therefore, forward-looking because it says something about an individual countries' future sustainability, and whether its consumption path is sustainable. However, it also suffers from some limitations, such as not incorporating some types of natural capital and aspects of environmental capital (Acar, 2017).[10] Another problem is linked to the incorporation of slow-moving and fast-moving variables. This means that there is an inconsistency in the time frequency between the variables, and this can give inconsistent results in determining sustainability. For example, the frequency in which we see changes in oil depletion and oil prices is from year to year basis, but changes in e.g. forests might not be annual. It is difficult to estimate annual changes in forests because they change slowly over many years. In other words, it is not interesting to look for structural changes in forest on an annual basis, because it would show relatively small changes.

2.1.5. Human Capital

Human capital is according to Behrman and Taubman (1982) defined as *"the stock of economically productive human capabilities"*. Investments in human capital are

[10] It does not take into account natural capital such as fisheries, biodiversity and various uses of water. By environmental capital, it is referred to degradation in soil and chemicals used to damage natural wealth, such as pesticides and artificial fertilizers (Acar, 2017).

interpreted in economic theory as a major determinant to economic growth and sustainable development. Establishing a formative environment for knowledge, research, and education reduce economic inequality. Furthermore, a reduction in inequality will lead to an increased knowledge-based economy, which creates future value (Finansdepartementet, 2017). In other words, human capital is the basis for technical change.

Gylfason & Zoega (2003), and Oketch (2006) have studied the effect education has on economic growth. In their paper, education has increased economic growth, but also increased social- and physical capital. These investments in human capital have thus led to improved labor productivity. Among the OECD countries, Norway has the highest labor force participation rate. This is also linked to the fact that human capital makes up to six times more than oil and gas reserves in the Norwegian national wealth. This makes human capital the most important part of the national wealth (Finansdepartementet, 2017).

Human capital is linked to the theories of *learning-by-doing (LBD).* Romer (1989) defined LBD as skills or knowledge that was accumulated during production. Torvik (2001) extends earlier literature about LBD and Dutch disease by concluding that a foreign exchange gift gives the nation a chance to learn and experience how to handle the implications of the Dutch disease. He shows that there are *productivity spillovers* between the traded and non-traded sectors, which generate LBD.[11] In Bjørnland, Thorsrud, and Torvik (2018), this process was described as *"Shipyards workers who used to be welders, are today experienced in complex deep-sea technology".* In other words, the technology that was used to build boats is now used in the oil sector.

2.2. Resource Wealth Management

Most resource abundant economies have the opportunity to transform their natural resources into a factor of growth. However, developing and developed countries face constraints that can hinder them from maintaining economic growth. Government deficits and debt are such constraints, but they are often relaxed with

[11] Spillovers/Externalities are defined as the effect producing or consuming a good has on third parties not directly related to the transaction. This can be both positive and negative.

the discovery of natural resources because the resource becomes a source of income. This leads to economic growth, but also increased consumption in the short run. The problem arises when consumption becomes unsustainably high in the short run without planning for the future. This is a common pitfall in most resource abundant economies because they do not incentivize the discovery and development of their resource base. On the other hand, other regimes might be too generous, and does not capture the rents from extraction (Venables, 2011). This leads to declining utility as mentioned in section 2.1.

Auty (2001), Mehlum et al. (2006), and Torvik (2009) explain that developing countries lack the institutional quality to manage natural resources in a sustainable manner. They are affected by "grabber friendly" institutions allowing for *rent seeking* and *Dutch-Disease* to take effect. [12] Their study also found a correlation between institutional quality and the *resource curse*. This theory explains that resource discovery leads to lower economic growth. However, this is not the case for all resource abundant countries due to the fact that they have managed their resource wealth in such a way that ANS is either positive or zero.

2.2.1. Sovereign Wealth Funds

Policymakers in both developing and developed countries need to find ways to reduce the negative effect that natural resources have on the economy. One of the key mechanisms in explaining the resource curse is based on overspending the resource revenues gained from extraction and taxes (Torvik, 2009). In section 2.1.4 about ANS, we concluded that countries with positive ANS had higher economic growth and welfare, in contrast to countries with negative ANS. This is, therefore, a forward-looking indicator for whether a country is on a sustainable path, but also a measurement of whether natural resources are substituted with another form of assets through investments.

[12] Tornell and Lane (1999) show that in an economy with multiple powerful groups and a lagging institutional infrastructure that the productivity is negatively affected, thus reducing economic growth. They are negatively affected because these groups demand transfers, and the size of these transfers increases, the more productive a sector becomes. However, the problem is that resources are reallocated to less productive sectors that are safe from taxation, and this leads to decreasing growth. In other words, resources are pulled out of production and into rent seeking.

In this context, *Sovereign Wealth Funds (SWFs)* has become quite a popular way to create stability and intergenerational welfare over time because the resource rent from pumping up the resources are saved in an offshore fund (Moses & Letnes, 2017). In figure 2.3, we can see that the size of these SWFs are extraordinarily large and has become increasingly popular in countries with petroleum. Hartwick's Rule suggested that the financial assets gained from extraction should be invested in a diversified portfolio because in the long run, a country cannot solely rely on exhaustible resources. They cannot rely on exhaustible resources because they are volatile and will eventually deplete. Hence, it is in the government's interest to slow down the pace of development, and shield its nation's economy from unpredictable movements in the resource price.

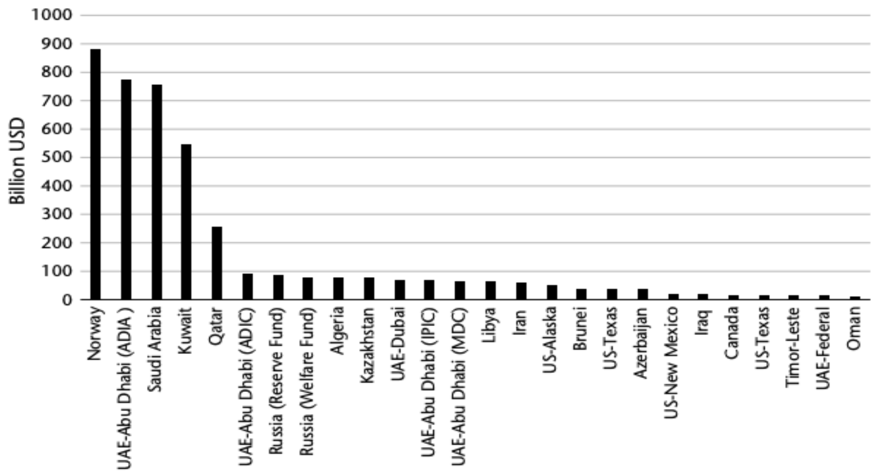

Figure 2.3: World's Largest Petroleum-Based Investment Funds

(Source: Moses & Letnes, 2017)

Cameron and Stanley (2017) identify five reasons why governments create funds. The first is linked to providing intergenerational equity through investing the rent from depleting finite resources. This helps to maintain or enhance the total capital stock. The second is based on smoothing governmental expenditure/spending and creating macroeconomic- and fiscal stability. The idea behind smoothing governmental expenditure is to avoid boom-bust cycles due to the volatile nature of resource prices. This type of smoothing allows the government to save the surplus during booms, but use the surplus to avoid busts. The third part is that these funds are used as a tool to earmark future development. In other words, a small portion of the fund is used to finance projects that reduce poverty, debt, but also increases technological development. This is also called *positive screening.*[13] The fourth reason is to avoid overheating the economy with resource revenues. If large amounts of resource revenues are spilled into the economy, the effects of Dutch Disease will take control.

Finally, the sixth reason is especially important because governments need to separate resource revenues from non-oil revenues. It should be separated because resource rent is also counted as income in the national accounts. However, in real sense, it is not income. It is not income because it is transformed into wealth and gives an *"illusion of economic growth"* (Bjerkholt & Niculescu, 2004). This illusion comes from the mechanisms connected to the Dutch Disease literature. In short, when the economy discovers natural resources, it starts to extract these resources. The resource sector experiences both an inflow of investments and labor force that shies away from the manufacturing sector, also known as the *crowding out effect.* As the booming sector becomes larger, the resource rent also increases. This increase is seen as a positive contribution to economic growth, but is just an illusion. The economy has become more dependent on its exhaustible resources, and has crowded out the manufacturing sector. In other words, we need to phase in more resource income into the economy to balance it out (productivity capacity and other means of generating income are reduced).

Repetto et al. (1989), Pearce et al. (1996), Hamilton & Clemens (1999), and Torvik (2009) also mention that transformed wealth is not seen as a positive contribution to net income or ANS. The reason can be illustrated by a person who owns a car that is worth $60.000. If he sells the car today, and then deposit the money in the bank. He will not become any richer than before. This perspective can also be used in the case of a country that sells its oil, and places the revenues in a fund. In this case, total wealth remains unchanged. However, if the country consumes the revenues, then the savings rate is negative. The problem lies in the national accounts because the savings rate is calculated as zero due to the sales of natural capital being listed as income (Torvik, 2009). In other words, the savings rate is overestimated, and an indicator such as ANS becomes crucial.

[13] According to Report no. 16 (2007-2008); the government in Norway considers both the financial and ethical effects of investing in environmental technology and developing countries

2.2.2. Permanent Income Hypothesis

One of the most important benchmark models for fiscal sustainability in resource-rich countries is based on the theory brought forth by Milton Friedman (1957). This model is called the *permanent income hypothesis (PIH),* and allows for a non-declining utility as illustrated in section 2.1. [14] In other words, the PIH allows the same level of consumption in all perpetuity. One of the core features in the PIH is based on the literature regarding *"precautionary savings"* (Cameron & Stanley, 2017). Van den Bremer & Van der Ploeg (2013) also mentions that exhaustible resources are volatile. Commodity prices are assumed to follow a *random walk*, thus causing uncertainty regarding future prices. [15]

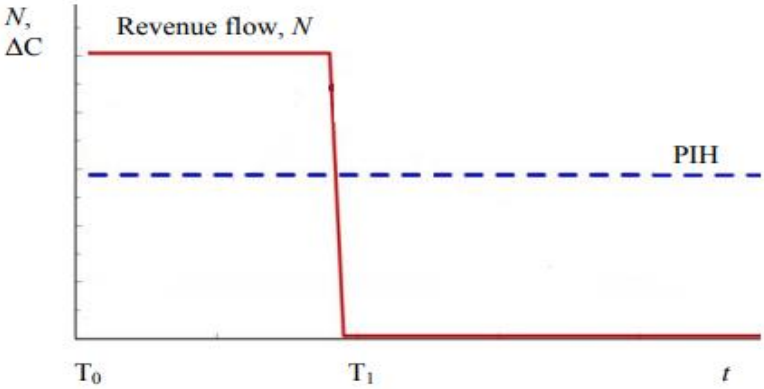

Figure 2.4: Incremental Consumption and Revenue Flow under the PIH

(Source: Van der Ploeg & Venables (2011))

According to Van der Ploeg & Venables (2011), figure 2.4 represents the PIH model. The graph shows the time profile of the flows of income and consumption. For simplicity, we assume that at time T0, the economy has discovered natural resources and has no foreign assets or debt. As seen in figure 2.4, at the date of discovery, the windfall revenues (N) start flowing in and remain constant until it is depleted at T1. The dotted line shows the increase in consumption (ΔC). The PIH is represented by the horizontal dotted line. This gives a constant and lasting increase in consumption. The idea is based on saving, whilst revenue is flowing in to build up the SWF. When this becomes large enough, consumption is to be

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[14] PIH is also known as a *constant-expenditure rule.*

[15] A random walk (RW) describes fluctuations in a variable or indicator as having no distinct pattern or trend.

maintained through interest on the fund in perpetuity. This interest is often called the *spending rule*. [16]

The PIH is also in line with the celebrated Hartwick rule. It is in line because the government accumulates assets during the period oil is extracted. In other words, ANS must be zero because the accumulation of assets equals the decline in oil wealth (Akitoby & Coorey, 2012). This is the optimal strategy compared to accumulating after the oil is depleted because it will force the government to rapidly use up its saved assets, and eventually lead to borrowing because they cannot sustain the *non-oil deficit*. This is also an unsustainable fiscal stance. In order to assess the fiscal stance from a long-run perspective, the government needs to focus on the primary non-oil balance compared to the national wealth. This is done by separating oil and non-oil revenues and cost. Therefore, the non-oil deficit shows the nation's revenues excluding income from petroleum, and is an important measure of fiscal sustainability (Barnett and Ossowski, 2002).

2.2.3. Bird-In-Hand

Another model that is often brought up in the discussion of how to manage windfalls is the *bird-in-hand (BIH)* rule. The BIH approach implies that all resource revenues gained from extraction are accumulated into financial assets in a SWF (Hartwick's Rule). However, the government is only restricted to the interest in the SWF during the build-up to boost governmental spending or cut taxes. Figure 2.5 shows the consumption path for BIH, we see that the government gradually increase consumption, unlike the PIH. The peak level of consumption reached in BIH is higher than the PIH because it presumes no rise in consumption before the windfall, but gradually which allows for an excessive accumulation of financial assets (Van der Ploeg, 2012). This implies positive ANS and a higher chance of escaping the resource curse, as mentioned earlier (Akitoby & Coorey, 2012). After depletion (T1), the accumulated assets in the SWF is used to sustain consumption in all perpetuity, similar to the PIH.

[16] This is a fiscal rule that allows for a certain percentage of the fund to be used in the national budget on public spending. It can also be reinvested, in order to build up more assets.

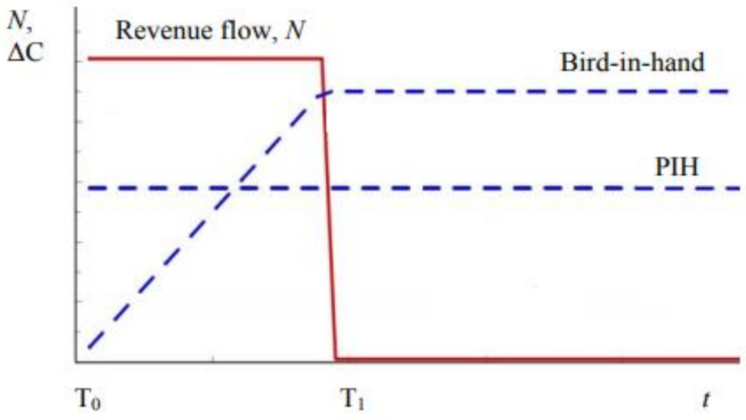

Figure 2.5: Incremental Consumption and Revenue Flow under the BIH

(Source: Van der Ploeg & Venables (2011))

Harding and Van der Ploeg (2009) mention that the BIH can be seen as a method to buffer against future oil- and price shocks because the rule is considered a very conservative and prudent approach to precautionary savings. A negative shock to future oil prices can lead to welfare losses and higher costs on extraction. The uncertainty regarding future oil prices and revenues leads to a higher commitment to extract natural resources more rapidly than that suggested by the Hotelling rule mentioned in section 2.1.2. The idea is based on creating less vulnerability to future oil demand by leaving less oil reserves for the future. The more risk averse a government is, the faster it will extract oil reserves and depart from the Hotelling rule. This can be compared to the literature regarding prudence and optimal monetary policy because some policies "respond more or less aggressively to shocks when the preference for robustness increases, depending on the source of uncertainty and the type of shock" (Leitemo & Söderström, 2008).

3. Methodology

In this section, we will first present an overview of the relevant variables, and why these variables are of interest. Second, we explain how we analyze the theories that were mentioned in the previous section, which is divided into two categories; sustainability and resource wealth management. These categories give an alternative perspective on how Norway should manage its wealth and avoid the resource curse, in comparison to GDP per capita. Larsen (2005) used GDP growth as an indicator to determine the presence of a resource curse. This will, therefore, also be a relevant variable for sustainability and resource wealth management due to GDP being calculated based on e.g. savings, investments, and consumption. The aim is to replicate his approach to finding breakpoints in indicators of economic development, but with intent to broaden the discussion around alternative ways to avoid the resource curse. The replication of Larsen (2005) can be found in appendix 8.4. Even though the empirical framework is the same as in Larsen (2005), the approach and analytical tools used are different. Since we have had no access to the codes and specifics of how Larsen conducted his analysis, we built our own code by using MATLAB (See appendix 8.5).

The comparison between Norway, Denmark, and Sweden provides an interesting insight into how similar these countries are based on institutions, welfare system and policies. These similarities have often been characterized as *the Nordic model.* This makes it reasonable to assume that these three countries would, therefore, react similarly to both endogenous and exogenous developments. E.g. if there is an acceleration in GDP for Norway, it is probably related to a positive shock in oil, and not other factors. In our analysis, we will use Norwegian data and subtract it with Danish and Swedish data respectively. This means that our analysis builds on the strong assumption that the developments in Sweden and Denmark represent what the development in Norway would have been, had they not found the oil in 1969. This will, therefore, provide us with two comparative variables of interest to study, and further motivate the use of a structural break analysis.

3.1. Data

The time series used in this analysis are exponential with varying degrees of variance. This can cause some problems with inconsistent estimates due to nonlinear development in the time series. This means that the model might struggle to get consistent estimates when trying to capture an exponential development. Moreover, nonlinear time series can also inflate F-ratios at certain points in the analysis. This motivates the transformation of our time series, thus creating a *log-linear model*. We found that this increases the fit of the model, and the significance of the estimated parameters. It should be mentioned that this deviates from Larsen's (2005) methodological approach.

The time series are also at an annual frequency, which makes it easier to compare breakpoint years across variables. However, it does not take into account slow moving- and fast-moving variables, as mentioned in section 2.1.4. An example is

ED, which can have structural changes annually; see section 4.2.3. On the other hand, this might not be the case for slower moving variables, such as forest depletion. Our analysis might not be able to identify structural changes when the frequency is limited to be annual.

3.1.1. Real GDP Per capita (PPP)

The first variable is the output-side real GDP (rgdpo), and is extracted from Penn World Tables (PWT), which covers almost 180 countries (Feenstra et al, 2015). This is the latest release from PWT, and shows available data from 1960 to 2017. According to Feenstra et al. (2015); this measures the productive capacity of an economy at constant prices for goods and services across countries and over time. It should be known that this is not the same as "current-price" real GDP.

This dataset is also adjusted for purchasing power parity (PPP) and per capita. Adjusting for PPP solves the issue with local currency units, as PPP improves the accuracy of comparisons between countries when it comes to economic performance. The reason why the accuracy of measurement is increased is due to the currency units being converted into a common unit of value. Moreover, it uses the ICP (International Comparison Program) benchmarks for 2011. They provide benchmark comparisons of price and volume measures of GDP (World Bank, 2019a). On the other hand, using per capita data is simply the difference in population over time. This is important to take into account because countries differ in size and population. Sweden has a larger population, but this does not necessarily mean that they are more productive in per capita terms.

Like Larsen (2005), we chose to split the data series before and after parity, i.e. when Norwegian GDP moved ahead of Swedish- and Danish GDP. The motivation for this is that we expect our model to potentially capture two breaks, the first being positive and due to oil discovery, and the second being negative because it could tell us something about an oil-induced relative change in productivity. We also split the periods because Norway is consistently below its neighbors before parity. Parity in the data is achieved at the end of the 1970s. However, due to the structural break analysis not being able to search for breaks at the edges of the sample, something that will be explained later, the two datasets will overlap slightly. The dataset before parity will span from 1960 to 1984, while the dataset after parity will be from 1974 to 2017. This makes 1979 the year where the search before parity is succeeded by the search after parity

3.1.2 Adjusted Net Savings

The data for ANS consists of several variables as mentioned in section 2.1.4. This data is extracted from the World Bank World Development Indicators (Lange et al., 2018), and is from 1990 to 2016. Furthermore, the data is converted to the natural logarithm, which gives a close approximation of the percentage change between the years. On the other hand, in contrast to real GDP per capita, ANS is reported in units of current US dollars. This is an important variable on the assessment of sustainability because real GDP per capita does not take into account the broader view of how natural- and human capital affect the productivity and welfare of the nation.

The variables that we wanted to test in the ANS equation is GNS, HC, and ED. We have not taken into account all the variables as this requires extensive work in interpretation, and rather choose to focus on three variables that affect ANS, and is closely linked to our literature. GNS is one of the variables affecting ANS, and is used as a measurement of accumulated national wealth (Lin & Hope, 2004). According to the World Bank (2018); GNS "reflect a movement toward capturing changes in real wealth so as to inform policy makers whether they are saving enough for the future and investing in the assets needed to sustain development in the long run.".

On the other hand, HC looks at current public expenditure on education included. wages and salaries, pension, purchased services, welfare services, books and teaching material, etc. (World Bank, 2018). This is seen as a valuable asset because it should offset the negative impact energy depletion has on ANS, as seen in section 2.1.4. In the national accounts, only a portion of expenditure on education is treated as consumption (fixed capital, such as school buildings, investment). However, in wealth accounting, all expenditure on human capital is seen as an investment (Hamilton, 1994).

The final variable in the ANS equation that we will look at is energy depletion (ED). This is one of the main components for the extraction of natural resources. This variable illustrates the pace of which a country is building down its natural capital, and therefore gives a broader picture of the extraction rate. The data for this variable is from 1972 to 2016, which allows us to capture the entire "after-parity" period. The variable consists of crude oil, natural gas, and coal, and is measured in terms of the rents generated from extraction. According to World Bank (2018); they calculate the annual depletion of non-renewable resources by first finding the value of the resource stock (V_t), then they divide this by time to exhaustion (T).

$$(1)\ D_t = \frac{V_t}{T}$$

This gives the annual depletion (D_t). In other words, the ratio of PV of rents.

3.1.3 Government consumption

Government consumption, also known as the consumption of public goods is an important indicator on the level of national income. This variable reacts to changes in how much income is generated from production, and what the government spends their generated income on in the public sector. Furthermore, the variable becomes necessary in the discussion of fiscal sustainability with regards to PIH and BIH. The data is from 1960 to 2017, and is defined as "the government final consumption expenditure for goods and services", as a percentage of GDP. This is in current US dollars, which is influenced by the effects of inflation; see World Development Indicators (2018) for more.

3.2. Structural breaks

In this paper, we are interested in identifying whether there is an acceleration or deceleration in our variables of interest. In other words, we are looking for breakpoints, also known as structural breaks in the time series. These breakpoints are based on the idea of a structural change, discontinuity or shift in key variables. The interpretation of what this structural break means, depends on the variable being analyzed, and at what point in time the break occurs. It is important to identify structural breaks in economic indicators because failing to do so can cause misleading estimation results (Bjørnland & Thorsrud, 2014). The results will, therefore, become paramount in answering the research question.

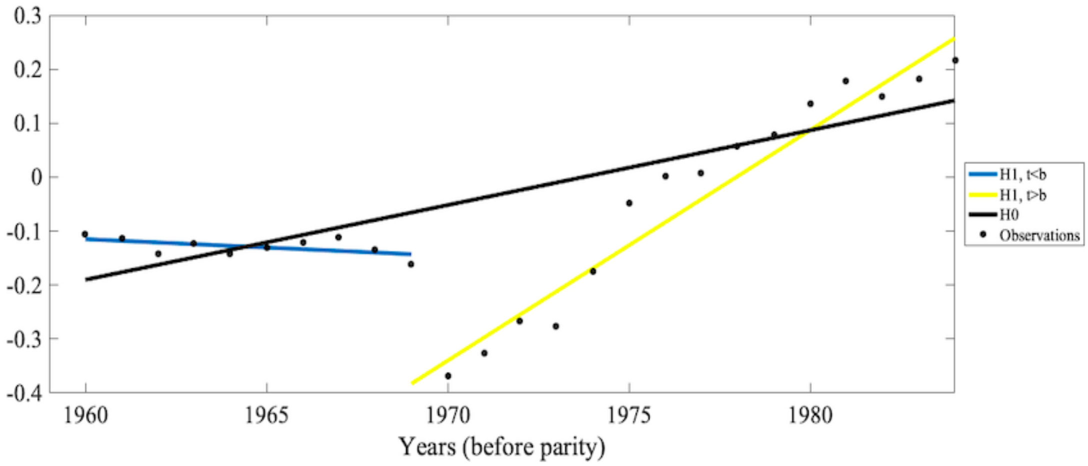

Figure 3.1: Breakpoints in a Structural Break Analysis

(Source: Own Calculations, data from PNT 9.1(2019))

In figure 3.1, we can clearly see the breakpoint around 1969 - 1970 by the sudden drop in the time series. The solid black line illustrates the null hypothesis, but the blue and yellow show the alternative hypothesis before and after the breakpoint. The point of this analysis is, therefore, to see if there is change large enough to cause a shift in the time series. If there is a shift, then we have to examine the difference before and after a structural break. The rejection of the null will be determined by the F-test, as seen in section 4.

There are many ways of looking for structural breaks, but one of the first and most fundamental tests in structural break testing is the *Chow test* (1960). This based on testing the null for no structural breaks versus the alternative that there is a structural break. However, it suffers from the limitation that the candidate breakpoint years are known beforehand, or through a priori data inspection. We will not use this test, but rather follow the same method as Larsen (2005).

3.3. Empirical framework

In the pursuit of widening the discussion around the impact of natural resources on Norwegian resource wealth management. Larsen's (2005) method also becomes relevant for our other variables than GDP per capita, so we will, therefore, illustrate the process behind his framework. The main limitation of this framework is that it can only find one statistically significant structural break, as it only compares one consistent linear trend to one candidate breakpoint at the time. There would either be an acceleration or deceleration in the development over time. This is the reason why we separate between before and after parity in GDP, and only look for breaks after 1990 in multiple variables. If there were multiple breaks in a single time series, our analysis would only be able to find one of them. We, therefore, consider the most significant candidate breakpoint to be the most likely breakpoint year (Hansen, 2001).

The main idea is to find the observed F-ratios based on a null hypothesis that assumes that the comparative development in a given time series follows a consistent path, represented by a linear trend with a first-order autoregressive residual. The comparative variables are denoted as $\delta_1^t = y_t - x_t$ for Norway (y_t) minus Denmark (x_t), and $\delta_2^t = y_t - z_t$ for Norway minus Sweden (z_t).[17]

$$(1)\ \delta_i^t = \alpha_i + \beta_i t + e_i^t, \quad i \in \{1,2\}, t \in T$$
$$(2)\ e_i^t = \varphi e_i^{t-1} + \varepsilon_i^t, \quad i \in \{1,2\}, t \in T$$
$$(3)\ \varepsilon_i^t = IN(0, \sigma_i^2), \quad i \in \{1,2\}, t \in T$$

The parameters α and β represents the main linear mechanism behind the difference between Norway, Sweden and Denmark respectively. In the residual *(e)* and the autoregressive parameter *(φ)*. The first part (1) represents a deterministic time trend, and the second part (2) is a *difference stationary process* with white noise provided by *(ε)*. This model does not allow for any oil induced structural changes. To find this, we introduce the alternative hypothesis, which includes a lever and a pace effect, where *(κ)* augments the intercept, while *(λ)* augments the determinant time trend.

$$(4)\ \delta_i^t = \alpha_i + \beta_i t + u_{1i}^t, \quad when\ t < b$$
$$and \quad \delta_i^t = (\alpha_i + \kappa_i) + (\beta_i + \lambda_i)t + u_{2i}^t$$
$$when\ t \geq b,\ i \in \{1,2\}, t \in T$$
$$(5)\ u_{ki}^t = \varphi_{ki}^t u_{ki}^{t-1} + \varepsilon_{ki}^t, \quad i,k \in \{1,2\}, t \in T$$
$$(6)\ \varepsilon_{ki}^t = IN(0, \sigma_{ki}^2), \quad i,k \in \{1,2\}, t \in T$$

[17] The comparative variables show the difference between Norway, Denmark and Sweden. If Norway is lagging behind, then the difference will be negative. However, if Norway is leading it is positive (Larsen, 2005).

Although the execution of this method will vary slightly depending on what variables we are using, the core idea is to find observed F- ratios by sequentially varying the breakpoint year in the alternative model. We, therefore, run one regression based on the data before the candidate breakpoint year, and one regression after. Since it would be impossible to search for structural breaks at the beginning and end of the samples, the candidate breakpoint years begin and end at five data points into the datasets. This will provide us with a series of unrestricted squared residuals, while the regression in the null gives us restricted squared residuals. We then calculate the *F-statistic*:

$$(7) \qquad F = \frac{\left[\frac{(RSS_R - RSS_U)}{r}\right]}{\left[\frac{RSS_U}{(n-K)}\right]}$$

where (RSS_R) is the restricted sum of squared residuals, and (RSS_U) is the unrestricted sum of squared residuals. *(r)* is the number of linear restrictions in the null. This is 3, since we restrict the intercept, slope and the autoregressive parameter. (n) is the number of observations. (*K)* is the number of parameters in the unrestricted case, and this is 6, since we have different parameters both before and after the breakpoint. Furthermore, in order to find where there are spikes in the F-ratio (this represents a structural break), we must run 500 *Monte Carlo bootstrap simulations* of the model, and then find the series of F- ratios for each simulation. This allows us to compute a 90^{th}, 95^{th}, and 99^{th} percentiles threshold for rejecting the null. Larsen (2005) does not specifically mention how these percentiles are calculated. We, therefore, choose to take the largest F- ratio of each simulation, and calculate the different percentiles based on these. Using different methods of determining percentiles might lead to different thresholds for finding significant structural breaks.

In order to estimate the parameter values for both the observed values and the simulated manifestations, we use *feasible generalized least square (FGLS)*; see section 3.4.2 for more on FGLS

3.4. Challenges in statistics

In this section, we will go through some of the challenges that arise in our model when performing a study on breakpoints. This is linked to tests, such as the *Durbin-Watson (DW) test*, and a discussion on insignificant parameters versus fitness of the model.

3.4.1. Test for Autocorrelation

To find out whether we can use an AR (1) process in the residual, we conduct a DW-test for each variable (Wooldridge, 2016). Under the null hypothesis, there is no autocorrelation in the residual, thus only leaving us with the alpha and beta as parameters. We calculate the p-value of the test, i.e. the probability of observing a DW-test statistic more extreme than (or as extreme as), the observed value under the null hypothesis. We find that the null is rejected at 5 percent, which suggests autocorrelation. On the other hand, there are some weaknesses linked to using a DW-test. Rejection of the null does not guarantee that there is an AR (1) in the residuals. This could be because the autocorrelation is there for other reasons, such as a higher order autoregressive process. However, as long as the DW-tests indicates an AR (1), we continue to use the model described above for all the variables.

3.4.2. Feasible General Least Square

Like Larsen (2005), we have also chosen to use FGLS to derive our parameter estimates. Having established that there is autocorrelation in the residuals, we need to take this into account when estimating parameters. According to the *Gauss-Markov theorem*, errors must be uncorrelated for OLS in order to be the best linear unbiased estimator (BLUE). If *(φ)* is large, the bias in the OLS variance estimator can also be very large (Wooldridge, 2016). Since, the true *(φ)* is rarely known, we instead use a consistent estimate of it in order to obtain quasi differenced variables. Although FGLS is not unbiased, it is asymptotically more efficient than the OLS estimators, given that the AR (1) model holds.

3.4.3. Significance of the estimation.

In the presence of a structural break in a time series, estimating with a single linear model is bound to produce incorrect estimates. If there is a presence of a structural break, we can still be able to get statistically significant parameters under the null.

If there is a significant break at the end of the sample, the FGLS regression after the candidate breakpoint year is only based on five observations. This will make it difficult to determine significant lever- and pace effects. This becomes especially problematic, since we do not use dummy variables in the same regression, but instead make two distinct regression before and after the breakpoint. Instead of focusing on the significance of the specific variables, our analysis mainly focuses on the overall fitness of the model.

4. Empirical Analysis

In this part of the paper, we introduce the empirical results from the structural break model. The results illustrate an empirical pattern in the data, which showcases how Norway accelerated in GDP per capita after oil discovery in comparison to Sweden and Denmark. This part of the analysis lies closest to the one performed by Larsen (2005). On the other hand, our approach widens the discussion by searching for structural breaks in ANS and government consumption. We use the same model specifications for all the time series, and find that either the intercept, slope, or both are non-significant for certain variables. However, these models are still valuable since our analysis depends on significant F-ratios.

4.1. GDP

Before parity, we find significant structural breaks between 1969 and 1970. For Norway vs. Denmark case, the peak F-ratio is at 62.29, and within the 95th percentile, as shown in figure 4.1. This break has a negative lever effect, but a positive pace effect. This means that the observations drop significantly, followed by a steep increase in the slope. The slope before the breakpoint was slightly negative, meaning that this breakpoint represents a fundamental change in the relative growth of the economy. Another interesting finding is that we also find high F-ratios in the mid-1970s within the 95th percentile for Norway vs. Denmark. This finding is consistent with Larsen (2005), as 1975 was the structural break that he identified for this variable.

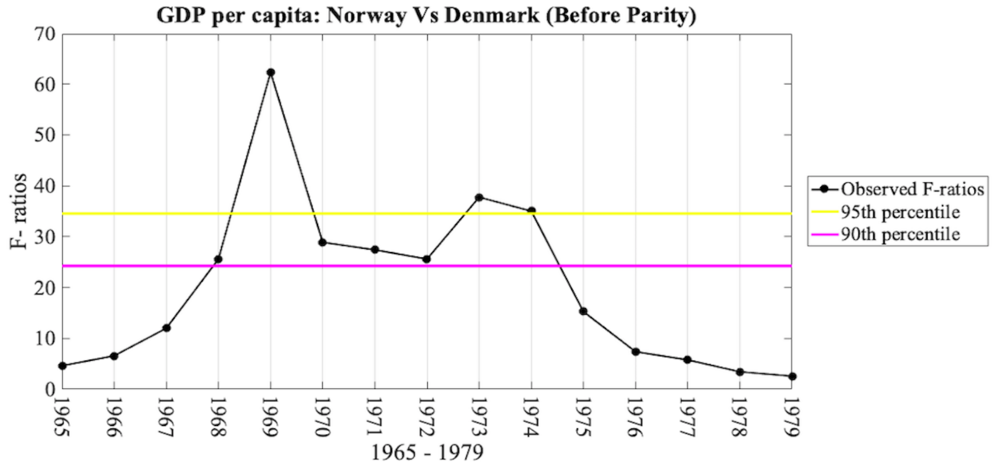

Figure 4.1: F-Ratios in GDP Before Parity: Norway vs Denmark

(Source: Own Calculations, data from Feenstra et al. (2015))

In Norway vs. Sweden case, the F-ratio is 23.15, but only within the 90th percentile at the same breakpoint year as with Norway vs. Denmark (see appendix 8.3.1). The lever and pace effect of the break also follows similar patterns as Norway vs. Denmark.

In the analysis after parity, we find no significant structural breaks, as shown in figure 4.2. The FGLS coefficient estimates under null for Norway vs. Denmark and Norway vs. Sweden is displayed in the appendix 8.1.1, and 8.1.2.

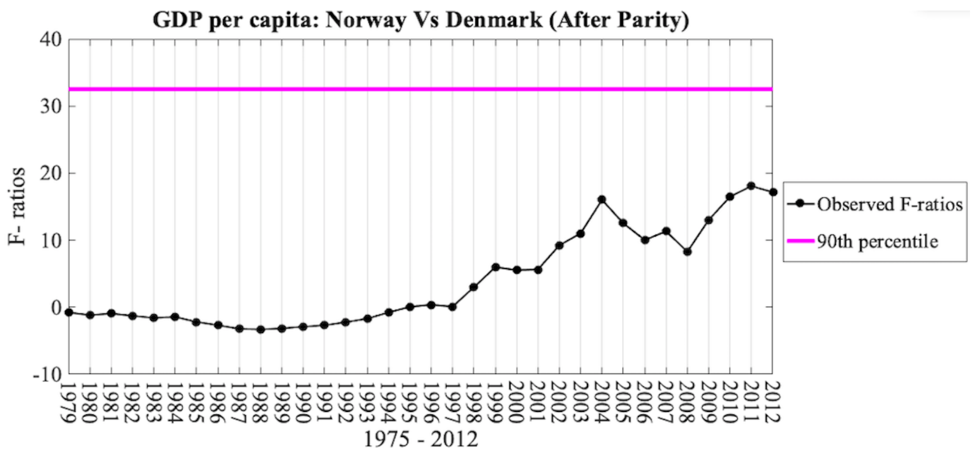

Figure 4.2: F-Ratios in GDP After Parity: Norway vs Denmark

(Source: Own Calculations, data from Feenstra et al. (2015))

4.2. Adjusted Net Savings

We performed the same structural break analysis on ANS, as this gives us an indication of the relative level of sustainability between Norway, Sweden, and

Denmark. In figure 4.3, the computed F-ratios shows the percentage change in ANS between Norway and Denmark. The results indicate several high F-values between 2005 – 2011, but the highest computed F-value is 67,502 in 2011. This is within the 99th percentile, which suggests a structural break in the percentage change in 2010 – 2011. However, we find that the t-value of the *(α)* coefficient is less than 1,708 for a 90 percent confidence level, but the t-value of *(β)* is greater than 1,708 (See section 3.4.3 for discussion of non-significant parameters). The analysis implies that the F-ratios between Norway and Denmark are increasing, so the alternative hypothesis becomes better at explaining the model. The pace effect is found to be positive before 2011, but negative after the break. The results indicate a deceleration in ANS, during the period 2010-2011. On the other hand, the lever effect shows a jump in the observations (in the growth rate of ANS) followed by a rapid decline, which makes this a negative structural break. This means that after the break, the percentage difference between Norway and Denmark is significantly reduced. However, it can also be interpreted as the Norwegian level of ANS becoming stronger than Denmark in the period from 1995 - 2011.

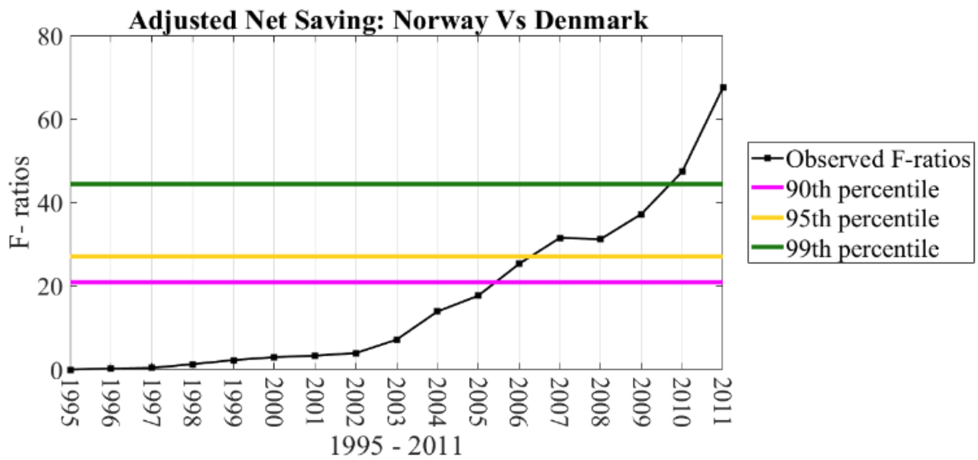

Figure 4.3: F-Ratios in ANS: Norway vs Denmark

(Source: Own Calculations, data from Lange et al. (2018)

In figure 4.4, we find the computed F-values for Norway and Sweden. The analysis finds no breakpoints in the period 1995 – 2011. However, the highest computed F-value is 7,8 in 2011. This is very close to the 90th percentile, but not close enough to be significant. The parameters *(α)* and *(β)* are found to be significant within a 90 percent confidence level, which means that both parameters are significant according to the t-test. The pace- and lever effect is very similar to Norway and Denmark, where we find a negative pace effect after 2011, but a jump in the observations followed by a rapid decline. In other words, this can also be identified as a negative structural break. We find the analysis quite interesting because both F-ratios suggests that the percentage difference is highest in 2011, but that we also have a negative trend over time. This means that there is a strong indication of a slowdown in the level of ANS over time.

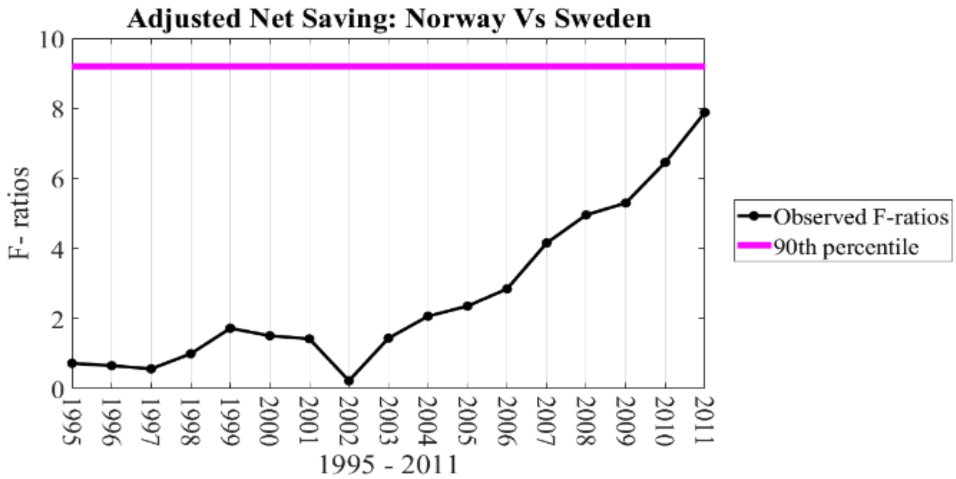

Figure 4.4: F-Ratios in ANS: Norway vs Sweden

(Source: Own Calculations, data from Lange et al. (2018))

4.2.1. Gross National Saving

In this section, we performed the same technique on gross savings. This is one of the variables in the ANS equation mentioned in the literature review. In appendix 8.3.2.1, we find the estimated F-ratios for Norway versus Denmark were the highest computed F-ratio is estimated to be 28,9 in 2011, and within the 95th percentile. The results are similar to the analysis in ANS between Norway and Denmark. The *(α)* coefficient is less than 1,708 for a 90 percent confidence level, but the t statistics for *(β)* is higher than 1,708. We also have the same negative pace effect after 2011 and a jump in the lever effect. This makes sense, since GNS affects the dependent variable ANS in the equation. In other words, there seems to be a correlation between ANS and GNS, and this further strengthens the theory of a slowdown in ANS after 2011.

On the other hand, the analysis between Norway and Sweden also indicates a similar result as in ANS (See appendix 8.3.2.2). However, here we find a significant break within the 90th percentile with an F-value of 10,62 in 2011. The parameters α and β are found to be significant within a 90 percent confidence level, which is in accordance with the t-test. The pace effect is also negative after 2011, but there is no jump in the lever effect, but a deceleration in the observations. It is noticeable that in the ANS analysis, the F-ratios are increasing, but we found no break, even though it has the same trend as GNS. This break can be explained by idiosyncratic factors in Sweden, but over time, Sweden is saving more than Norway due to this being a negative structural break.

4.2.2. Human Capital

In the appendix 8.3.3, we find the results for the developments for human capital in percentage growth between Norway, Denmark, and Sweden. The test finds a significant break between Norway and Denmark in 2011, within the 99th percentile with an F-ratio of 9,623. The parameters α and β are also found to be significant within a 90 percent confidence level, which is in accordance with the t-test. It is interesting to see that we also find a jump in the lever effect, then followed by a strong deceleration. This result, like the other tests, creates an overall impression of a decline in the level of Norwegian ANS.

On the other hand, for Norway and Sweden, the test finds no breakpoints (see appendix 8.3.3.2). This indicates that Norway has a similar trend to Sweden from 1995 – 2011. However, the highest F-value is 3,37 in 2011. Both α and β are also found to be significant within a 90 percent confidence level. There is also no jump in the lever effect, only a rapid decline in the pace effect after 2011.

4.2.3. Energy depletion

In appendix 8.3.4, we observe the candidate breakpoint years from 1977 - 2011 between Norway and Denmark. The test provides several series of potential candidate breakpoints from 1980 - 1992 within the 90th percentile. However, the highest F-ratio is within the 99th percentile in 1981 with a value of 33,69. The break in 1981 suggest that Norway’s relative change in depletion pace stabilized rather than taking off, even though the inspection of the raw data would indicate that Norwegian depletion grew out of control at this point. This illustrates the importance of using natural logarithms. The observations before breakpoint year were highly volatile and steeply downwards sloping, while it follows a consisted and slightly negative path afterward. The lever effect is negative, and the pace effect is positive, though still downwards sloping. This means that the relative growth in energy depletion went from being high and sporadic compared to Denmark throughout the 1970s, but shifted towards an almost entirely consistent path afterward.

4.3. Government Consumption

The results from the analysis between Norway and Denmark show several statistically significant breakpoints within the 95th percentile. However, as mentioned earlier, the highest observed F-ratio is considered to be the most likely candidate (Hansen, 2001). This breakpoint is between 2007 - 2008 and has an F-ratio of 38,07 (see appendix 8.3.5.1). The lever effect shows that government consumption in Norway has a negative development from 1990 to breakpoint in 2007 - 2008, but then strongly accelerates relative to Denmark.

On the other hand, in Norway and Sweden case, we only find one significant break in 2003 - 2004 within the 90th percentile with an F-ratio of 11,11 (see appendix 8.3.5.2). The lever effect shows a fall in government spending for Norway during the break year, while Sweden maintains a stable path. However, after 2003 - 2004, the lever effect is positive.

5. Discussion and Future Prediction

In this part of the paper, we will discuss the results from the previous section, and combine this with the literature review to give a structured discussion on growth, sustainability, and resource wealth management.

5.1. GDP per Capita

For this part of the discussion, we will build on Larsen's (2005) assumption that a negative relative break in GDP could indicate the presence of a resource curse, i.e. inadequate resource management. If we were to find this in the GDP, it would give a basis for further discussion of the other theoretical frameworks.

The structural break between 1969 and 1970 is an acceleration one could expect to find in a country that has recently discovered oil. Even though many newly resource-rich countries face a resource curse at a later point, a significant oil discovery may boost the economy in the short run. It is essential to distinguish between the state's net cash flow and GDP when looking at the growth effect of an oil discovery. This distinction is important because even if the oil were discovered at the end of 1969, revenues would not immediately follow. The actual extraction on the first oil field in Norway, Ekofisk, did not begin until July the 15th in 1971 (Olje- og energidepartementet, 2019). A structural change in GDP would instead indicate a major shift in the structure of the Norwegian economy.

An example would be to look at the already flourishing Norwegian shipbuilding industry. After the discovery, the industry started producing a large number of oil platforms, while the production of ships only declined marginally (Olsen, 2015). This shift, together with both domestic and foreign investments in the oil sector, represents an overall shift in the engine growth that goes beyond revenues and cash flows.

The lack of any breaks after parity means that there were no structural changes to the economy except oil discovery. An oil-related relative deceleration in this period would be in line with Sachs and Warner (2001), where they show that resource-abundant countries have slower growth than countries with less or no natural resources. In other words, GDP tends to slow down over time, as the country extracts more oil.

Although Larsen (2005) found significant structural breaks in the 1990s, our analysis found none after parity. This is most likely due to newer and larger datasets, and different approaches and analytical tools. Judging by relative GDP growth alone, there seems to have been no oil induced deceleration in Norway so far. By looking at the raw data in figure 5.1, the most substantial fluctuations happened after 2013. However, this is a very recent event, and it would be too early to conclude that the break could represent a deceleration in Norwegian growth.

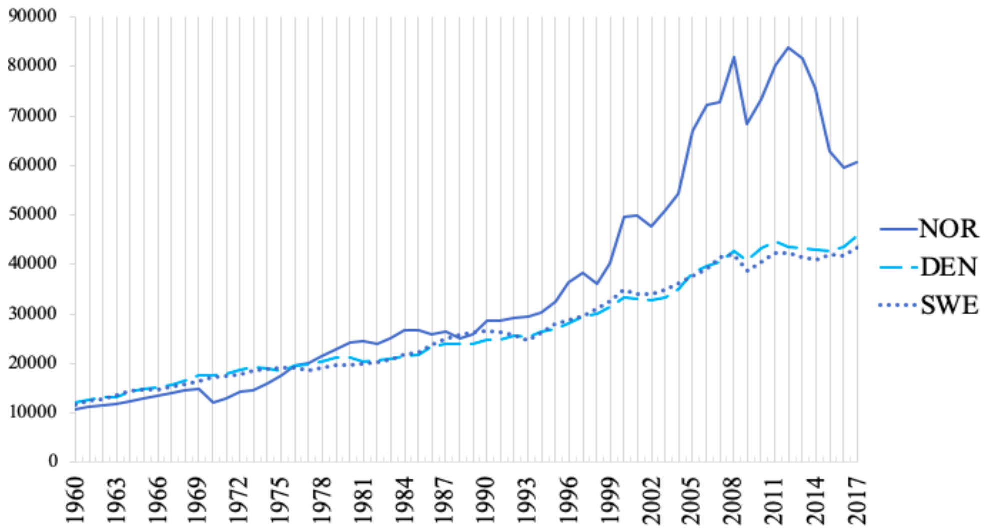

Figure 5.1: GDP per Capita

Source: Data from Feenstra et al. (2015))

5.2. Sustainability and Savings

This section will take a closer look at the discussion regarding sustainability and savings for our three countries. We will discuss the chosen components in the ANS equation during the period 1970 – 2016. This implies an evaluation of GNS, HC, ED, and finally, end with ANS. This section will therefore mainly focus on how sustainability has been affected by shocks and events in the economy.

5.2.1 Gross National Saving

GNS is used as a measurement of accumulated national wealth as mentioned in section 3.1.2. In figure 5.2, we can observe the GNS from 1975 – 2015. It shows that the Norwegian GNS rate has been higher than the Danish GNS, since 1980. However, it is interesting to see that the Swedish GNS has been sustainably higher than Norwegian GNS from 1975 – 2004. There seems to be an increasing trend for all countries after 1993, although Norwegian- and Swedish trend seems to be more volatile and similar. The empirical findings for GNS in section 4.2.1 are easy to observe in figure 5.2. The reason is that the break in 2011 - 2012 is justified by Norway’s increasing trend, but also both Denmark and Sweden illustrate a declining path from 2011-2012.

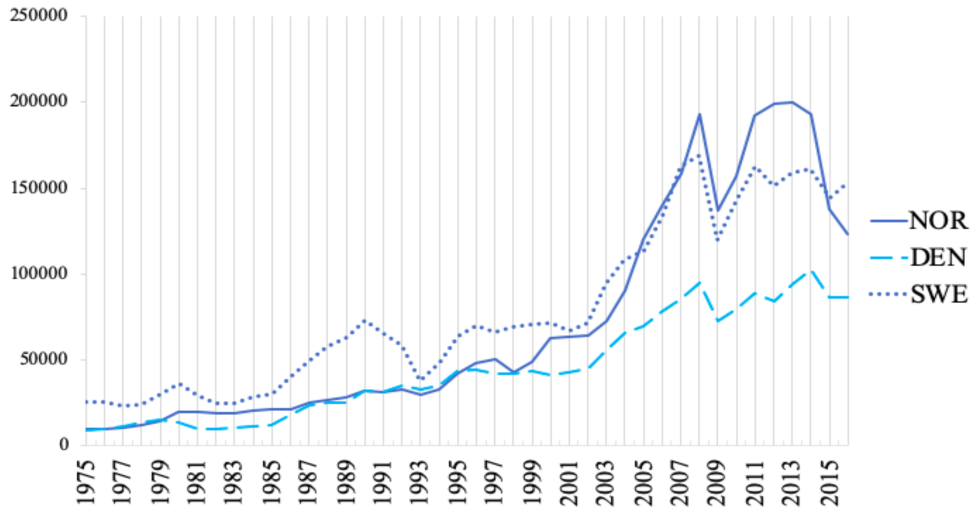

Figure 5.2: Gross National Savings

(Source: Data from Lange et al. (2018))

Figure 5.2 shows us two significant drops in GNS that are interesting to discuss. The first slowdown is connected to the financial recession in 2008, but the second is primarily based on the oil price fall in 2014. The financial crisis affected many countries simultaneously and led to a global recession. The GNS in Norway from 2007 to 2009 dropped from 39,5 percent to 35,4 percent. On the other hand, the oil price fall in 2014 seems to have a similar effect on GNS as the financial crisis, although it has lowered GNS more. This is from 38,5 (2014) percent to 32,7 percent (2016). We can also observe that Sweden and Denmark are less affected than Norway under this particular event.

It is important to accentuate that GNS alone does not give a complete measurement of real wealth and growth, and on the effect that these events had on the economy. To get a better perspective on how savings pattern is affected by oil price, we also look at the *Net National Saving* (NNS). This is similar to ANS, but only takes into consideration the differences between GNS and consumption of fixed capital without adjusting for the other variables in the equation. The NNS is shown in figure 5.3 and looks very similar to figure 5.2. However, it is considered to perceive a more volatile savings pattern.

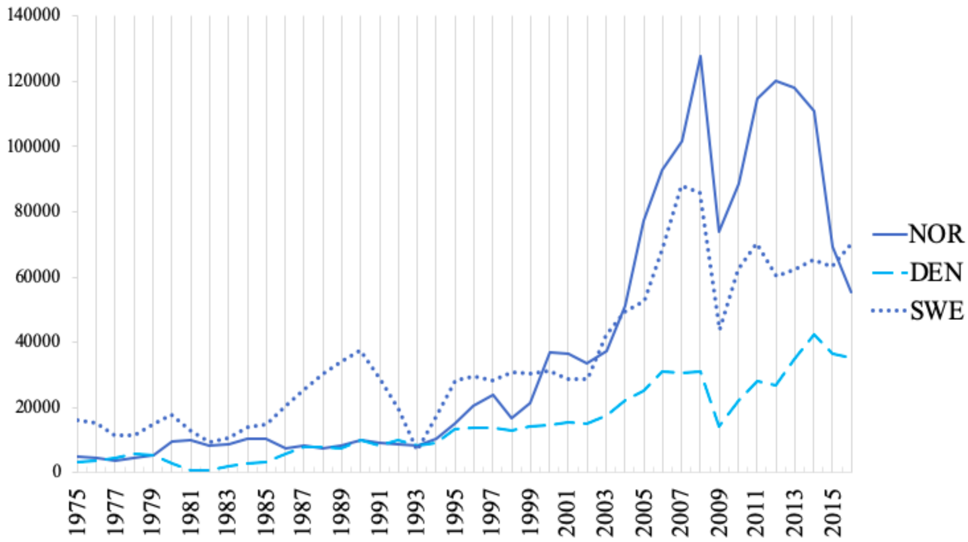

Figure 5.3: Net National Savings

(Source: Data from Lange et al. (2018))

The effect of an oil price correlation can be observed in the NNS pattern during the period 2000 – 2008, and 2012 – 2016. In figure 5.4, we have the annual crude oil brent prices, and this provides evidence for this correlation as the effect of an increase in the oil price is much stronger in Norway, compared to Denmark and Sweden. According to the Swedish Riksbank Monetary Policy Report (2015); lower oil prices lead to lower global inflation, but this has a greater direct effect in countries that are oil-exporting like Norway. Furthermore, the impact oil prices have on inflation also depends on the duration of the price fall and the cyclical position of the economy (Mortensen & Staghøj, 2015). It should be mentioned that the reduction in oil prices in the period from 2007 – 2008 was justified by a global recession as mentioned earlier, which created a demand shock (Fueki et al., 2018). This is why all countries drop during this period. However, our analysis found a significant break in 2011- 2012 in both cases, which can be justified by the increasing oil price effect on Norway compared to Sweden and Denmark. It is a bit strange that both Denmark and Sweden illustrate a downwards trend from 2011 – 2012 to an increase in the oil price, but this can be due to idiosyncratic events. We also find it interesting to see that the oil price fall in the period 2013 – 2014 leads to a fall in GNS and NNS for all countries. This displays strong co-movement across countries in business cycles, even if the effect is stronger for oil-exporting countries (Berghold, 2015).

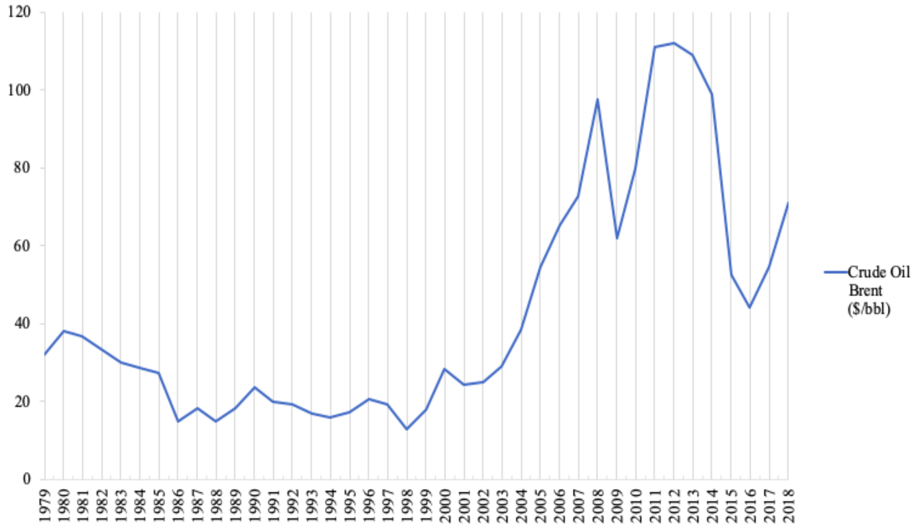

Figure 5.4: Average Crude Oil Price Brent

(Source: World Bank (2019b))

5.2.2. Human Capital

In the literature review, we established that human capital is a major determinant of economic growth and sustainable development. It is the basis for technical change and allows for better scientific and technological developments. However, in sustainable development, we are mostly interested in total wealth and welfare because sustainability is important for growth over time. Furthermore, GDP does not consider changes in tangible- and intangible assets, which makes it an inappropriate measurement of welfare and HC (Acar, 2017).[18]

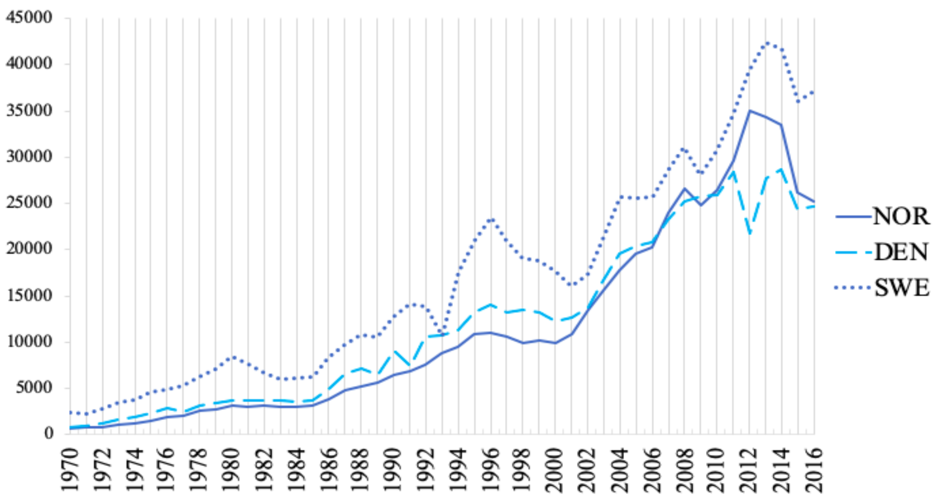

Figure 5.5: Human Capital

(Source: Data from Lange et al. (2018))

[18] With tangible assets, it is referred to human-made capital, natural capital, etc. However, with intangible assets, we mean human capital and institutional capital.

In figure 5.5, we find that Norway closely follows Denmark, but is outperformed by Sweden from 1970 – 2016. However, Norway seemed to catch up with Denmark in 2010. Our empirical analysis shows a break in the percentage change in 2010 – 2011 between Norway and Denmark. We find this break to be caused by an idiosyncratic development in Denmark, relative to Norway and Sweden, which cannot be explained by developments in oil prices. According to OECD (2014); Denmark has been held back by weak productivity growth due to low competition between some sectors, and shortcomings in innovation. This is also noticeable in their GDP per capita because this has hardly grown since 2010. The housing bubble in early 2000s is also partly responsible for the slowdown in productivity due to a misallocation of resources. We also notice that Norway and Sweden follow a similar trend. This explains why we do not find any structural breaks in the percentage difference between Norway and Sweden. During this period, the oil price was around 100 $/bbl, which greatly benefited the net cash flow from oil activity due to exploration and extraction activities being profitable.

It is evident that GDP has grown significantly after the Norwegian oil discovery in the 1970s. This is due to the fact that Norway did not have a large industry sector, but was built on farming and their fish industry. They did have some small businesses and factories, but not anywhere near the level today. On the other hand, the development of the oil industry has been largely affected by the government's participation, immigration, and the surrounding industries investment in infrastructure and human capital (Hunter, 2014). There was a steady rise in migration during the early 1960s and, the middle of the 1970s. This is due to Norway discovering oil, but also to the early phase of the industrial development. The Norwegian population was relatively small during this period, and there was a lack of workers in the labor market. The immigrants that traveled to Norway are an important part of the calculation of HC because many of them remained in Norway, established families, invited family members, worked, and studied. The international oil companies that worked in the North Sea, also aided with their expertise and technology (Gursli-Berg & Myhre, 2018). The exchange of ideas and technologies have given Norway the change to learn and now establish itself as a leader in offshore and especially deepwater petroleum technology (Noreng, 2004). These events have led to a significant improvement in HC development, as a stronger and more educated labor force boosts the productivity of the economy. As a result, more is spent on education to maintain and further strengthen the labor force, which is in line with Hartwick's Rule and the literature about HC in section 2.1.5.

On the other hand, the structure of the Norwegian economy presents a weak spot in human capital development. According to Meld. St. 4 (2018); a substantial restructuring of the Norwegian industry is required to reach the 3 percent target in total R&D expenditure. The national budget in 2019 has estimated the R&D expenditure to be around 1,02 percent (Kallerud & Sarpebakken, 2018). In comparison to other Nordic countries where business R&D accounts for approximately 70 percent. The Norwegian Business R&D accounts from only 54 percent of total R&D expenditure in 2015 (OECD, 2017). One of the reasons for this is based on the structure of the Norwegian economy. There is a "large share of commodity-based activity and related low share of industries with high R&D intensity, as well as the relatively large share of smaller sized companies" (OECD, 2017). In other words, the developments in human capital are linked to benefitting the extraction of oil. This creates a dependency on the oil sector, but also less competitiveness in the long run. The technologies (external spillovers) gained from extraction of oil need to be used as a stepping stone to diversifying the national economy from the volatile nature of the petroleum and gas industry. This means that when the oil sector is affected by low oil prices and activity, the production should be switched to other sectors to avoid a fall in GDP (Bjørnland & Thorsrud, 2016).

Finally, since the HC variable only measures public expenditure on education, and several other factors, as mentioned in section 3.1.2. It does not take into account the creation of knowledge and skills in a society (Acar, 2017). Furthermore, it assumes that HC does not depreciate. This is not realistic because it can decline, become outdated, or kept with retired people. It is difficult to adjust for these problems, but providing a comparison of HC between countries is a step in the right direction.

5.2.3. Energy Depletion

Although the Hotelling rule focuses on the change in oil prices compared to the return on financial assets, it could still be interesting to study this through a structural break analysis. When looking at energy depletion, comparing Norway to Denmark and Sweden is more complicated. While for example Sweden has more mineral resources rather than oil and gas, it would not make sense to compare the depletion of offshore oil to iron ore mining. We do, however, find an interesting relationship between Norway and Denmark. As mentioned earlier, Denmark is also an oil exporter, though on a much smaller scale than Norway. Despite this, the energy depletion rate in these two countries followed a similar path until the end of the 1970s, when Norway moves exponentially ahead. This analysis partially violates our initial assumption that Denmark and Sweden function as counterfactuals to Norway, since they are similar at most points except oil. In this analysis, we compare the Norwegian oil extraction to the much more modest Danish extraction, as seen in figure 5.6. This comparison is, however, useful in the way that we compare the extraction to a case where the oil income is only a minor source of wealth, thus eliminating external factors to oil extraction that would affect all countries, and highlights the changes that are idiosyncratic to Norway.

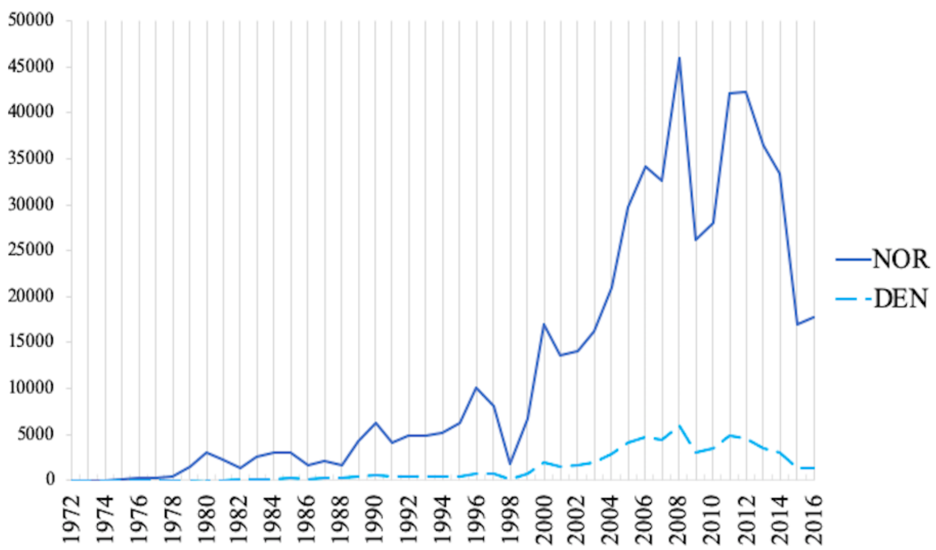

Figure 5.6: Energy Depletion

(Source: Data from Lange et al. (2018))

The breakpoint between 1981 and 1982 coincided with the peak in oil prices in the same period. Before this peak, Norwegian depletion (relative to Denmark) was very sporadic, but stabilized at a lower level after. There could be many alternative explanations for this. However, Norway and Denmark were in the early stages of their oil adventures and were continuously discovering new areas and building competence. In a white paper from the Storting (Stortingsmelding) in 1974

(Finansdepartementet, 1974), there were clear ambitions about extracting the oil at a moderate pace, and that the oil wealth should be used to make society qualitatively better. It would thus seem that the volatile period before the breakpoint was due to adjustments.

We see from history how awareness of the principles behind the Hartwick rule has existed since the beginning of the oil adventure. The ambition was that the oil reserves should last as long as possible, and the politicians were early to set a maximum ceiling on oil extraction (Smith-Solbakken & Ryggvik, 2018). It can be argued that the break found in 1981 was a managed escape from a path that would otherwise be the fate of other resource abundant nations. The high and sporadic growth in the extraction rate could be more typical for a resource-cursed country that does not follow any strict rules. As previously discussed, resource cursed countries have a tendency not to save their accumulated wealth, which is linked to negative ANS.

Although the Hotelling's rule is helpful to understand how to best manage a depletable resource wealth, this rule makes some assumptions that are not that relevant in today's situation. If discounted net price shock should be equal across time, there can be no technological progress (lecture by Eirik Romstad, spring 2019, NMBU). We now know that new technologies and newly discovered oil fields can both decrease oil prices over time, while lowering extraction costs. Instead of having a positive Hotelling's price path, we see the oil price falling over time (after 2013).

Another problem with the Hotelling's rule is that Norway is a price taker when it comes to oil. This means that whether Norway chooses to increase or decrease oil extraction, this will have little to say on the oil price. Further discussions on the Hotelling's rule relative to Norway, depends on a set of assumptions regarding the need for oil in the future. If there is a scenario where oil supply is low and prices increases, there might be a peak price leading to a backstop. In an attempt to incorporate a backstop technology to the Hotelling's pricing model, Levy (2000) found that this would lower the spot price of oil. In a time where the importance of renewable resources is increasing, a potential backstop technology could have implications on extraction. Such a "threat" could force Norway to transfer as much of the wealth to the other forms of capital as possible, since a lower demand of oil would make the oil in the ground obsolete.

5.2.4. Adjusted Net Savings

In this part, we will discuss if Norway is following a sustainable path with the recent developments in the Norwegian economy. We have so far analyzed GNS, HC, and ED which all affect the rate of ANS. The discussions in the sections above imply that Norway is a sustainable country due to a positive level of ANS. However, the economy is to a large extent dependent on energy depletion, in contrast to Denmark and Sweden. This is quite obvious because the three variables in the equation have reacted negatively to a fall in oil prices. Furthermore, the effect of an oil price shock creates volatile movements in NNS, HC and ED, which provides further proof of dependency on natural resources.

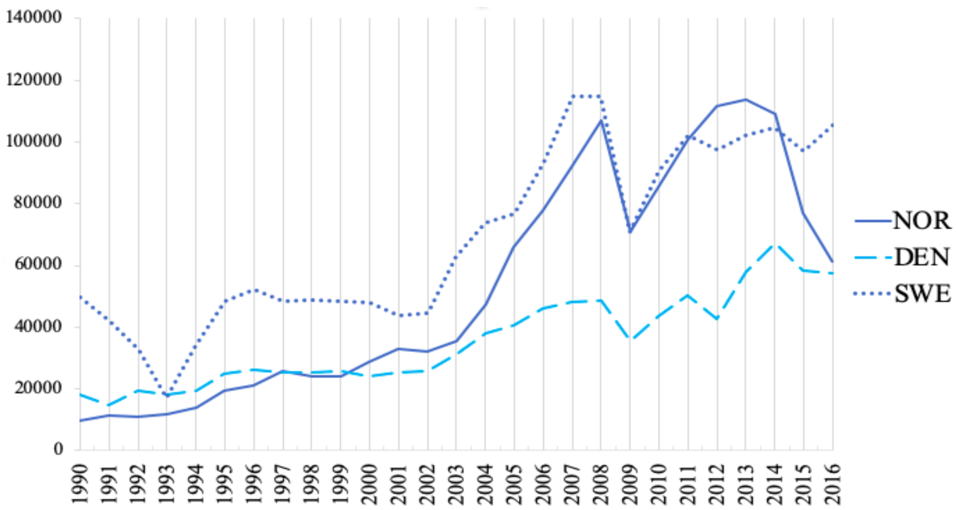

Figure 5.7: Adjusted Net Savings

(Source: Data from Lange et al. (2018))

The findings so far indicate that Norway's GDP per capita has suffered from a relative, but not absolute slowdown. This is also consistent with our data for ANS. In figure 5.7, this slowdown can be illustrated from 2013 - 2016. The trend shows the volatile impact oil prices have on Norway's pattern of sustainability and savings. In the scenario of a high oil price, they become more sustainable, GDP per capita increases, and they outperform both Sweden and Denmark. However, when the oil price is reduced, the variables of interest indicate a relative slowdown. In other words, in the long run, the Norwegian economy is not sustainable due to their dependency on energy depletion.

The assumption of non-declining total wealth is also an essential topic in this discussion. The discussion is about whether total wealth is reduced over time or remaining constant. In 2005, the ANS was $66.019M, but increased to $113.882M in 2013, during a period of high oil prices. In 2016, this was reduced to $61.274M. In other words, Norway's relative level of sustainability has been reduced to almost the same level as in 2005. This leads to several implications for non-declining total wealth. The first being that Norway's total wealth from 2005 - 2016 has been reduced, which may violate the assumption of non-declining total wealth. It does not necessarily mean that Norway's total wealth has shrunk because our analysis does not provide evidence of this, but it does show that there is a significant downward trend after the break year in 2011-2012. In order to provide any more evidence for a contraction of total wealth, a more in-depth investigation of sustainability is required.

The second point is connected to Hartwick's rule and if this is enough to ensure sustainability in a country that already has a positive level of ANS. Hartwick's rule implies that the resource rent (Hotelling Rent) is invested in reproducible assets that generate income in the long run, as mentioned in section 2.1.3. The fact that Norway invest all its rents in the fund rather than spending it directly is consistent with the rule. This also means that if the assumption of non-declining wealth is to be maintained, the government cannot spend more of its financial wealth than what would preserve the value of the fund. This analysis does not go into detail on the correlation between fiscal spending and oil price, but it seems that spending of oil wealth is more prominent in periods requiring fiscal stimuli. Strictly speaking, this means that Norway violates the idea that oil spending should only be invested in reproducible capital. According to Romstad (lecture at NMBU, spring 2019), the breakpoint around 2008 in government spending sparked a resistance against the fiscal rule. The value of the fund was reduced, thus also the expected real return. During this time, there was a broad political consensus to temporarily violate this rule and spend more than this return, in order to reduce the negative effects of the financial crisis. After 2010, the oil fund got back to its old value. This was arguably because they did not sell off their old securities, but rather waited for them to rise in value. Although the oil price fall in 2013 was not a demand shock, such as the one in 2008, the government responded with further increasing the non-oil deficit. In sum, this development has made 2008 a turning point in the spending of oil wealth.

One of the main problems Norway experiences today is the fact that they are able to spend well within the spending rule, as mentioned earlier. This development makes the Hartwick rule less critical, since it allows for ever-growing non-oil deficits, as long as the government does not spend more than what makes the value of the fund shrink. This issue leads to the broader discussion on weak and strong sustainability, as discussed in 2.1.1. The Hartwick rule, which is related to weak sustainability, states that different forms of capital are substitutable. This means that investing in a sovereign wealth fund, human capital or infrastructure is just as good as keeping the oil in the ground. It seems that the main difference between financial capital and natural capital, is that financial capital can be combined with e.g. a BIH consumption over time, something that will be discussed later. In that way, Norway can both fulfill a weak sustainability rule, while at the same time satisfy the public's desire for increased consumption.

5.3. Wealth Management

In 2001, the GPFG was supplemented with an explicit fiscal rule in defense of the political pressure to spend the oil windfalls. This fiscal rule was based on the idea of PIH, as mentioned in section 2.2.2, which allows for fiscal sustainability where consumption is non-declining in all perpetuity. Furthermore, the fiscal policy in Norway incorporates three elements from the BIH: (i) all resource revenues gained from extraction is transferred to the GPFG; (ii) annual withdraw of 3 percent from the GPFG to finance non-oil budget deficit; and (iii) no future borrowing ahead of the resource revenues (Harding & Van der Ploeg, 2012). In other words, there is a combination of both the PIH and BIH in Norway's fiscal policy. The NOU (2015:9) suggests that the fiscal rule takes into account the "long-term perspective to the management of Norway's petroleum wealth", and shields the national budget from fluctuations in petroleum revenues by placing the revenues in the GPFG. However, they also mention that spending will adapt to the macroeconomic situation at any given time. This means that spending can be boosted during periods of rising activity in the oil sector, and allows for a gradual increase in the use of oil revenues.

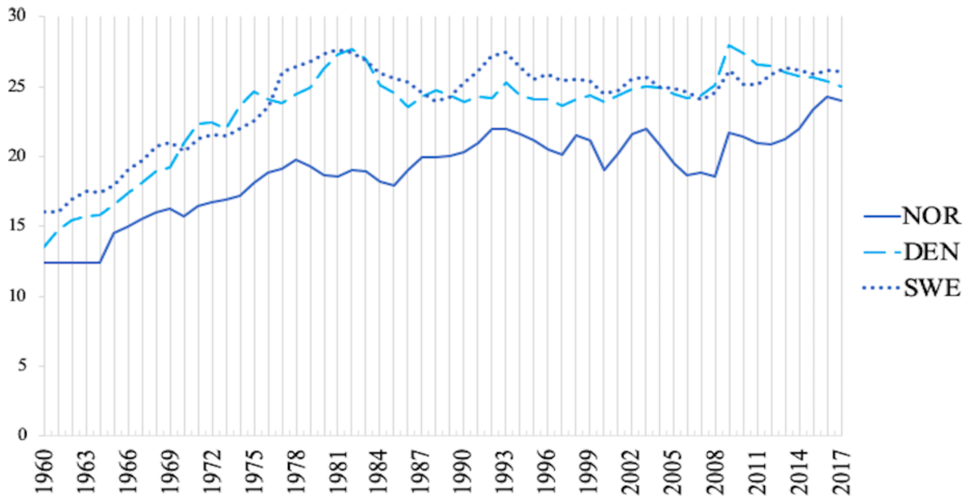

Figure 5.8: Government Consumption

(Source: Data from World Development Indicators (2018))

In our analysis, we find that Norwegian government consumption is on a lower level relative to Sweden and Denmark, as seen in figure 5.8. This makes sense if we take into account that Norway is a smaller country. On the other hand, it is interesting to see that Norway maintains a relatively stable consumption path, even though the GPFG is growing. This can be observed in figure 5.9, as it illustrates that the structural non-oil deficit grows over time, even though the government manages to keep spending under the fiscal rule.[19]

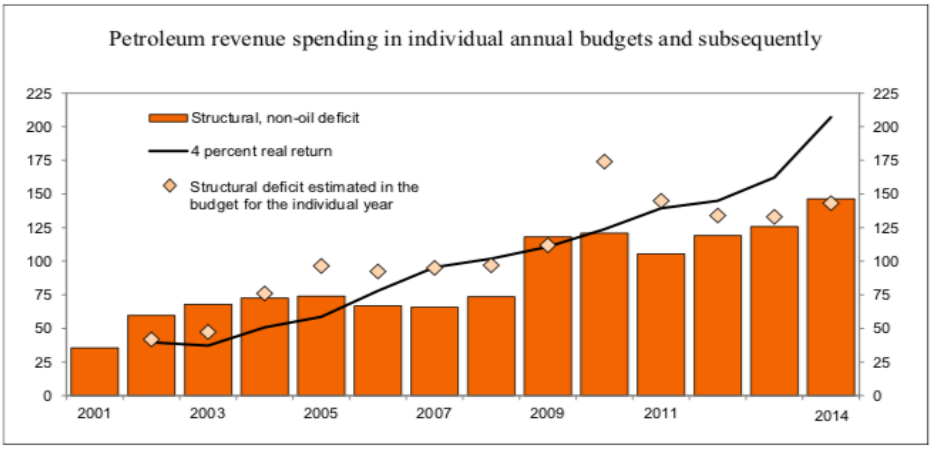

Figure 5.9: Structural Non-Oil Budget Deficit

(*Source: NOU, 2015:9)*

[19] The fiscal rule was previously 4 percent, but was changed to 3 percent in 2017. It was changed after several recommendations due to the rule giving politicians room to increase spending. It is often discussed that this should be even lower because the size of the fund is increasing, which allows for more spending.

The first case between Norway and Denmark shows there is a breakpoint in 2007 - 2008 in the percentage change. It is not obvious whether this event is oil induced or solely a reaction to the financial crisis. The three Scandinavian countries reacted with countercyclical monetary policies to dampen the effects of the crisis. In other words, they increased government spending. However, the relative break between Norway and Denmark could also be affected by how Norway chooses to respond to the recession. In the national budget for 2009, the government increased the structural non-oil deficit with 14 million NOK from 2008 (Finansdepartementet, 2008). This means that Norway fought the recession to a large degree with oil wealth, something that was not an option for Sweden and Denmark. This raises the question of whether such response violates the principles of consumption smoothing and resource wealth management in general because a breakpoint leads to a structural change in government spending.

On the other hand, in Norway vs. Sweden case, we do not find the same structural break. This is much less significant break of opposite signs in 2004. According to the data, government consumption was on a decreasing path for all the Scandinavian countries before the financial crisis. In Norway, this fall in growth seemed to be a bit larger and can be explained with lower tax revenues in both 2004 and 2005 (Vinje, 2009).

In section 2.2.3, Harding and Van der Ploeg (2009) mentioned that the BIH approach creates a buffer against future oil and price shocks. It could, therefore, be argued that this substantial increase in government consumption and the non-oil deficit would in this case not violate these rules, as they smooth out negative shocks in periods of weak growth. This same reasoning could be applied for the 2014 fall in oil prices, as the non-oil deficit grew even larger. However, this also makes the consumption path unpredictable, as consumption is too high in certain periods, and then goes gradually back to its initial level. Shocks can be long-lasting; thus, good fortune cannot be expected in every instance (NOU, 2015:9). Furthermore, it is mentioned by Harding and Van der Ploeg (2012) that BIH does not take into account the wealth in the ground. This makes the consumption path even more uncertain because the non-oil deficit will increase with each year. It will gradually increase because as more natural resources in converted to financial capital, the

GPFG allows for higher real return. This makes us more dependent on the revenues from the oil sector because the non-oil deficit increases, and is covered by the real return on the fund.

5.4. Current and Future Prediction of the Fiscal Rule

In the past 15 years, there have been many events that influenced the economic growth in the economy. Most of these events have been unexpected, which makes predicting future economic disruptions difficult. Since natural resources can be a blessing and a curse, the challenges connected to managing the oil wealth will not disappear. These challenges are often linked to the question of spending versus saving, as the economy can succumb to the “Dutch disease”, and run down an unsustainable path. Norway has implemented several important and effective policies to limit these effects, but cannot escape the uncertainty on the fund’s return, and its vulnerability to rent seeking.

The fiscal rule is both credible and sustainable because it is based on the theories of PIH, as mentioned in section 2.2.2. The problem is that this is in the absence of uncertainty. In other words, the PIH does not take into account future expenditure, such as aging and population (Iacono, 2012). This is an important challenge in terms of sustainability in Norway. Therefore, it makes sense that Norway follows a more prudent approach to fiscal policy, such as the BIH. However, Harding and Van der Ploeg (2009) argue that neither the PIH nor BIH will be prudent enough for the increasing expenditure from the aging population and pension commitments. Their results suggest that Norway’s fiscal reaction has been forward-looking in terms of the rising pension expenditure, but backward-looking concerning the oil and gas revenues (Harding & Van der Ploeg, 2012). In other words, this argues towards allocating more of the petroleum revenues to saving.

The recent adjustment to the fiscal rule from 4 to 3 percent was necessary to ensure a responsible policy. However, the Mork committee argues that this is not enough due to the size of the GPFG, and how this will affect future spending (NOU, 2016:20). Norway might end up in a situation where the spending is higher than the real return on the GPFG, and this why changes in the fiscal rule is required.[20] The rule was not meant to be followed obediently with each passing year, but used as a limit that should be discussed and adjusted over time. In theory, the PIH allows for non-declining consumption in all perpetuity, but the real return on the GPFG is uncertain. If this is lower than what is expected, then the fund will gradually shrink. Furthermore, the low interest rates could lead to reduced real return on the shares in the GPFG. This will be the case if we assume that the premium remains at the same level it has been historically. The committee, therefore, predicts that the rule could be reduced to 2 percent in the future (Riekeles & Juel, 2017).[21]

The adjustment from 4 to 3 percent was also followed by an increase from 60 to 70 percent in the share of equities. This increases the real return to approximately between 2,5 and 2,7 percent. This is still below 3 percent, but due to the size of the fund, a small deviation from 3 percent can still amount to a large difference in government consumption. This means that the fiscal rule has to be gradually adjusted with the size of the fund to smooth out consumption (Riekeles & Juel, 2017). The real return from the GPFG is also prone to fluctuations in the exchange rate, as the fund is invested abroad. If the NOK appreciates, then the value of the fund falls in Norwegian kroner, and the opposite when it depreciates. Throughout this discussion, it is interesting to see that Norway is vulnerable to several factors that are difficult to control. This further strengthens the claim of resource wealth management, and it being paramount in avoiding unsustainable paths.

5.5. Environmental Issues

In the discussion of weak- versus strong sustainability, we mentioned that the degree of substitutability is what separates these two approaches to sustainability. However, as mentioned in section 2.1.1, weak sustainability does not hold in the long run. The increasing growth in world population and demand for natural resources creates a troublesome scenario for the environment and nature. This is problematic because most of the oil and gas are found in the ground and require extraction. The process of extraction has a negative effect on other natural resources

[20] If spending is higher than the real return, the wealth is gradually consumed. This is unsustainable in the long run.

[21] The share premium is relevant in the discussion of risk associated with the stocks and obligations in the GPFG. The risk will increase with uncertainty about economic developments

within the area of extraction, and on the environment in general.[22] For example, this could be deepwater drilling in the North Sea, which can cause nearby marine mammals and fish harm due to noise and pollution. On the other hand, countries such as Brazil, Nigeria, and Venezuela conduct extraction in the areas close to the rainforest. In other words, the exploitation and exploration of oil and gas can lead to problems such as deforestation, extinction of species, climate change, pollution of water and oil depletion (Mittal & Gupta, 2015). This is one of the main problems with weak sustainability because it does not take into account that other forms of natural capital can be depleted in the process of extracting oil and gas.

Another interesting perspective on the same problem would be if Norway would not have found oil, or decoupled from extracting oil. It only becomes natural to assume that they would exploit other forms of natural resources instead. "Throughout Norwegian history, people in Norway have made a living from fishing, whaling, and sealing" (Nærings- og fiskeridepartementet, 2007). The fisheries sector is also the second largest export industry after oil and gas. In other words, it is reasonable to assume that the fisheries sector would be the engine of growth, in the absence of oil discovery. This causes the dilemma of a shift in the exploitation of natural resources, because if Norway does not extract oil, then they would harvest fish instead. This can lead to significant pressure on the stock of fish available in the North-, Norwegian- and Barents Sea. Overfishing can cause uncertainty regarding the stock status, but also the extinction of certain species over time (Fiskeridirektoratet & Miljødirektoratet, 2018). This does not solve the issues of weak sustainability, but rather leads to declining natural wealth, which is not in accordance with strong sustainability.

5.6 Avenues for Future Research

Due to this paper facing a significant time constraint on its completion, we have had to limit the level of sophistication of the analysis. We also found that many of the most interesting events are too recent to be subject to a fruitful structural break analysis. The following section will briefly mention what future researchers could do to expand this study.

[22] The oil in the ground is surrounded by oceans, animals and forests.

5.6.1 End of Sample Results

One of the main limitations with the results of this analysis is that most of the changes seem to happen at the end of the samples. This is partially due to the long-term effects of the financial crisis of 2008, but also the more recent fall in oil prices. The spikes in F-ratios in many of the variables at the end of the samples could also be due to weaknesses with the analytical framework itself. In our opinion, the research question in this paper with the broad theoretical approach we apply, would be even more interesting to look at in the future. This would allow us to more closely study the recent structural changes that our analysis indicates, and determine whether these are actual signs of a resource curse or a decline in sustainability.

5.6.2 Synthetic Control Approach

A more rigorous approach that would not require our currently strong assumptions of Sweden and Denmark serving as counterfactuals to Norway without oil, could be the synthetic control approach. This approach assigns countries that could be compared to Norway a weight based on the similarities. The sum of these weights would then represent a synthetic counterfactual country that more accurately isolated changes that are due to oil in the different variables. In this paper, both Denmark and Sweden are assigned full weight respectively, since we separate the two comparisons in two different analyses per variable.

5.6.3 Frequency of Time Series

A final avenue for future research is to use different frequencies for different variables within ANS. A key challenge in the ANS variable is that it does not take into account the difference between slow-moving and fast-moving variables, as described in section 2.1.4 and 3.1. The most interesting changes in certain variables could be long- term, such as forest depletion, and an idea could be to instead look for breaks per e.g. decades. We might identify more structural breaks, if we were to conduct a study on finding appropriate frequencies for each variable, rather than treating them all annually.

6. Conclusion

After the Norwegian oil discovery at the end of the 1960s, their GDP per capita grew rapidly. This led to the suspicion of a *Resource Curse*, as the classical assumption of a deceleration in relative GDP growth can provide evidence of this phenomenon. This paper finds no negative structural breaks that would indicate this for Norway. On the other hand, as expected, there are only positive breaks in GDP growth in the early 1970s, related to the oil discovery. However, GDP suffers from limitations that does not necessarily make it the appropriate indicator for economic growth. As such, this paper provides a connection between sustainability and economic growth, through the importance of wealth management.

This paper finds evidence of a decline in Norwegian sustainability over time, through the *Adjusted Net Savings* indicator. There is an indication of a possible deceleration in the early 2010s, which seem to vary with the oil price. When the oil prices increase, the economy grows and becomes more sustainable. However, when it declines, the growth slows down, and they become more unsustainable in contrast to Denmark and Sweden. This is the case after 2014, which suggests dependency on natural resources, and commodity prices, which is unsustainable in the long run. This is connected to the literature regarding the resource curse, as a negative adjusted net savings, or slowdown can cause declining total wealth, which means that the country consumes more than it saves. The deceleration is also observable in the other indicators affecting adjusted net savings, such as gross national savings, human capital, and energy depletion, which indicates a comovement between the variables.

The importance of resource wealth management cannot be underestimated; therefore, we also consider government consumption based on the literature regarding *the Permanent Income Hypothesis*, and the *Bird-In-Hand* theory. The fiscal policy in Norway incorporates both elements, which allows for additional consumption during times of macroeconomic instability. This is consistent with our findings because it suggests a structural change during the financial crisis in 2007. This raises the question of whether such a response violates the principles of consumption smoothing and wealth management. It can be argued that this is reasonable and in accordance with the fiscal rule and bird-in-hand approach. However, it does make the consumption path unpredictable and uncertain with each passing year, as the fiscal rule does not take the wealth in the ground into account. The non-oil deficit will therefore grow while being covered by the real return on the fund.

It is evident that Norway is dependent on its natural resources, and the past years have highlighted this. It is both difficult and too early to determine whether the structural breaks in adjusted net savings is due to the presence of a resource curse, even if the results illustrate a development towards an unsustainable path. It is therefore interesting to see how Norway as a large oil exporter will develop in the future, in contrast to Denmark and Sweden.

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8. Appendix

The different results and findings that is refereed to in the paper is found in this section. The appendix includes firstly the FGLS estimations for real GDP, and ANS. Secondly, the results from the different variables in the structural break analysis. Thirdly, a replication of Larsen (2005), and the MATLAB code used.

8.1. FGLS Estimations for Real GDP

8.1.1. Difference between Norway and Denmark

Parameter	Parameter Estimates, 1960 - 1984 (SE)	t-stat	Parameter Estimates, 1974 - 2017 (SE)	t-stat
Intercept, α	0.2040 (0.1220)	1.6721	-0.0548 (0.1231)	0.4452
Time Coefficient, β	0.0138 (0.0072)	1.9167	0.0120 (0.0044)	2.7273
Autoregressive coefficient, φ	0.8871		0.8643	
Number of observations, N	25		44	
Durbin-Watson	0.2573		0.3529	

8.1.2. Difference between Norway and Sweden

Parameter	Parameter Estimates, 1960 - 1984 (SE)	t-stat	Parameter Estimates, 1974 - 2017 (SE)	t-stat
Intercept, α	0.2040 (0.1220)	1.6721	-0.0548 (0.1231)	0.4452
Time Coefficient, β	0.0138 (0.0072)	1.9167	0.0120 (0.0044)	2.7273
Autoregressive coefficient, φ	0.8871		0.8643	
Number of observations, N	25		44	
Durbin-Watson	0.2573		0.3529	

8.2. FGLS Estimates for Adjusted Net Savings:

8.2.1. Difference between Norway and Denmark

Parameter	Parameter Estimates, 1990 - 2016 (SE)	t-stat
Intercept, α	-0.4140 (0.3327)	1.2444
Time Coefficient, β	0.0322 (0.0184)	1.7500
Autoregressive coefficient, φ	0.8396	
Number of observations, N	27	
Durbin-Watson	0.5124	

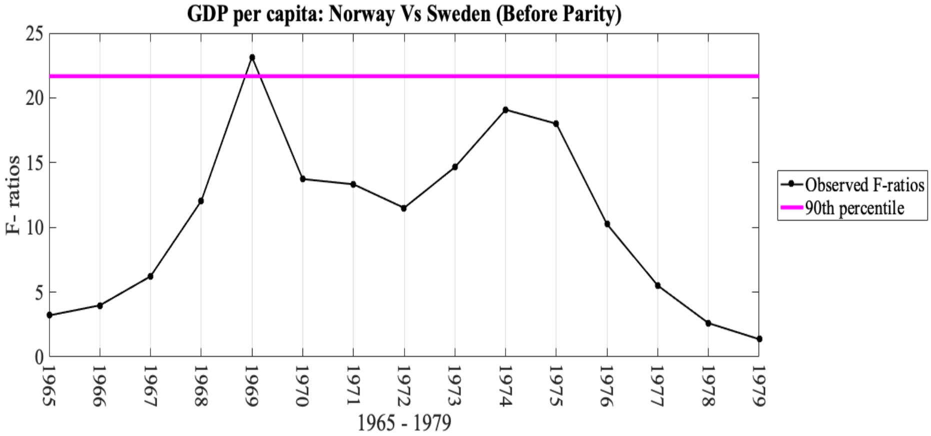
8.2.2. Difference between Norway and Sweden

Parameter	Parameter Estimates, 1990 - 2016 (SE)	t-stat
Intercept, α	-1.1705 (0.2250)	5.2022
Time Coefficient, β	0.04550 (0.0136)	3.3088
Autoregressive coefficient, φ	0.5384	
Number of observations, N	27	
Durbin-Watson	0.8565	

8.3 Testing for Structural Break

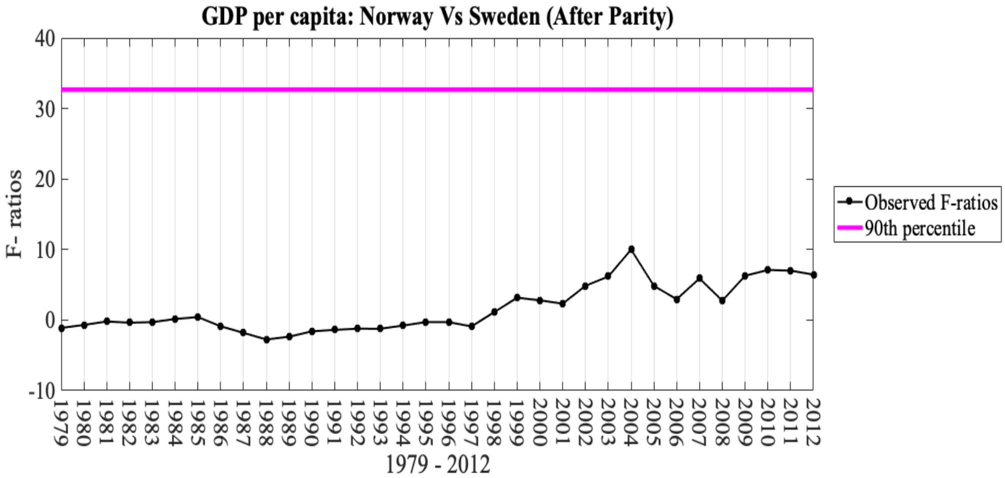
8.3.1. GDP per Capita, Norway versus Sweden

8.3.1.1. Before Parity



(Source: Own Calculations, data from Feenstra et al. (2015))

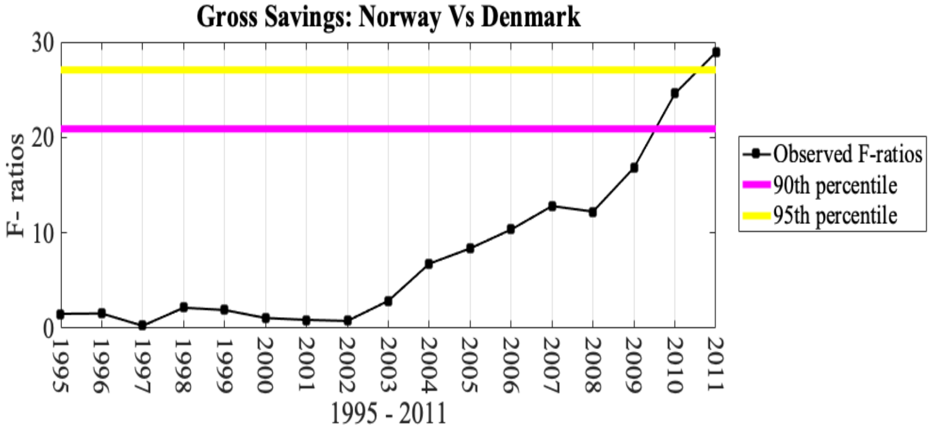
8.3.1.2. After Parity



(Source: Own Calculations, data from Feenstra et al. (2015))

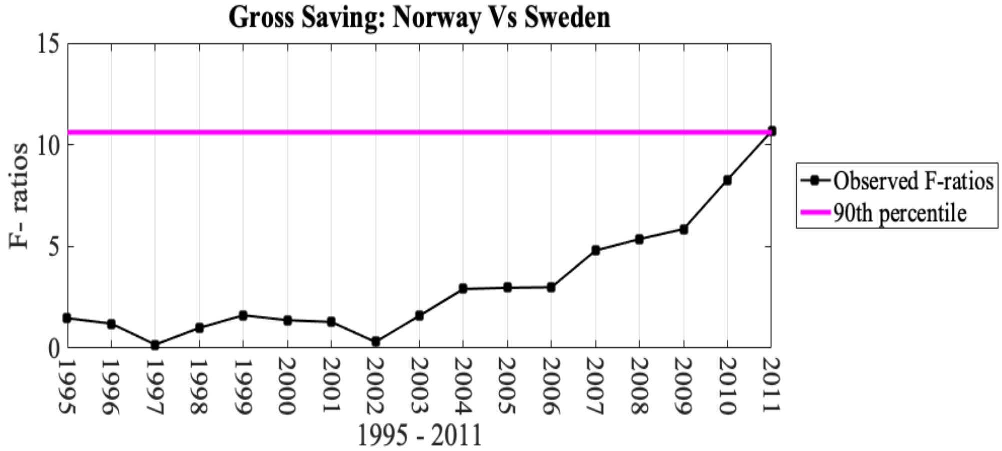
8.3.2. Gross Savings

8.3.2.1. Difference between Norway and Denmark



(Source: Own Calculations, data from Lange et al. (2018))

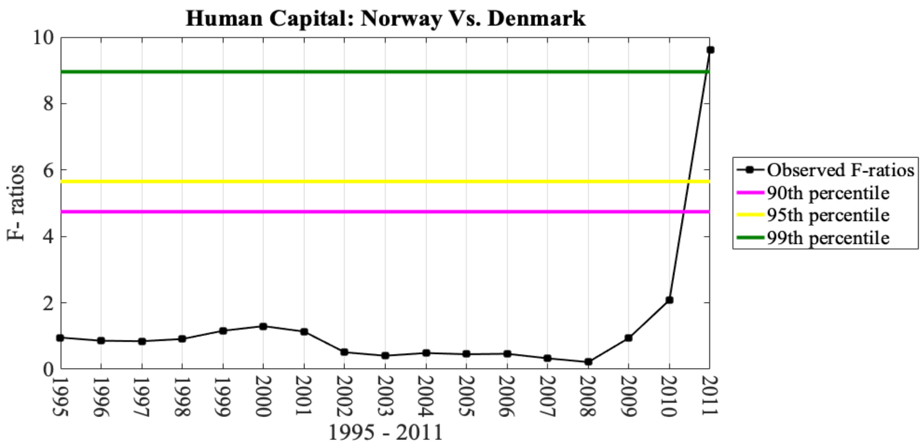
8.3.2.2. Difference between Norway and Sweden



(Source: Own Calculations, data from Lange et al. (2018))

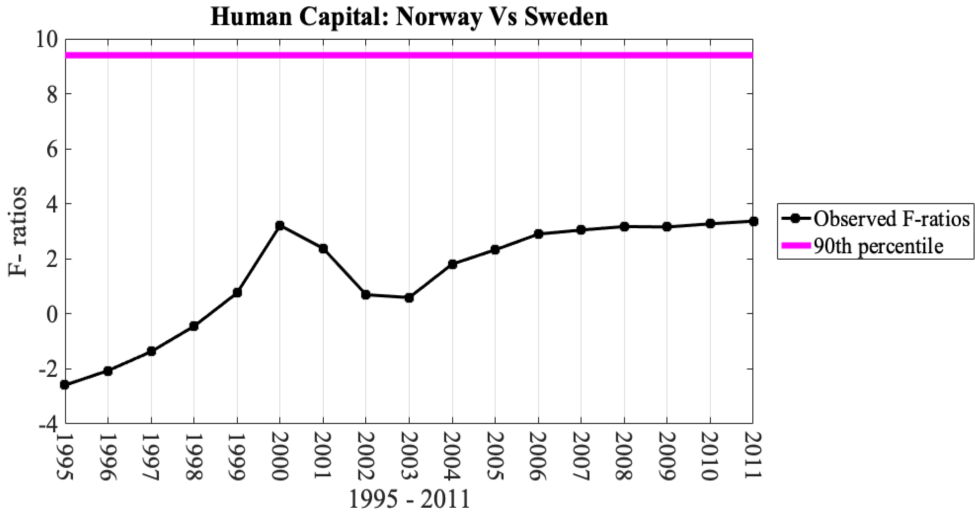
8.3.3 Human Capital

8.3.3.1. Difference between Norway and Denmark



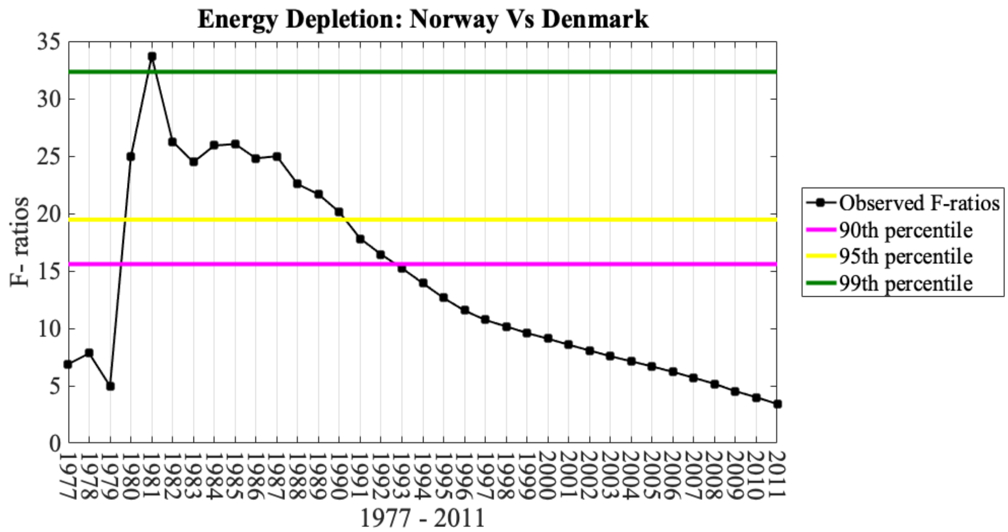
(Source: Own Calculations, data from Lange et al. (2018))

8.3.3.2. Difference between Norway and Sweden



(Source: Own Calculations, data from Lange et al. (2018))

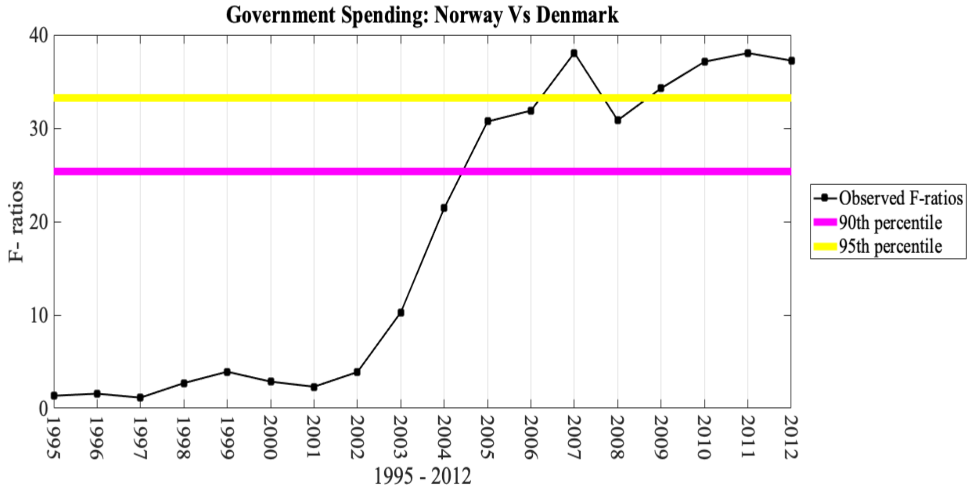
8.3.4. Energy Depletion, Norway versus Denmark



(Source: Own Calculations, data from Lange et al. (2018))

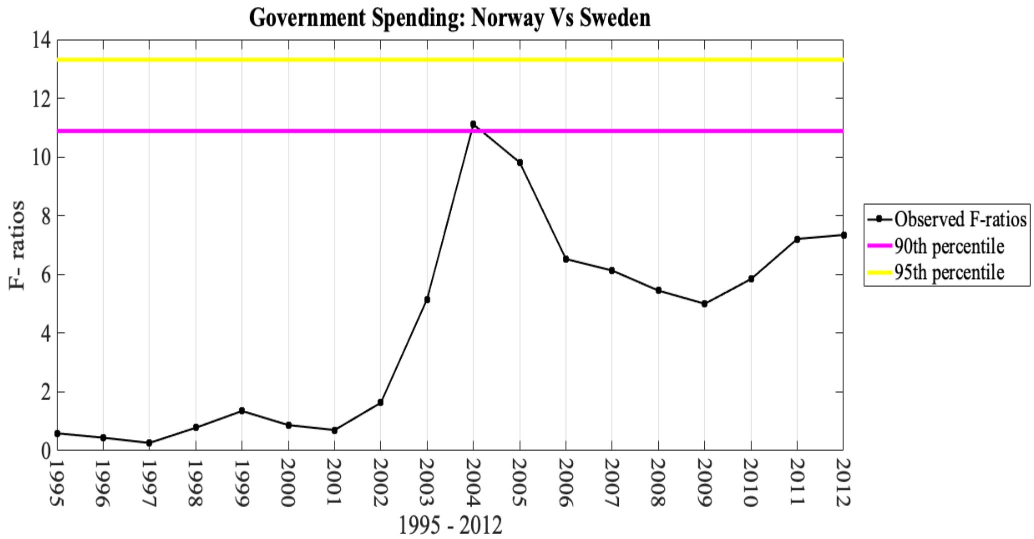
8.3.5. Government Consumption

8.3.5.1. Difference between Norway and Denmark



(Source: Own Calculations, data from World Development Indicators (2018))

8.3.5.2. Difference between Norway and Sweden



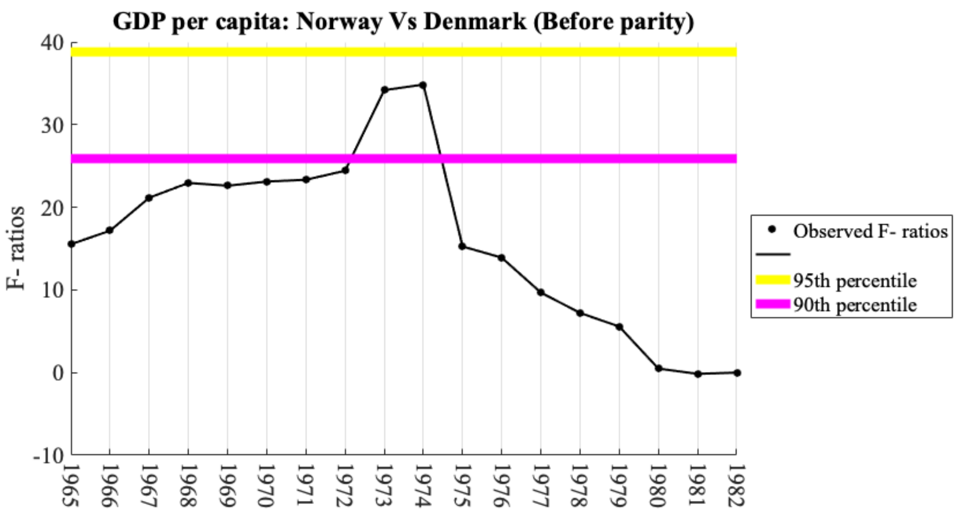
(Source: Own Calculations, data from World Development Indicators (2018))

8.4. Replication of "Are rich countries immune to the resource curse? Evidence from Norway's management of its oil riches", by Erling Røed Larsen, 2005.

In order to find a suitable method of identifying structural breaks, we chose to replicate the methodology used in this paper, published in Resource Policy 30 (pages 75-86). This version of the paper was received in revised form on October 8th, 2004 and accepted on December 28th, 2004. Larsen (2005) addresses the problem of the resource curse and wants to find out whether a rich country like Norway is immune to this phenomenon. They do this by comparing Norwegian real

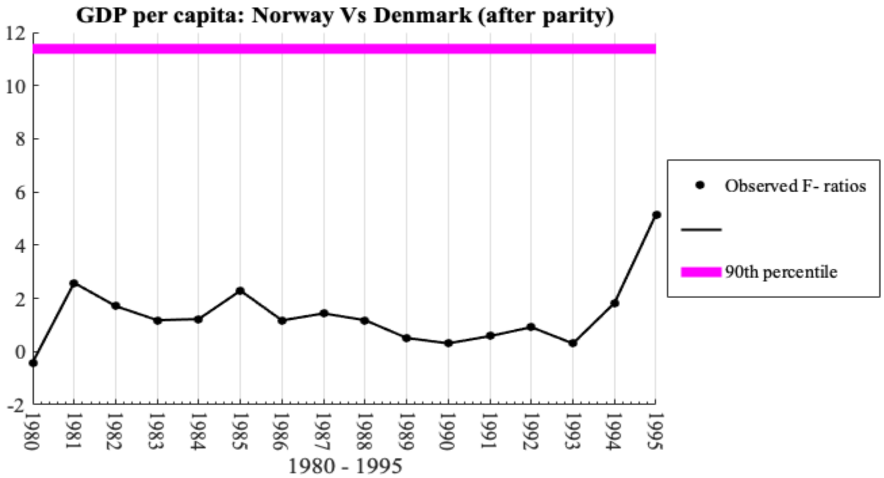
GDP per capita (PPP), with the same data from Sweden and Denmark, respectively. According to Larsen, a negative acceleration in this time series would indicate that Norway suffers something that it otherwise would not have experienced if it continued to follow the path of Sweden and Denmark, since the main difference between Norway and its neighbors is resource wealth. The data is collected from the US Department of Labor, Bureau of Labor Statistics, Office of Productivity and Technology. In can be found on page 9, table 1 in the 'Comparative Real Gross Domestic Product Per Capita and Per Employed Person. Fourteen Countries. 1960–2002' from 2003. The analysis starts by separating the dataset in two periods, namely before and after parity. With parity, he means when Norwegian GDP per capita caught up with and surpassed its neighbors.

The model and notation used in this analysis is identical to the one we use in our analysis. For details, see section 3.3 on the empirical framework.



(Source: Own Calculations, data from BLS (2003))

The test for before parity includes the entire data for GDP per capita, but mainly focuses on the period from 1965 to 1982. Although, we found the same peaks in F-ratio as Larsen (2005), the breaks are not as significant in our replication (between 1973 and 1974, and between 1974 and 1975). The breaks are within the 90th percentile (purple line), but in Larsen's analysis, the same points fell within the 99th percentile.



(Source: Own Calculations, data from BLS (2003))

For the after-parity case, we are faced with the same problem. Larsen (2005) found a peak at the breakpoint between 1995 and 1996 within the 95th percentile. On our replication, we found this peak, but it was not significant.

In the Norway vs. Sweden analysis, we find no significant breaks either before or after parity. We still choose to consider the replication a success, even though the breakpoint years were not as significant. Since we are confident that our analysis is not making type-II errors, we believe that the reason for this deviation is the use of different analytical tools. We constructed the analysis from the beginning in a different programming language (MATLAB). We did, however, find reasonably similar parameter values.

8.5 MATLAB code from GDP per capita, 1960- 2017, Norway versus Denmark

The following is the code behind the GDP part for our analysis. This code is more or less identical for all the other variables, except where the data is cut, and the "after-parity" part of the code. The simulations, calculation of residual squares and F-ratios are performed in different functions. The graphs with observed F-ratios and thresholds are put together in the base code.

The Base Code

```
rng (6030); % random seed for replication
clear;
clc;

data = readtable('GDP2017.xlsx');
delta1 =
fints(datenum(data.DATE,'dd.mm.yyyy'),data.Norway-
data.Denmark,'delta1','A');
dataset = fts2mat(delta1);
%% Find F- ratios before parity based on data
datasetcut = dataset(1:25) % cuts the dataset
FbData = Fb4_func(datasetcut);
time = (1:length(datasetcut));
%%  make 500 simulations of delta1 after
numsim = 500;
YsimTb = zeros(numsim,length(datasetcut));
h = waitbar(0,'Simulating...');
for s = 1:numsim;
    Ysimb = ReplarsenSim_func(datasetcut);
    for j = 1:length(datasetcut)
        YsimTb(s,j) = Ysimb(j)';
    end
    waitbar(s / numsim);
end
close(h);
YsimTb = YsimTb'
%% find F before parity ratios from simulations
FbT = zeros(numsim,length(YsimTb));
h = waitbar(0,'Simulating...');
for i = 1:numsim
    YsimTarow = YsimTb(:,i);
    Fb = Fb4_func(YsimTarow);
    for j = 1:length(YsimTarow)
        FbT(i,j) = Fb(j);
    end
    waitbar(i / numsim);
end
close(h);
FbData(FbData==0) = NaN;

maxb = max(FbT,[],2);
prc90a = prctile(maxb,90);
prc95a = prctile(maxb,95);
prc99a = prctile(maxb,99);

line = prc90a*ones(length(datasetcut),1);
line2 = prc95a*ones(length(datasetcut),1);
line3 = prc99a*ones(length(datasetcut),1);

plot(time,FbData,'-o')
xtickangle(45)
ylabel('F- ratios', 'FontSize', 12);
```

```
xlabel('1965 - 1979', 'FontSize', 12)
hold on;
plot(time,line,'DisplayName','90th percentile')
hold on;
plot(time,line2,'DisplayName','95th percentile')
hold on;
plot(time,line3,'DisplayName','99th percentile')
legend('show')
hold off;

%% same analysis for after parity parity_____________
%% Find F- ratios after parity based on data
datasetcut = dataset(15:end); % cuts the dataset
FaData = Fa4_func(datasetcut);
time = (1:length(datasetcut));
%%  make 500 simulations of delta1 after
numsim = 500;
YsimTa = zeros(numsim,length(datasetcut));
h = waitbar(0,'Simulating...');
for s = 1:numsim;
    Ysima = ReplarsenSim_func(datasetcut);
    for j = 1:length(datasetcut)
        YsimTa(s,j) = Ysima(j)';
    end
    waitbar(s / numsim);
end
close(h);
YsimTa = YsimTa'
%% find F after parity ratios from simulations
FaT = zeros(numsim,length(YsimTa));
h = waitbar(0,'Simulating...');
for i = 1:numsim
    YsimTarow = YsimTa(:,i);
    Fa = Fa4_func(YsimTarow);
    for j = 1:length(YsimTarow)
        FaT(i,j) = Fa(j);
    end
    waitbar(i / numsim);
end
close(h);
FaData(FaData==0) = NaN;

maxb = max(FaT,[],2);
prc95a = prctile(maxb,95);
prc99a = prctile(maxb,99);
prc90a = prctile(maxb,90);

line = prc90a*ones(length(datasetcut),1);
line2 = prc95a*ones(length(datasetcut),1);
line3 = prc99a*ones(length(datasetcut),1);

plot(time,FaData,'-o')
xtickangle(270)
```

```
ylabel('F- ratios', 'FontSize', 12);
xlabel('1979 - 2012', 'FontSize', 12)
hold on;
plot(time,line,'DisplayName','90th percentile')
hold on;
plot(time,line2,'DisplayName','95th percentile')
hold on;
%plot(time,line3,'DisplayName','99th percentile')
legend('show')
hold off;
```

Function: Monte Carlo bootstrap simulation (ReplarsenSim_func)

```
function [Ysim] = ReplarsenSim(x)

y = x
T = length(y);
time = (1:T);
X = time';
% sample of 500 simulations

coeff =
fgls(X,y,'arLags',1,'display','off','numIter',1);
alphahat = coeff(1);
betahat = coeff(2);
e = y - (alphahat + betahat*time');

m = ar(e,1);
phi = -m.A(2); %NB! See matlab documention. Estimates -
phi
sigmauhat = sqrt(m.NoiseVariance);

epsilon = zeros(size(1:T));
sigmaepsilonhat = sqrt((sigmauhat^2)/(1-(phi^2)));
epsilon0 = normrnd(0,sigmaepsilonhat);
u = normrnd(0,sigmauhat);

epsilon(1) = phi*epsilon0 + u;

for t = 2:T
    u = normrnd(0,sigmauhat);
    epsilon(t) = phi*epsilon(t-1) + u;
end
Ysim = alphahat + betahat.*time + epsilon;
```

Function: Calculate residual sum of squares (RS_func)

```
function RS = RS_func(y)

T = length(y);
time = (1:T);
X = time';
```

```
coeffhat =
fgls(X,y,'arLags',1,'display','off','numIter',1);
alphahat = coeffhat(1);
betahat = coeffhat(2);
ehat = y - (alphahat + betahat*time');

RS = (ehat).^2;
```

Function: Calculate F- Ratios before parity (Fb4_func)

```
function Fb = Fb4_func(x)

T = length(x);
time = (1:T);
X = time';
RSr = RS_func(x);
RSSr = sum(RSr);

% breaks under alt______________________________

low = 6;
high = 20;% limits where the analysis begins and ends
r = 3; % # linear restrictions
K = 6; % # of parameters in unrestricted case
%before
parity___________________________________________

Fb = zeros(size(x)); % F ratio before parity
RSSu = zeros(size(x));

for b = low:high;

    yp1 = x(1:b);
    yp2 = x((b+1):end);
    T1 = length(yp1);

    %before breakpoint year

        RSu1 = RS_func(yp1);
        RSu2 = RS_func(yp2);

    SRu = [RSu1;RSu2];
    RSSu(b) = sum(SRu);

    Fb(b) = ((RSSr-RSSu(b))/r)./(RSSu(b)/(T-K));
end
```

Function: Calculate F- Ratios after parity (Fa4_func)

```
function Fb = Fb4_func(x)

T = length(x);
time = (1:T);
X = time';
```

```
RSr = RS_func(x);
RSSr = sum(RSr);
%RSSr
% breaks under alt_________________________________

low = 6;
high = 39;% limits where the analysis begins and ends
r = 3; % # linear restrictions
K = 6; % # of parameters in unrestricted case
%before parity____________________________________

Fb = zeros(size(x)); % F ratio before parity
RSSu = zeros(size(x));

for b = low:high;

    yp1 = x(1:b);
    yp2 = x((b+1):end);
    T1 = length(yp1);

    %before breakpoint year
        RSu1 = RS_func(yp1);
        RSu2 = RS_func(yp2);

    SRu = [RSu1;RSu2];
    RSSu(b) = sum(SRu);

    Fb(b) = ((RSSr-RSSu(b))/r)./(RSSu(b)/(T-K));
End
```