Diagnosing an Early Symptom of Dutch Disease: An Empirical Analysis of the Norwegian Real Exchange Rate

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While I am blessed to have supportive friends and family all around the world, nothing matches the support and help that I have received the greatest husband in the world. Thank you, Kjell Tangjerd for putting up with my craziness this past year.
“If I meet Mrs. Thatcher in heaven, since that is where I intend to go, the biggest thing I will tax her with is that she blew North Sea oil. [...] Norway, on the other hand, went about it in the typical sober way you expect of good Scandinavians”

Robert M. Solow

(Sustainability: An Economist’s Perspective, 1991)
This thesis discusses the theoretical aspect of Dutch disease in detail, but focuses on investigation of real appreciation in the Norwegian kroner as a symptom of Dutch Disease. The Behavioral Equilibrium Exchange Rate model (BEER) was applied to analyze the misalignment of the kroner from its expected equilibrium. In this paper, the BEER model takes into account four economic fundamentals relevant to Norway, that being oil price (proxy for Terms of trade), final government consumption, a productivity differential and a trade openness variable. The analysis carried out required the implementation of a Vector Error Correction Model and thereafter a brief application of the Hodrick Prescott Filter. The results obtained indicate that that the Norwegian krone exhibits a trend of being overvalued.
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1. Introduction

According to convention, a country’s natural resource endowments are often viewed a curse, with limited instances of it being a blessing. Essentially, good macroeconomic performance in resource rich economies depends on efficient management of revenues stemming from these resources. Over the past 40 years, the Norwegian oil and gas sector has played a pivotal role in the country’s steady economic growth, making Norway an exemplary example of natural resource stewardship. The establishment of the world’s largest sovereign wealth fund together with the introduction of a fiscal rule (“Handlingsregelen”) in 2001, have been instrumental in the gradual phasing in of oil revenues into the Norwegian economy, while simultaneously “imposing constraint on oil revenue spending” (Olsen, Ø, 2015). The country’s conservative “bird in hand” fiscal policy is widely praised for considering the well-being of both future generations and its current ageing population (Van der Ploeg & Venables, 2011). In 2013, the petroleum sector constituted 21, 5 percent of GDP, 29, 1 percent of government revenues, 30,7 percent of total investments and 48,9 percent of total exports (Norwegian Petroleum Directorate, 2014”), these figures are a clear indication of how reliant the Norwegian economy is on its oil and gas sector.

However, the pronounced decline in activity levels in the Norwegian Continental Shelf since 2001 (due to decreased demand) and the severe impact of negative oil price shock of 2014/2015, has given rise to growing concerns regarding the depth of Norway’s dependence on its oil and gas sector, thus resulting in the somber question: Is Norway starting to exhibit symptoms of the dreaded Dutch Disease? The term Dutch Disease was first coined by “The Economist” in 1977, to explain the de-industrialization that occurred in the Netherlands during the late 50’s and early 60’s due to the appreciation of the Dutch Guilder that followed the discovery of natural gas in the North Sea (Gylfason, 2001). The appreciation of the guilder resulted in inflation which in turn reduced the competiveness and profitability of the service and manufacturing sectors.
1.1. Purpose
Diagnosing any of the Dutch disease symptoms is a complex matter. Therefore the purpose of this paper is to investigate the real appreciation of the Norwegian krone as a symptom of Dutch Disease.

1.2. Motivation
The author first gained interest in the Dutch Disease phenomena after reading an article in the Financial Times in 2014, titled “Norway, Cruise Control.” The article describes challenges the Norwegian Economy face due to its reliance on oil. The author, interviews several subject matter experts that all believe that Norway is in danger of catching the dreaded Dutch disease.

1.3. Research Question
While as a whole, the author is interested about the presence of Dutch Disease in Norway, the key research question in this paper is:
Is the Norwegian krone showing real appreciation?

1.4. Methodology
The Behavioural Equilibrium Exchange Rate model was applied to test for real appreciation in the kroner. For the purposes of implementing this model four economic fundamentals that contribute to movements in the real exchange rate were included in the analysis, that being: terms of trade (oil price), government spending, a productivity differential (relative GDP per capita) and a Trade Openness variable. Quarterly data for the above listed variables was collected from several different databases, with the datasets all fixed from the first quarter of 1994 to the second quarter of 2014.

1.5. Structure/ Outline
This paper begins with a review of the theoretical models of Dutch Disease, starting with the static Core Model and then to a discussion of a dynamic models, namely the Learning by Doing Models. A model of learning by doing is illustrated and there after a review of previous research/studies relevant to Norway is carried out.
A brief historical economic background on Norway is presented and thereafter a discussion of the macroeconomic variables that will be included in the econometric analysis is given. The empirical analysis starts with concise technical details on the functioning of the Behavioral Equilibrium Exchange Rate model and thereafter a description of the data variables is presented. This is followed by a description of the econometric methodology. After the ADF and Cointegration tests are run, the Vector Error Correction Model is carried out. The results are presented, that being that the Norwegian Kroner is overvalued due to real appreciation.
2. Theoretical Framework

2.1. Resource Curse vs. Dutch Disease

Both the “Resource Curse” and “Dutch Disease” describe the potential adverse effects that may stem from natural resource wealth. It is imperative to make a distinction between the two phenomena, as it is common error to use these two terms interchangeably. The resource curse or the “Paradox of Plenty” is based on the observation that resource rich economies, on average, tend to grow slower than resource poor economies (Sachs & Warner, 1999). More explicitly, it is the negative correlation between resource endowments and GDP growth (Bulte, Damania & Deacon, 2004). While a resource discovery or windfall may boost economic development and raise standards of living, it may also lead to lower and unbalanced growth across the other sectors of the economy – thus a resource boom is often described as being paradoxical in nature.

Economic literature describes a wide variety of transmission mechanisms for the curse. For example Auty (2001a), cited in (Stevens, 2003), categorizes three exogenous causes – structuralist policies, Dutch disease, and two endogenous factors – policy failure and inefficient investment, and rent seeking and political economy. On the other hand, Stevens (2003), lists “long-term decline in terms of trade, revenue volatility, Dutch disease, crowding out effects, increasing the role of the state, and the socio-cultural and political impacts” as key drivers. The scope of this paper does not allow for a discussion of all these factors and will focus primarily on the Dutch disease theory and models.

One of the earliest arguments linking resource wealth to decelerated economic growth is Dutch disease, which the most prevalent culprit of the resource curse. Typically, when a country experiences a resource boom, its currency appreciates as its productivity, output and income increase relative to the rest of the world (Balassa - Samuelson effect). A boom in the resource sector can take three forms: a technology-induced increase in productivity, a significant resource discovery, or a rise in the international price of an abundant resource (Smith, 2014). “A real appreciation reduces the international competitiveness of other tradable sectors because resource-based exports crowd out commodity exports produced by those sectors.” (Plasschaert, pg.1 2009). Furthermore, Real Exchange Rate appreciation not only indicates the tradables sector’s loss of external competitiveness but it may also be an indication of loss in internal competitiveness.
Dutch Disease Models

2.2. The Core Model (a Static Model)

The Core Dutch Disease theoretical model developed by Corden and Neary (1982) and Corden (1984), is a Booming Sector Model and essentially this model is an adaptation of Salter’s “dependent economy” model (1959). This model assumes three sectors, namely: the Booming Sector (natural resource), the Lagging or Tradeable Sector (manufacturing) and Non-Tradeable Sector (services). Corden and Neary’s Booming Sector Model consists of three “semi-models” – each characterized by different assumptions about the factor mobility between sectors. The key assumptions underlying their first “semi” model are (Corden & Neary, 1982):

- Small open economy producing three goods, two tradable goods are traded at exogenously given world prices and a third non-tradable good at a flexible price decided by the supply-demand equilibrium.

- $X_e$ (output of energy good), $X_m$ (manufacturing output) and $X_s$ (services)

- Trade is always balanced.

- Real exchange rate is given by the relative price of non-traded goods in relation to traded goods

- Labour is mobile and capital is sector specific. In the second “semi-model”, capital is mobile between $X_m$ and $X_s$ and then thirdly, capital is mobile among all three sectors.

While these assumptions appear to be restrictive, they assist in depicting the impact on the economy when there is a boom in $X_e$. The two effects resulting from the Core model analysis are the “Resource Movement Effect” and the “Spending Effect”.

2.2.1. The Resource Movement Effect

The resource movement effect suggests that the booming sector pulls production factors from the lagging tradable sector and the non-tradable sector. This shift occurs due to the higher marginal productivity of both capital and labor in the booming sector (relative to the other sectors). This movement of labor from $X_m$ and $X_s$ to $X_e$ is an effect known as “direct de-industrialization” and gives rise to several adjustments in the economy, one key mechanism
of adjustment being the real exchange rate (Corden & Neary, 1982). The real exchange rate (RER) is be defined as:

\[
\text{RER} = \frac{P_n}{P_t}
\]

Where, \(P_n\) is the price level of non-tradables and \(P_t\) is the price level of tradables. The prices in the tradable sector (\(P_t\)) are determined by global supply and demand. Depending on domestic levels of demand and supply, the country will import/export this particular good. In the non-tradable sector, the prices (\(P_n\)) are fixed by domestic demand and supply. The movement of production factors from \(X_m\) and \(X_s\) to \(X_e\), results in a reduction of output in both the manufacturing and service sectors (i.e. a decrease in supply). A reduced supply and an unchanged demand, results in excess demand in both the sectors. “This excess demand will lead to increasing imports in the lagging sector, but to clear the non-tradable sector, \(P_n\) will have to rise, leading to a real exchange rate appreciation” (Mevius, pg. 2, 2008)

### 2.2.2. The Spending Effect

The spending effect on the other hand occurs from the increased demand for services that occur as a result of the increase in real income caused by the resource boom. The increased demand for services leads to higher prices in the service sector. Higher demand for the non-booming tradable goods will lead to a higher level of imports and therefore the price level of the manufacturing sector is not explained by the spending effect, since it is determined by global prices (Mevius, 2008). Like the resource effect, the spending effect is also a transmission channel for the appreciation of the real exchange rate. This occurs as a result of increased demand of non-traded goods pushing up non-traded prices, through either nominal appreciation or increased domestic inflation. Both the outflow of labor, and the increased demand for goods from the non-tradable sector causes additional movement of labor from the manufacturing sector to the non-tradable sector; this is called “indirect de-industrialization.” (Corden & Neary, 1982)
2.2.3. Effects of the Boom when Labour is the only Mobile Factor – A Graphical Illustration

The “pre-boom” equilibrium corresponds with points “A” (initial full employment) and “a” in figures 1 and 2 respectively. The economy’s total labor supply shown by the distance $OSOT$ in figure 1. Labor input into services is measured by the distance from $OS$, while the distance $OT$ measures the total labor input in the two the traded goods sector. The labor demand schedules are as follows: services sector ($LS$), the manufacturing sector ($LM$), and the total traded sector ($LT$).

Figure 1: Effect of the Boom on the Labor Market

The resource movement effect causes an upward shift in the energy sectors labor demand schedule and thus the total traded labor demand schedule shifts upwards as well. The new labor demand schedule for traded goods is denoted by the dashed $LT'$ curve. The position of the $LT'$ curve causes a new equilibrium at point $B$. Wages rises from “$w0$” to “$w1$” and labor is drawn out of the manufacturing sector. This new equilibrium leads to direct de-industrialization since employment in the manufacturing sector falls from $OT_m$ to $OT_m'$. Additionally, the resource movement effect gives rise to excess demand for services. In order to restore equilibrium between the traded goods and services markets (illustrated in Figure 2),
there must be an appreciation of the real exchange rate (the price of non-traded goods relative to traded goods increases). Therefore, higher prices in the service sector results in its labor demand shifting upwards (from LS to LS'). The new equilibrium point is G which in turn increases wages even further from “w1” to w2”.

The TS-curve represents the pre-boom Production Possibilities curve (PP) of the total amount of goods attainable, while “O_n” denotes the income-consumption curve and point ”a” is the initial point of equilibrium before the boom. Following the boom the TS-curve shifts, outwards from TS to TS’ (since the attainable amount of traded goods increases). With the real exchange rate is held constant, the equilibrium moves from point a to b (labor moves from services and the output in the sector falls). The curve “On” shows the demand for services at the initial exchange rate, it is assumed that demand for services rises with income. This curve intersects the T’S at “c”. Yet again, there is an excess demand for services and real appreciation must take place to restore equilibrium. In order for output of services to rise, the new equilibrium must lie somewhere between j and c. “When the two effects are combined we see that both contribute to a real appreciation: the final equilibrium at point g in Fig. 2 has a higher relative price of services than the initial equilibrium at a. However, the resource movement effect tends to lower the output of services whereas the spending effect tends to raise it, and there is no presumption as to which will dominate.” (Corden & Neary pg. 831, 1982)

**Figure 2: Effect of the Boom on the Commodity Market**

![Figure 2: Effect of the Boom on the Commodity Market](image)

*Source: (Corden & Neary, 1982)*
2.2.3 Combining the Two Effects

The combined effect of the spending and resource movement has namely four outcomes (as illustrated in the table below):

- Output and employment in the manufacturing sector falls;
- The effect on employment and output in the petroleum sector is uncertain, because the resource and spending movements move in opposite directions.
- However, if there is low labor mobility in the country’s oil sector, the spending effect is expected to dominate. (Oomes & Kalcheva, 2007).
- If labor is mobile, the overall wage level will increase. The real exchange rate appreciates mainly because the relative prices of services increases.

![Figure 3: Combining the Resource and Spending Effects](image)

<table>
<thead>
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<tr>
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<td>services sector</td>
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<td>–</td>
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<td>indeterminate</td>
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<td>manufacturing sector</td>
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<td>services sector</td>
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<td>indeterminate</td>
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</table>

Source: (Oomes & Kalcheva, 2007)

2.3. Learning by Doing (Dynamic Models)

2.3.1. Variants of Learning by Doing (LBD) Models

By increasing its capital with additional investment, each firm simultaneously learns how to produce more efficiently and increases its stock of knowledge - a phenomenon called learning-by-doing. (Arrow, 1962) Several studies on Dutch Disease have criticised the restrictions of Corden and Neary’s static model, stating the model ignores the “Learning-By-Doing” effects (LBD). Many authors have relaxed the assumptions of the Core model arguing that the effects of the boom on the traded and nontraded goods sectors are implicitly dynamic.
For example, Bjørnland and Thorsrud (2014) disagree with traditional Dutch disease models that treat productivity as an exogenous variable and use the following example to illustrate their point:

“…the exploitation of natural resources could have substantial productivity spillovers to the other sectors in the economy. For example, as the development of offshore oil often demands complicated technical solutions, this in itself could generate positive knowledge externalities that benefit some sectors. If these sectors trade with other industries in the economy, then there are likely to be learning-by-doing spillovers to the overall economy.” (Bjørnland & Thorsrud, 2014, pg.4)

“Learning- By-Doing” is a characteristic of the manufacturing sector and in elementary terms, LBD models of Dutch disease view technological progress as a by-product of production activities. According to Torvik (2001), the four most significant studies relating LBD and Dutch disease are: Van Wijnbergen (1984a), Krugman 1987, Sachs and Warner (1995) and Gyfason et al. (1997). Wijnbergen (1984) applies a two period model to investigate the effects of a natural resource boom on the manufacturing sector by including technology as an endogenous variable. Due to the crowding out that the non-oil traded goods sector faces during a resource boom, industry specific LBD effects are delayed thus reducing that sectors comparative advantage. Van Wijnbergen concludes that during periods of high resource revenue production subsidies must be provided to the lagging sectors that possess LBD effects, especially in countries that consume their revenues instead of investing. In the case of countries that expend their revenues for the purposes of accumulating foreign assets, no clear-cut answer is provided. He further states that: ‘in some cases, a country may not need to revert to production in the non- oil traded goods sector in the post oil period due to the income from foreign asset accumulation.’

In his paper about trade in the presence of dynamic scale economies, Krugman(1987) presents a model in which comparative advantage accumulates over time through “Learning by Doing” and not because of any intrinsic attributes of a country. Conventional economic theory dictates that a country should specialize in sectors where they have comparative advantage; however, there is a shift in this comparative advantage after a resource discovery/boom.
Kruger further describes the appreciation of a domestic currency (because of the resource boom) has having the same effect of tight monetary policy; both cause the export sector to lose its competitiveness. Sachs and Warner (1995) implement an endogenous growth model to investigate the low economic growth rates in resource rich countries. They analysed natural resource exports as a percentage of GDP in relation to the annual growth rate per capita of a specific country. Even after controlling for several growth related variables, the authors found a negative relationship between natural resource dependency and economic development.

Gylfason et al. (1999) apply a two-sector stochastic endogenous growth model to diagnose the symptoms of the Dutch disease. Their paper provides empirical evidence from 85 countries from 1965 to 1998 and suggests that abundant natural resources may on average cause crowding out, thus stagnating economic growth. Additionally, their results also suggest that abundant natural resources may “hurt saving and investment indirectly by slowing down the development of the financial system”. In Van Wijnbergen’s (1984a), Krugman’s (1987) and Gylfason et al. (1999) models, LBD is only generated in one sector and a natural resource windfall may shift factors of production away from that sector therefore constricting productivity. On the other hand, Sachs and Warner (1995) also assume that only one sector generates learning by doing, but additionally describe a perfect spillover to the rest of the economy. Torvik (2001) makes a new contribution to existing/earlier LBD literature by offering a model in which every sector contributes to learning and there are imperfect spillovers between all of them. First, the model has implications for real exchange rate dynamics in the event of an increased foreign exchange gift. Although the short-term response is a real exchange rate appreciation in the standard fashion, the long-term response is real exchange rate depreciation. This is due to a shift in steady-state relative productivity between the traded and the non-traded sector. Second, the standard result in the Dutch disease literature that the output of traded goods (not experiencing a productivity boom) must fall may be turned around. The conditions for increased or decreased long-run productivity and production in both sectors are worked out. Torvik criticize earlier models for being too extreme and argues that each economy needs to be treated individually. He states “an abundance of natural resources may lower growth, depending on the structural characteristics of the economy at hand.” (Torvik, 2001, pg.456)
2.3.2. A Model of Learning by Doing

For the purposes of illustration, the initial stages of the LBD model applied in Torvik (2001) have been directly replicated by the author in this discussion. Torvik’s model differs from previous studies in two ways, that being: both the traded and non-traded sector contribute to learning and the second assumption is that there are learning spillovers between sectors. The author makes these assumptions based on the intuition that traded and non-traded sectors differ significantly between countries, “and what must be grouped under the non-traded sector in some countries must be grouped under the traded sector in others, and vice versa” (Torvik, 2001, pg. 286)

Additionally the model follows the following assumptions:

- There is no unemployment.
- The foreign exchange inflow stemming from the sale of natural resources or foreign aid is exogenous.
- Thirdly, the model includes balance trade.
- Finally, labour is the only factor of production. This condition has two simplifying implications. The first is that there is only productivity dynamics in the different sectors with capital stock dynamics being absent. The second implication is that together with the third assumption, the final assumption implies that the savings rate equals zero.

Production and productivity (or human capital) in sector $i$ at any point $t$ in time are denoted $X_{it}$ and $H_{it}$, respectively. $i = N$ refers to the non-traded sector, and $i = T$ to the traded sector. The total labour force is normalised to equal one, and $\eta_t$ denotes the labour force employed in the non-traded sector at time $t$. The production functions in the two sectors take the following form (Torvik, 2001):

\[
X_{Nt} = H_{Nt}f(\eta_t), \quad f'(\eta_t) > 0, \quad f''(\eta_t) < 0, \quad (1)
\]

\[
X_{Tt} = H_{Tt}g(1 - \eta_t), \quad g'(1 - \eta_t) > 0, \quad g''(1 - \eta_t) < 0. \quad (2)
\]

Equations 3 and 4 (below) represent a modification to previous restrictive models; models that assume that LBD can only be generated in one out of the two sectors and
models that imply perfect spillovers or no spillovers. The equations consist of the following variables:

One unit of labour use in the non-traded sector contributes with a productivity growth rate of $u$ in the nontraded sector, while in the traded sector one unit of labour use contributes with a productivity growth rate of $v$ in the traded sector. It is assumed that a fraction $\delta_T$ of the learning from employment in the traded sector spills over to the non-traded sector, and that a fraction $\delta_N$ of the learning from employment in the non-traded sector spills over to the traded sector. It should be noted that the analysis is restricted to cases where the spillover effects cannot be stronger than the direct effects.

$$\frac{\dot{H}_{St}}{H_{St}} = u\eta_t + v\delta_T(1 - \eta_t), \quad 0 \leq \delta_T \leq 1,$$

$$\frac{\dot{H}_{Tt}}{H_{Tt}} = u\delta_N\eta_t + v(1 - \eta_t), \quad 0 \leq \delta_N \leq 1.$$ (3)

In Van Wijnbergen (1984a) and Krugman (1987) LBD, the equations above are represented by $u = \delta_N = \delta_T = 0$, while Sachs and Warner (1995) present a case where $u = \delta_N = 0$ and $\delta_T = 1$

3. Previous Studies /Research Relevant to Norway

While there has been substantial theoretical contributions made, with respect to both the absence and presence of Dutch disease symptoms in the Norwegian economy, the number of empirical studies are significantly limited. Bye et al. (1994) and Cappelen et al. (1996) carried out two of the first pioneering empirical analysis. The results from both these studies find that the Norwegian manufacturing sector benefited from the energy booms. In a contrasting study, Brunstad and Dyrstad (1997) report evidence of the Norwegian petroleum sector causing weak manufacturing performance. The empirical results exhibit sizeable demand effects for a number of the petroleum relevant occupations, and positive cost-of-living effects in areas that are regionally close to this sector (Brunstad and Dyrstad, 1997). Hutchison (1994) uses a vector error correction model (VECM) to investigate whether the North-Sea oil boom created DD-type effects in the UK, Norway and the Netherlands. His analysis finds
that “positive effects of real oil price shocks and energy booms on manufacturing output in Norway the first two to three years (although initially the effect of an energy boom is negative), but thereafter the effect fluctuates around zero.”. (H. Bjørnland, 1998 pg.575)

Bjørnland (1998) carried out an exercise similar to Hutchison however; she implemented a structural vector auto regression model (VAR) that focused only on Norway and the United Kingdom. The model included manufacturing production, oil and gas extractions, real oil prices, and the inflation rate (calculated from the GDP deflator) data from 1976:1 to 1994:3 for both countries. Not only does the paper examine the effects of an energy boom on manufacturing output, but it also looks at three other structural disturbances: demand, supply and oil price shocks. Bjørnland’s results provide only weak evidence of Dutch Disease for the UK in the long run, while concluding that the Norwegian manufacturing sector actually benefited from energy booms and higher oil prices. Conclusively, the author discusses the role of government policies in reaction to external energy shocks and additionally describes how macroeconomic policy was conducted very differently during two major oil price shocks. Gylfason (2001a) detected weak signs of the Dutch disease in Norway from the end of the 1990’s, and lists the key symptoms of an outbreak as stagnant exports, low levels of foreign direct investments and the absence of a “vibrant” high tech manufacturing industry. A decade later, Gylfason (2011) blames Norway’s oil exports for crowding out non-oil exports one-for-one relative to GDP and he again places emphasis on the country’s lack of high-tech companies by making comparisons with neighboring Sweden’s LM Ericsson, Finland’s Nokia and Denmark’s Bang and Olufsen.

Røed Larsen (2004) describes the Dutch disease as an economic illness that is linked closely to a: i) factor movement; ii) an excess demand; iii) a spillover loss effect. In 2004, he compared the Norwegian, Swedish and Danish GDP per capita from 1960 to 2002 and was able to find a structural break in the time series that indicated Norway experienced increased growth because of its booming oil sector. Conventional economic theory implies that this would make Norway susceptible to both the Resource curse and Dutch disease but on the contrary, Norway has managed to maintain steady growth for more than two decades. According to Røed Larsen (2005), “deliberate macroeconomic policy, the arrangement of political and economic
institutions, a strong judicial system, and social norms” were main factors that allowed to Norway escape the both the Resource curse and the Dutch disease. However, Larsen notes that it in the late 90’s, Norway started to display reversed relative growth compared to Denmark and Sweden. He specifically describes the contraction of the industrial sector and speculates that this may be an early symptom of DD. He further points to the growing public sector and increased government spending as a possible signs of the spending effect.

Bjørnland and Thorsud (2013) apply a Bayesian Dynamic Factor Model (BDFM) to identify and quantify the spillover effects from Norway’s booming energy sector into the non-oil sectors, thus the study just covers one symptom of Dutch Disease. The results from their analysis show that gains from an increase in real oil price vary depending on the source of the increase. Oil price increases caused by global demand tend to stimulate the entire economy (and vice versa for a decline in demand), while supply-side related price increases stimulate certain sectors and have smaller spillover effects. The authors claim that there is no evidence of Dutch disease but instead “find evidence of a two-speed economy, with non-tradables growing at a much faster pace than tradables” (Bjørnland & Thorsrud, 2013).

In 2014, Bjørnland and Thorsud further analyse the effects of commodity price shocks on the Norwegian economy. More specifically, the authors investigate the impact of a 25% decrease in oil price. Their results illustrate that a 25 percent drop in oil price, due to a decline in global activity, has severe consequences for Norway – the country could expect its mainland GDP to fall by 2-2.5 percent. However, oil importers benefit from the decrease in oil prices due to excess supply. The lower prices lead to an increased demand for other products increase and this softens the blow to the Norwegian economy, with country’s GDP Mainland only expected to fall by 0.5 percent.

Essentially, DD literature can be classified into three groups: (i) studies based on cross-country or panel data estimations; (ii) specific country studies based on time-series regression analysis; and (iii) country case studies that depend on stylized facts. It is evident from the discussion above that regardless of the methodology applied; researchers have provided mixed results concerning the diagnosis of DD. To determine whether a country suffers from Dutch Disease, one is required to prove that
there is real appreciation of the exchange rate, slower manufacturing growth, loss of manufacturing employment and higher overall wages – isolating each of these effects can be very challenging as they can occur as a result of a number of diverse factors.

4. The Norwegian Economy

4.1. Norway’s Economic Background

Historically, the Norwegians were skilled seamen and shipbuilders. With regards to providing export revenues, this implied that exports of services compensated for the almost non-existent manufacturing sector, that is required for producing tradable goods (Cappelen & Mjøset, 2009). From the 1950’s to the mid 70’s, Norway had a relatively low GDP per capita compared to both the OECD average, and its Scandinavian neighbors - Denmark and Sweden. Today, Norway is one of the richest countries in the world and is rated every year as one of the top 5 countries to live in due to the high standard of living and an integrated welfare system.

**Figure 4: GDP per capita, current PPP: 1970-2006 -Denmark, Norway, and Sweden**

(OECD = 100)

Source: (OECD National Accounts)

In 1969, Philips Petroleum discovered oil at the Ekofisk field, which was part of the Norwegian continental shelf. This discovery enabled Norway to run a countercyclical financial policy during the stagflation period in the 1970’s (Gylfason, 2011). Until 1980, oil revenues were relatively small and Norway ran substantial current account deficits to finance foreign investments (Holden, 2011). Significant importance was placed on the oil sector during the late 70’s and early 80’s due to high oil prices; with
petroleum production totalling between 15-20 percent of GDP (Bjerkholt, Olsen & Strøm, 1990). However, in 1986, sharp decline in oil prices 1986 took the share down to less than ten percent of GDP in the late 1980s.

**Figure 5: Natural Resource Rents as Percentage of GDP**

Data Source: World Bank

Norway is often referred to as being a “resource based economy” or a country “rich in natural resources”, however this perception is slightly distorted. Apart from oil and gas, the contribution of the country’s natural resources to the nation’s wealth is relatively minuscule. For example, Norway’s second largest “natural export” fish had a total export value of 570 million kroner while oil and gas was approximately NOK 550 billion kroner in 2014 (www.ssb.no). According to the World Bank, total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents, therefore fish (a renewable resource) is not included in figure 6. The obvious conclusion from figure 6 is that oil and gas rents make a substantially larger contribution to GDP than any other of Norway’s natural resources.

4.2. Oil – Production, Pricing

All of Norway’s oil reserves are located on the Norwegian Continental Shelf (NCS), with eight in the North Sea, two in the Norwegian Sea and with the first production activity in the Barents Sea to commence in the summer of 2015. According to the *Oil & Gas Journal* (OGJ), Norway had 5.83 billion barrels of proven crude oil reserves as of January 1, 2014, the largest oil reserves in Western Europe. Production of oil
peaked in 2000 while gas output began to increase in 1995. “The increase in gas production reflects the development of large gas fields such as Troll, Åsgard and Ormen Lange, with associated pipelines and land facilities.” (Norwegian Petroleum Directorate Resource Report, 2014, pg.14).

“Norway’s liquids production peaked at about 3.4 million barrels per day in 2001 and then declined to 1.8 million barrels per day in 2013” (OPEC’s World Oil Outlook Report, 2014, pg. 144). Mature oil fields, such as Ekofisk, Statfjord, Oseberg and Gullfaks that were developed in 1970s and 1980s, have played a significant role in terms of oil production; however, output from these fields over the past decade has declined substantially (Norwegian Petroleum Directorate Resource Report, 2014).

**Figure 6: Net Petroleum Production (1000 Sm3 O.E)**

![Net Petroleum Production](image)

*Data Source: Statistics Norway*

“O. E” is an abbreviation for “Oil Equivalent”, a term used to give oil, gas, natural gas liquids (NGL) and condensate the same unit of measurement.

The years 2014 to 2019 marks a phase new oil field developments in Norway, with a “total of 20 new projects with a capacity of about 960,000 barrels per day are planned to come on-stream. Thirteen of these are under development and another seven are in the planning phase” (OPEC’s World Oil Outlook Report, 2014, pg.144). Even with more 50% of all known gas and oil reserves in the NCS still to be produced, the Norwegian economy needs to adapt to the significant reduction in demand from the oil sector.
Apart from the collapse of oil prices in the second half of 2014, there have been five other significant episodes of drastic oil price declines occurring in 1985 to 2013 period. Each of these episodes are characterized by price reductions of 30% or more in a six-month period, with each slump reflecting events and changes in the global economy and oil markets (Global Economy Prospects, 2015):

- **1985-1986**: During this period, oil prices dropped 60% from January to July 1986. The decline was related to the change in supply conditions, “As the Organization of the Petroleum Exporting Countries (OPEC) reverted to its production target of 30 million barrels per day despite rising unconventional oil supply from the North Sea and Mexico” (Global Economic Prospects, 2015, pg.28). After this sharp decline, low oil prices prevailed for another 15 years.

- **1990-91**: The oil price decline of 1990-1991 was marked by the U.S recession, triggered by the first Gulf War.

- **1998**: The price slump in this episode was associated with the weakened demand due to the Asian crisis of 1997. Additionally, OPEC’s expansion in production until mid-1998 pushed prices even further down. (Global Economic Prospects, 2015)

- **2001**: Sluggish global activity and the disruptions caused by the September 11 terror attacks in the US were the main triggers behind the decline of 2001.
• **2008-2009:** The severe weakening in global demand that began in 2007 caused all commodity prices to tumble, and this eventually lead up to the Great Recession of 2008-2009. However, “the combined impact of a rapid rebound in commodity prices and declining interest rates supporting capital flows to developing countries created particularly favourable conditions for commodity-exporting developing countries in 2010–12” (Global Economic Prospects, 2015, pg.28)

• **2014:** After the global financial crisis of 2008-2009, most commodity prices including oil peaked in 2011 and until the summer of 2014 with oil averaging around 100 US dollars per barrel. Several factors contributed the sharp price decline, that being: excess supply, deteriorating demand, changes in OPEC’s policy objectives (from price targeting to market share) and the appreciation of the US dollar against major currencies. Another unexpected trigger responsible for further driving down the price is the “receding geopolitical concerns about supply disruptions” (Global Economic Prospects, 2015, pg. 157). Conflict in the Middle East, Libya and Iraq did not affect output to the extent predicted.

4.3. The Norwegian Exchange Rates and Inflation

Due the high levels of inflation in the 1970’s and 1980’s, lowering the rate of inflation became the key objective the Norwegian Central bank. Inflation was most extreme in 1986, when the interest rate differential between Norway and the European average was about 8 percent, resulting in reduced investment and contributing to the prolonged recession in Norway in the late 1980’s. The Norwegian Central bank (Norges Bank) practices inflation targeting, implicitly adopted in 1999 but announced at the beginning of 2001. In their price stability mandate of the Norges Bank states that:
“The operational target of monetary policy shall be annual consumer price inflation of approximately 2.5 per cent over time.” It also indicates how inflation should be measured in some detail: “In general, the direct effects on consumer prices resulting from changes in interest rates, taxes, excise duties and extraordinary temporary disturbances shall not be taken into account.” (www.norgesbank.no)

Figure 8: Inflation as measured by the Annual Growth Rate of the GDP Implicit Deflator

Source (Statistics Norway)

Historically, Norwegian monetary policy focused on maintaining a fixed exchange rate but from the beginning of the 1970’s, due to the demise of the Bretton Woods agreement, the country decided to join the European Economic Community (ECC) and their practice of exchange rate targeting (Kleivset, 2004). In December 1978, Norway abandoned this approach after four consecutive devaluations and switched to holding the kroner fixed against the currencies of its main trading partners. During this period, the kroner experienced several substantial devaluations, particularly in 1982, 1984 and 1986 (Bjørnland & Hungnes, 2002).
The exchange rate mechanism of crisis of 1992, forced several European countries including Norway to change from a fixed exchange rate regime to a floating exchange rate system. Allowing the kroner to float was intended to be a temporary measure; however, it proved difficult to revert to a normal fixed exchange rate system (Bjørnland & Hungnes, 2002). In May 1994, Norway made their practice of the floating exchange rate practice official. For the latter part of the 1990’s, interest rates were lowered to curb the appreciation of the kroner to relieve the economy of excess demand pressures. (IMF Country Report No. 05/197, 2005). However, due to Norges Bank maintaining high interest rates relative to its trading partners, the kroner appreciated substantially from the middle of 2000 to the beginning of 2003.

“The interest rate differential widened in 2002 when Norway’s main trading partners reduced their interest rates to stimulate growth while Norges Bank increased its key interest rate in the wake of higher-than-expected wage pressures. High oil prices and conflicts in the Middle East also contributed to the strength of the krone, as investors considered the krone as a “safe-haven currency.” (IMF Country Report No. 05/197, 2005, pg.6).

Stagnating global economic activity resulted in a reduction of Norway’s mainland GDP and this prompted Norges Bank to slash the key interest rates from the end of 2002 to March 2004. This lead to the kroner depreciating by 16% in nominal effective terms between 2003 and 2004. (IMF Country Report No. 05/197, 2005). The two other pronounced krone depreciations depicted in figure 9: The first occurred between

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Figure 9: Real Effective Exchange Rates (2010 = 100)

Data Source: World Bank
2008-2009, as a reaction to the global financial crisis. The second decline is between 2013 and 2014, reflective of declining terms of trade (mainly the demand for Norway’s oil exports).

**Trade - Imports and Exports**

Traditionally, Norway’s trade has been mostly with advanced economies in the EU, with the UK, Germany, Netherlands, France and Sweden being its main export partners, making up more than 65% of its exports. “The country has been running a surplus in merchandise trade for more than 20 years. With sizeable exports of crude oil and natural gas, the surplus on the current account exceeded 10% every year during 2007-11”(www.wto.org/english/tratop). “The total export value of oil and gas in 2014 was about NOK 550 billion. This corresponds to approximately 46% of Norway’s total exports. Exports of crude oil from Norway totalled about 70 million Sm³ and gas sales totalled about 108 billion Sm³, which covered about 20% of total European gas consumption.” (www.norskpetroleum.no/en/economy/exports-
norwegian-oil-and-gas).

**Figure 10: Net Trade in Billion NOK**

The overall trade surplus is mainly due to the positive offshore balance, while the non-oil trade balance has been in negative for more than three decades. The non-oil deficit has “remained stable at around the -7% of mainland GDP” (IMF Country Report, 2013, pg.3). The trade deficit of “traditional” (non-oil) products are indicative of crowding out by oil and gas related exports, thus making the country vulnerable to large and sustained declines in oil price.
Data Source: World Bank (note blue bars depict petroleum exports)

Sweden, Germany, China, the UK and Denmark are Norway’s primary import partners making up for approximately 47% of its import trade. However, the trend towards increasing trade with other parts of the world, in particular Asia, has continued over the last four years. Norway has been benefitting from improved terms of trade as prices for its exports of energy, energy-intensive products, and fish have been generally favourable, while imports of consumer goods have been sourced more cheaply, particularly from Asian suppliers (www.wto.org/english/tratop).

4.4.2 Government Spending and Fiscal Policy

The Norwegian government receives a substantial portion of the revenues generated by the petroleum sector, in the form of both domestic and foreign currency. These revenues are in both foreign currency and Norwegian kroner. Some of the oil revenues are absorbed in the Norwegian economy by being used to cover the nonoil budget deficit. The remainder is transferred to the Government Pension Fund Global (GPFG) “The State’s tax revenues are currently transferred to the Government Pension Fund – Global, which was valued at more than NOK 700 billion as of 1st of June 2014. The deficit is additionally financed by real returns from the GPFG, a practice that is guided by fiscal rule (introduced in 2001). The Fiscal Policy Rule states that: “Fiscal policy is guided by the fiscal rule, stipulating a gradual phasing-in of oil revenues in the Norwegian economy in line with the expected real returns on
the Government Pension Fund Global, estimated at 4 percent. The fiscal rule permits spending more than the expected return on the Fund in a cyclical downturn, while the use of oil revenues should lie below the expected return when capacity utilisation in the economy is high” (National Budget, 2012)

**Figure 11: Government Final Consumption - Percentage Change from Previous Year**

![Graph showing government final consumption percentage change from previous year]

*Data Source: Federal Reserve Bank of St. Louis*

The pronounced changes in government spending coincide with significant events or changes in both domestic and global activity. The upward trend in spending from 1994 to 1998 can associated with the Norway joining the European Economic Area (EEA) and subsequently providing economic assistance to the least developed countries (Greece, Ireland, Northern Ireland, Portugal and Spain) in the European Union. The contributions made by all three EEA countries in this four-year period was called the “Financial Mechanism”. Additionally, the peak in 1998 is representative of domestic spending to stimulate the economy in the aftermath of the Asian Crisis. The year, 2001 also marks a sizeable change in government consumption. This is reflective of dampened global activity triggered by the uncertainty of the 9/11 terror attacks.

Increased spending is 2007-2009 is reminiscent of the international financial crisis. Fortunately, the impact on the Norwegian economy was not as severe as in many industrialized economies. However, to curb the effects of this downturn the Norwegian government implemented a countercyclical measure in the form of a stimulus package: “in January 2009 Amount: NOK 20 billion (0.84% of 2009 GDP)
(1.08% of 2009 mainland GDP) Distribution: NOK 16.6 billion for increased public expenditure, NOK 3.3 billion in tax cuts. The increases in expenditure primarily related to the purchase of goods and services from the private sector, particularly from the construction industry, while NOK 6.4 billion transferred to municipalities.”

3. Empirical Approach and Econometric Methods

As previously discussed the resource movement and spending effects result in the following symptoms of Dutch Disease:

(i) Real exchange rate appreciation
(ii) Higher overall wages
(iii) Reduced growth in the manufacturing sector;
(iv) Faster service sector growth

Testing for the presence of all of these symptoms in the Norwegian economy simultaneously is far beyond the scope of this paper. Controlling for alternate factors that could contribute to similar outcomes is both a difficult and complex task, thus the author has chosen to focus on the two most predominant indicators of Dutch disease, that being real exchange rate appreciation and high wage growth. An appreciation in a country’s real exchange rate often results in an overvaluation of its currency. The Behavioural Equilibrium Exchange Rate (BEER) model is applied to test for real appreciation and the overvaluation of the Norwegian kroner. The choice of methodology is based on the works of Oomes & Kalcheva (2007) and Cerutti & Mansilla (2008), in which both these studies investigate presence of Dutch Disease symptoms. Figure 11 provides an overview of alternate exchange models.

Figure: 11 Time Hierarchy of the Different Approaches

Source: (Clark & Macdonald, 1998)
5.1. The BEER Model

By using the “Behavioural Equilibrium Exchange Rate (BEER) model, the empirical long-run relationship can be estimated between the real exchange rate and its determinants, after which the error correction term is interpreted as the deviation from the long run equilibrium, that is, the extent of exchange rate misalignment.” (Oomes & Kalcheva, 2007, pg.11) The term BEER, originates from Clark and Macdonald (1998), where they make a comparison of the BEER method to the fundamental equilibrium exchange rate (FEER). According to Clark and Macdonald (1998), a good alternative to the FEER, is an estimated reduced-form equation (i.e. BEER) that can be used to explain the behaviour of the real effective exchange rate with the associated economic fundamentals over a sample time period:

\[ q_t = \beta_1 Z_{1t} + \beta_2 Z_{2t} + \tau T_t + \epsilon_t \]  

(1)

\( Z = \) a vector of economic fundamentals that are expected to have persistent influence on the real exchange rate in the long run.

\( T_t = \) a vector of transitory factors affecting the real exchange rate in the short run.

\( \beta_1, \beta_2 \) and \( \tau = \) vectors of reduced-form coefficients.

\( \epsilon_t = \) random disturbance term.

\( q_t = \) actual, observed real effective exchange rate.

The equation (1) means that the actual real exchange rate can be explained exhaustively by a set of fundamental variables, \( Z \), and some transitory variables that affect real exchange rate on the short run, \( T \), and the disturbance term, \( \epsilon \). From equation (1), the current misalignment, \( cm_t \), and the total misalignment, \( tm_t \), are defined as the following:

\[ cm_t = q_t - \beta_1 Z_{1t} - \beta_2 Z_{2t} + \tau T_t + \epsilon_t \]  

(2)

\[ tm_t = q_t - \beta_1 Z_{1t} - \beta_2 Z_{2t} + \tau T_t + \epsilon_t + [\beta_1 (\overline{Z}_{1t} - \overline{Z}_{1t}) + \beta_2 (\overline{Z}_{2t} - \overline{Z}_{2t})] \]  

(3)

In equation (2), the current misalignment, \( cm_t \), is the “difference between the actual real exchange rate and the equilibrium real exchange rate given by the current values of all the economic fundamentals.” (Clark & Macdonald, 1998) In equation (3), the total misalignment, \( tm_t \), is the “difference between the actual real exchange rate and the equilibrium real exchange rate given by the sustainable or long-run
values of the economic fundamentals, which are denoted by $Z_{1t}$ (bar) and $Z_{2t}$ (bar)" (Clark & Macdonald, 1998). Therefore, through manipulations of the three equations listed above, the total exchange rate misalignment can be separated into the transitory factors effect, random disturbances, and the magnitude to which economic fundamentals drift from their equilibrium values. When testing for appreciation and misalignment in the Norwegian kroner, we specify the REER as a function of a vector of macroeconomic fundamental variables, $F$, as:

$$BEER = f(GOVs, OPEN, TOT, PROD) + Error$$

5.2. Data Description – Long Run Determinants of the Real Exchange Rate

Prior to implementing the BEER approach, the economic fundamental variables that determine the real exchange rate, need to be chosen. Both the number and type of economic fundamentals depend on the country (i.e., developed vs developing economies) as well as availability of data. This analysis includes four economic fundamentals: government final consumption, terms of trade, productivity, and degree of openness. The data is presented on a quarterly basis and spans are from the first quarter of 1993 to The last quarter of 2014. Concise descriptions of the variables and the data sources are listed below. All the calculations were done using MS Excel and the statistical software EViews.

5.2.1 Real Effective Exchange Rate

Real effective exchange rate is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs. The European Central bank uses Harmonised Index of Consumer Prices (HICP) deflator. The data was retrieved from the Eurostat Database.

5.2.2. Oil Price - Proxy for Terms of Trade (TOT)

Similar to Akram (2003), oil price is used as a proxy for terms of trade between Norway and its trading partners. An improvement in the terms of trade (increase in oil price) positively contributes to the trade surplus Akram (2003). “This increases net foreign assets, which provides the basis for capital revenues from other countries. This in turn gives rise to a real appreciation as a larger trade deficit can be financed
by revenues from abroad” (Eitrheim & Gulbrandsen, 2003, pg.62). In previous studies that applied the BEER model, terms of trade is measured as a ratio of exports to imports. The data for this variable was retrieved from the US. Energy Information Administration database and describes crude oil Brent, measured in dollars per barrel. The dataset was seasonally adjusted by the author.

5.2.3. Government Final Consumption Differential (GOVS)
The government-spending variable is to be interpreted as a proxy for fiscal policy and is measured as a ratio of government spending to GDP ((Lebdaoui, 2013).

\[ GOVS = \frac{Government \ Final \ Consumption}{GDP} \]

The datasets for both general government final consumption and GDP were retrieved from the OECD database via the Federal Reserve Bank of St. Louis. The datasets were seasonally adjusted and are measured in kroner (millions).

5.2.4. Productivity - Relative GDP per Capita as a Proxy for Productivity
Associated with the Balassa Samuelsson Effect, is the productivity differential. Generally, if domestic productivity is higher relative to foreign productivity, the appreciation of the domestic currency is to be expected, due to inflation increasing because of the higher productivity. (Oomes & Kalcheva, 2007). The proxy for the productivity differential was calculated as Norway’s GDP per capita as a ratio to four of its main trading partners, Denmark, Sweden, Germany and the U. K. A weighted average was calculated for these four countries and they were chosen based on data availability. Data was collected from the Eurostat Database.

5.2.5. Openness to Trade (OPEN)
Trade liberalization or the rise of degree of openness reduces support to import competing industries and resources are channelled to nontraded goods sector, which ultimately results in depreciation. It means that the real exchange rate is affected by degree of openness negatively (Chen, 2007). The openness to trade is measured as the ratio of the sum of exports and imports (net trade) to the GDP and is representative of commercial policy. Data was retrieved seasonally adjusted from the OECD data base.
5.3. Empirical Approach and Econometric Methods

The vector error correction (VEC) model is a special form of the vector autoregressive (VAR) model and is applied for variables that are stationary in their differences (i.e., I(1)). The VEC can also take into account any cointegration relationships among the variables. Generally, the VEC model includes the following steps:

I. Checking for stationarity in all variables. In order to implement this model, all variables must have a unit root at level but will become stationary after “first-differencing”.

II. When the variables are integrated of the same order I(1), the unrestricted Johansen Cointegration test can be run. This test establishes existence or the number (if any) of co-integrating relationships amongst the variables.

III. After the existence of cointegration relationships are established, the VECM can be implemented.

5.3.1. Stationarity

Checking for stationarity in all variables (technically, the presence of unit roots), is the starting point for any analysis incorporating time series data. Time series variables, that have a unit root, can be made stationary merely by differencing the data, however the real challenge lies in knowing whether the data is “difference-stationary” or “trend-stationary” (Bjørnland & Thorsrud, 2014). Variables are preferred in in their level form, since differencing data results in valuable information being lost, however this very seldom possible.

5.3.2. The Augmented- Dickey Fuller Test

A common method for testing for the presence of a unit root is the Augmented Dickey-Fuller (ADF) test, due to Dickey and Fuller (1979). The null hypothesis for the test is that the variable contains a unit root, while the alternative is that it follows a stationary process.

- If the critical values (t*) is greater than the ADF test statistic, the null hypothesis cannot be rejected. I.e. a unit root exists.
If the critical (t*) is less than the ADF test statistic, the null hypothesis is rejected. I.e. no unit root exists.

Before differencing a variable/s to rid the data of the unit root problem, it is essential that a cointegration test be run on all the variables.

5.3.3. Cointegration

Cointegration entails identifying the degree of nonstationary of the variables in a manner that “makes the error term and residuals of an equation stationary” and any spurious regression results are removed (Stock & Watson, pg.439). The cointegration analysis is an essential part of the BEER model, because the equilibrium exchange rate is derived from the cointegration equation between the real exchange rate and its economic fundamentals, since testing for cointegration implies testing for the existence of such a long-run relationship between the economic variables. The cointegration analysis in the BEER model is essential since the equilibrium exchange rate is derived from the cointegration equation between the real exchange rate and its economic fundamentals.

5.4. Model Estimation and Results

The table below provides a summary of the descriptive statistics for the data set used in this analysis. It describes the number of observations, minimum values, maximum values, mean values and standard deviations for relevant variables.

**Table 1: Descriptive Statistics**

<table>
<thead>
<tr>
<th></th>
<th>REER</th>
<th>TOT</th>
<th>GOVS</th>
<th>OPEN</th>
<th>PROD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>99.85</td>
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<td>0.21</td>
<td>70.27</td>
<td>1.59</td>
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<tr>
<td>Median</td>
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<td>32.76</td>
<td>0.21</td>
<td>69.60</td>
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<tr>
<td>Maximum</td>
<td>111.90</td>
<td>138.4</td>
<td>0.23</td>
<td>75.89</td>
<td>1.68</td>
</tr>
<tr>
<td>Minimum</td>
<td>89.91</td>
<td>10.54</td>
<td>0.18</td>
<td>65.78</td>
<td>1.52</td>
</tr>
<tr>
<td>Std. Dev.</td>
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<td>36.43</td>
<td>0.012</td>
<td>2.78</td>
<td>0.034</td>
</tr>
<tr>
<td>Sum</td>
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<td>4287.15</td>
<td>16.90</td>
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<td>130.71</td>
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<td>82</td>
<td>82</td>
<td>82</td>
</tr>
</tbody>
</table>

*Source: EViews- Authors Calculations*
Table 2: Correlation Matrix

The table below is a correlation matrix, and describes the correlation between all variables.

The correlation between two variables measures the linearity in the relationship between two variables. The Openness to Trade variable and Government Spending variables are highly negatively correlated, in terms of economic theory this cannot be explained. The same applies for the productivity and terms of trade variables.

<table>
<thead>
<tr>
<th></th>
<th>REER</th>
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<th>GOVS</th>
<th>OPEN</th>
<th>PROD</th>
</tr>
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<tbody>
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<tr>
<td>GOVS</td>
<td></td>
<td>1.00</td>
<td></td>
<td>0.79</td>
<td>0.01</td>
</tr>
<tr>
<td>OPEN</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td>0.18</td>
</tr>
<tr>
<td>PROD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Source: EViews - Authors Calculations

Figure 12: Graphs of Variables as Generated by EViews
The starting point of the analysis was to run the ADF test to check for stationarity. As described in table 3 all variables were non-stationary in the level form, thus we fail to reject the null hypothesis.

Table 3: Unit Root test at Level

<table>
<thead>
<tr>
<th>Series</th>
<th>Intercept</th>
<th>Intercept &amp; trend</th>
<th>None</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>REER</td>
<td>-3.326043</td>
<td>-3.311951</td>
<td>-0.041421</td>
<td>Series Non Stationary at all levels - Intercept</td>
</tr>
<tr>
<td>GOVS</td>
<td>-2.111398</td>
<td>-2.059372</td>
<td>-0.060809</td>
<td>Series Non Stationary at all levels -Intercept</td>
</tr>
<tr>
<td>TOT</td>
<td>-1.219149</td>
<td>-3.717487</td>
<td>0.058343</td>
<td>Series Non Stationary at 1% level –Intercept &amp;Trend</td>
</tr>
<tr>
<td>PROD</td>
<td>-2.652759</td>
<td>-3.599306</td>
<td>-0.226240</td>
<td>Series Non Stationary at all levels –Intercept &amp;Trend</td>
</tr>
<tr>
<td>OPEN</td>
<td>-2.728208</td>
<td>-2.919608</td>
<td>-0.209737</td>
<td>Series Non Stationary at all levels Intercept &amp; Trend</td>
</tr>
</tbody>
</table>

*Source: EViews- Authors Calculations*

All variables become stationary at first difference I(1) (as illustrated in table 4). This allows for the testing of cointegration relationships between the variables by running the unrestricted Johansen Co-Integration Test. The Schwarz Information Criterion was used to determine the optimal lag length for both the ADF and Johansen Co-Integration tests. The optimal lag length prescribed was 4.
Table 4: ADF unit Root Test at First Difference

<table>
<thead>
<tr>
<th>Series</th>
<th>Intercept</th>
<th>Intercept &amp; trend</th>
<th>None</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>DREER</td>
<td>-7.385737</td>
<td>-7.358165</td>
<td>-7.432667</td>
<td>Series Stationary I(1) at all significance levels</td>
</tr>
<tr>
<td>DGOVS</td>
<td>-7.762670</td>
<td>-7.763244</td>
<td>-7.812265</td>
<td>Series Stationary I(1) at all significance levels</td>
</tr>
<tr>
<td>DTOT</td>
<td>-8.581429</td>
<td>-8.551394</td>
<td>-8.470478</td>
<td>Series Stationary I(1) at all significance levels</td>
</tr>
<tr>
<td>DPROD</td>
<td>-11.94921</td>
<td>-12.07496</td>
<td>-12.02057</td>
<td>Series Stationary I(1) at all significance levels</td>
</tr>
<tr>
<td>OPEN</td>
<td>-9.756008</td>
<td>-9.775231</td>
<td>-9.818432</td>
<td>Series Stationary I(1) at all significance levels</td>
</tr>
</tbody>
</table>

Source: EViews - Authors Calculations

As suggested by Johansen (1995) the two co-integration tests were applied. The trace and the Max-eigenvalue test, show that there is cointegration between various combinations of the variables at the 5% significance level. From the results displayed in table 5, there exists five co-integration relationships where both the Trace statistic and Max –Eigen statistic are greater than the critical values. Alternatively, all p-values are less than 5%, thus clear indication that the null hypothesis \( H_0 = \text{no cointegration} \) has to be rejected.
Table 5: Co-Integration Results

Sample (adjusted): 1996Q1 2014Q2
Included observations: 74 after adjustments
Trend assumption: Linear deterministic trend
Series: DREER DTOT DGOVS DOPEN DPROD
Lags interval (in first differences): 1 to 6

Unrestricted Cointegration Rank Test (Trace)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Trace Eigenvalue</th>
<th>Trace Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.397863</td>
<td>115.6510</td>
<td>69.8189</td>
<td>0.0000</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.345681</td>
<td>78.11306</td>
<td>47.85613</td>
<td>0.0000</td>
</tr>
<tr>
<td>At most 2 *</td>
<td>0.276756</td>
<td>46.72518</td>
<td>29.79707</td>
<td>0.0002</td>
</tr>
<tr>
<td>At most 3 *</td>
<td>0.185382</td>
<td>22.74856</td>
<td>15.49471</td>
<td>0.0034</td>
</tr>
<tr>
<td>At most 4 *</td>
<td>0.097311</td>
<td>7.575933</td>
<td>3.841466</td>
<td>0.0059</td>
</tr>
</tbody>
</table>

Trace test indicates 5 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Max-Eigen Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.397863</td>
<td>37.53794</td>
<td>33.87687</td>
<td>0.0175</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.345681</td>
<td>31.38788</td>
<td>27.58434</td>
<td>0.0154</td>
</tr>
<tr>
<td>At most 2 *</td>
<td>0.276756</td>
<td>23.97662</td>
<td>21.13162</td>
<td>0.0193</td>
</tr>
<tr>
<td>At most 3 *</td>
<td>0.185382</td>
<td>15.17263</td>
<td>14.26460</td>
<td>0.0358</td>
</tr>
<tr>
<td>At most 4 *</td>
<td>0.097311</td>
<td>7.575933</td>
<td>3.841466</td>
<td>0.0059</td>
</tr>
</tbody>
</table>

Max-eigenvalue test indicates 5 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: EViews- Authors Calculations

After establishing that at least one cointegrating relationship exists, the Vector Error Correction Model is estimated. The first cointegration equation (estimated with a one period lag) is applied to illustrate the long run relationship between the Norwegian krone and its fundamentals. All co-efficients are statistically significant.
Table 6 : Vector Error Correction Estimates: Long Run Estimates

*Included observations: 79 after adjustments

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>REER (-1)</th>
<th>TOT (-1)</th>
<th>GOVS(-1)</th>
<th>OPEN (-1)</th>
<th>PROD</th>
<th>C (Residual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector Co-Efficient</td>
<td>1.000</td>
<td>0.426003</td>
<td>-2.067001</td>
<td>-0.216396</td>
<td>9663.979</td>
<td>-223, 2575</td>
</tr>
<tr>
<td>Standard Errors</td>
<td>(0.13129)</td>
<td>(2.35308)</td>
<td>(1.08388)</td>
<td>(34.6709)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T Statistic</td>
<td>[3.24474]</td>
<td>[-0.87842]</td>
<td>[-0.19965]</td>
<td>[4.62613]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: EViews- Authors Calculations

Discussion of Results

The variables, except the OPEN variable, exhibit the expected sign and are significant in explaining the expected relationship. By using the results from the cointegration regression in table 6, the following equation is formulated:

\[ REER_t = -223,2575 + 0.426 \times TOT_t - 2.067 \times GOVS_t - 0.21 \times OPEN_t + 9663.98 \times PROD_t \]

-223, 2575 is the speed of adjustment of the disequilibrium, it is negative and significant, thus validating that there are long run relationships among the variables. The Terms of Trade /Oil Price has the appropriate sign and indicates in this model that a unit change in oil price results in the REER appreciating 0.426 units. With Norway being an oil exporting country an increase in oil price increases capital inflow, which consequently appreciates the kroner. The Government spending variable is negative, this occurs when the share of government spending on tradeables is greater than that of non-tradeable, in the current model, one unit increase in government spending results in a depreciation of -2.067 unit. The sign of the productivity differential corresponds with economic theory. An increase in productivity implies increased demand due to higher growth, thus domestic currency will be more in demand than foreign currency. From the above equation, 1 unit increase in productivity results in 9663.98 appreciation of the REER. The sign for the trade openness is unexpected, especially for an high commodity exporting country such as Norway. Higher openness is typically an indication of a healthy
current account balance (surplus instead of deficit, as in the case of Norway), which in turn results in real appreciation of the domestic currency. The fact that a one unit increase in the openness variable results in a 0.216 depreciation of the krone is questionable.

**Misalignment of the Norwegian Krone**

The final part of this analysis is to illustrate the misalignment/difference between the actual real exchange rate and the equilibrium real exchange rate as given by the sustainable or long-run values of the economic fundamentals calculated in the previous section. Similar to the method applied by Lebdaoui (2013):

\[
\text{Misalignment} = \left(\frac{(\text{REER} - \text{PEER})}{\text{PEER}}\right) \times 100
\]

The Permanent Equilibrium Exchange Rate (PEER) is the trend component of the estimated BEER and can be extracted by using the Hoderick-Prescott Filter. This was carried out on EViews using lambda = 1600. The PEER is illustrated in the figure below.

**Figure 13: Graph of Peer as Generate by EViews**

![Graph of Peer as Generate by EViews](image-url)
The results from the above diagram show a wide variation of kroner misalignment during the 1994-2014 period. Apart from the short episodes of undervaluation in 1996, 1998-1999, 2004-2005, 2009 and 2014, the kroner display a tendency of being overvalued due to real appreciation. While this is indicative of Dutch Disease, one cannot conclude that this is a system of Dutch disease. One of the reasons is that
countries with floating exchange rates experience more volatility in their exchange rates than countries that peg or fix their rates.

6. Conclusion

This main objective of this paper was to investigate the real exchange rate appreciation, a very common symptom of Dutch Disease. While the empirical analysis of this paper is limited to just this objective, the theoretical framework behind both static and dynamic Dutch Disease models is covered in detail. Additionally the description of the macroeconomic variables that play a fundamental or determining role with regards to the REER is presented.

As stated, previously the purpose of this paper was to investigate the presence of real appreciation in the Norwegian krone as a symptom of Dutch Disease and this was done by analysing the kroner’s misalignment/deviation from its equilibrium and its long run relationship with its determinants, by applying the Behavioural Equilibrium Exchange rate model. The error term in the model is interpreted as the deviation of the REER from its long run equilibrium. The application of the BEER model was carried out by identifying a set of relevant economic fundamentals, using a single equation, running unit root tests followed by a cointegration analysis. The economic fundamentals included four variables that the author felt was relevant to Norway, such as Oil Price (Proxy for Terms of Trade), Government Spending, a Productivity Differential (relative GDP Capita) and a variable for Trade Openness. All variables displayed the expected affect on the REER (in terms of signs) except for the Openness to trade variable.

After the BEER model was estimated, a Hodrick Prescott filter was used to extract the trend component, that being the PEER (Permanent Equilibrium Exchange Rate). With a very simple equation, the REER and the BEER was used to illustrate the krone’s misalignment. The results from the misalignment illustration depict a trend of overvaluation of the krone while this des
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