An econometric analysis of the relationship between the oil price and the value of the Norwegian krone

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Abstract

The purpose of this thesis is to investigate the relationship between the oil price and the value of the Norwegian krone. After the oil-price dropped 60% between July 2014 and January 2015, it seems that market consensus has evolved with respect to how the krone reacts to variations in the oil price. This raises the interesting question of whether the relation between these highly important macroeconomic variables has changed in the recent past.

Overall, we do not find statistical evidence supporting that the historical interlinkage is broken, yet we conclude that there has been a change in the relationship following the oil price collapse in 2014. We find that a long run, cointegrating relationship exists between the oil price and the respective exchange rate, solely after the oil price drop.

Time-series analyses have been carried out on daily data from 2001 to 2016, investigating the relation between the oil price and the value of the Norwegian krone. The analysis was split in subsamples to give room for comparison of results across different time periods, and to verify whether the results were robust when subjected to periodic events such as the financial crisis and the 2014 oil price drop. The Augmented Dickey-Fuller and Breusch-Godfrey tests were applied to investigate the nature of the variables with respect to stationarity. The test results suggested that all variables under investigation were integrated of order 1, across all samples. The two step Engle-Granger test was applied to examine whether there exists a long term relation among the variables. Where cointegration was found, error correction models were used to examine potential Granger causality in the short and long run. Granger causality from the oil price to the exchange rates was present both in the short and long term, while the reverse revealed an effect present only in the long run. For non cointegrated variables, short run Granger causality was tested using ADL models. Bilateral Granger causality was found in all samples, except for the period between January 2001 and July 2008, where unidirectional causality was present from the oil price to the exchange rates.

The thesis is supplemented with an analysis on monthly data to incorporate movements in potentially omitted variables. The section is included to provide a robustness check of the initial analyses.

The overall findings provide a mixed picture of the relation between the variables, which evidently relies on movements in a range of variables above and beyond what can be captured by the scope of econometric modelling. The thesis however provides an important contribution to the literature on the relation between the oil price and the value of the Norwegian krone.

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1. Introduction

1.1 Motivation

The world economy was shocked by the radical oil price drop in the second half of 2014. The oil price plunged from $114 to $45 per barrel between June 2014 and January 2015, near a 60% price dive in six months. During the same period, the Norwegian krone weakened 28% against the USD while the Norwegian nominal effective krone exchange rate depreciated 13%. The vast economic effects are inevitable, as oil and gas account for almost 25% of Norwegian gross domestic product (GDP) and 50% of total exports. Not surprisingly, the shock led to devastating falls in employment, reduced investments and economic uncertainty (OECD, 2016).

The discovery of oil transformed Norway from a shipping, fishery and agricultural based nation with below average GDP per capita, to an oil nation among the richest in the world. The oil price has steadily increased since the natural resource discovery in the 1960s, up until the financial crisis. The Norwegian "oil fund" has an accumulated wealth of over $900bn in assets, currently worth more than twice its mainland GDP (Akram & Mumtaz, 2016). Needless to say, Norway is highly dependent on oil revenues. However, as Norwegian exports only account for 2% of total oil production, the country has a limited impact on the global oil price formation (Norwegian Petroleum, 2017a).

Reading financial news, one gets the impression that the oil price and the value of the NOK are highly interdependent. In Norwegian media, the association seems unquestionable, with headlines such as "*Increased oil price strengthens the krone*"[1] (Øvrebekk Lewis, 2016), "*Krone dives after oil price sink again*" (Berglund, 2015), and "*How the krone follows in the footsteps of the oil*" (Gjendem, 2016). However, experts have recently questioned whether the relation still is as clear cut as previously expressed. The oil price recovered almost 64% by year-end 2016 from a record low in January. Simultaneously, the effective krone exchange rate and the NOK relative to USD only recovered by 6% and 3%, respectively. Speculations of whether the historical interlinkage is broken are spreading (Sundberg, 2016; Aarø & Norli, 2016), sparking the authors interest in investigating whether the oil-currency link has changed. The thesis is intended to help investors get a clearer understanding of the relationship. Is it correctly framed by analysts that the variables are intertwined, or does this information suffer from lack of proper statistical proof? If so, has this relation broken down after the dramatic 2014 oil price drop?

[1] Authors' own translation

1.2 Problem statement

1. To what extent does a short and/or long run relationship exist between the oil price and the value of the Norwegian krone?
    a. Has there been a change in the relationship following the oil price collapse in 2014?
    b. To what extent does a bilateral or uni-directional causal relationship exist among the variables of interest over time?

1.3 Methodology

The thesis is organized as follows. Section two provides an overview of prior literature within the field. Section three elaborates on the fundamental theories behind the determination of exchange rates as well as an overview of the factors seen as most important for oil price determination. Section four presents key factors characterising the Norwegian economy, its fiscal framework, monetary policy regimes and the likely effects of oil price changes for the Norwegian economy. In section five, the reader is given a presentation of the data and the historical development of the variables of interest. Section six presents the underlying theoretical models, empirical estimations and results. Section seven provides a robustness check of the results presented in section six. Section 8 summarizes our findings, while section nine provides a short critique of the applied methods. Section 10 opens up for alternative perspectives. Relevant calculations and SAS output not presented in the thesis can be found in appendix.

In order to answer our research questions, the authors will investigate whether the main variables of interest exhibit a long term relation by testing for cointegration. The cointegration model will be extended to additionally analyse short term effects through the error correction method. For non-cointegrated variables, the Granger causality methodology will be applied to analyse the presence of short term causality.

All data used in the thesis is based on public information. The main emphasis is put on published material from acknowledged institutions and organizations such as the Norwegian central bank, OECD and the World Bank.

2. Literature review

Oil prices and exchange rates are central macroeconomic factors, studied thoroughly throughout global literature over time. Theoretical and empirical research regarding the possible causal relationship show a wide range of results.

Krugman (1980) and Golub (1983) established a clear relation between the two variables through their theoretical work regarding the balance of payments. The authors studied how an increase in the price of oil affected the US dollar exchange rate. They reason that oil exporting nations can expect an appreciation of their exchange rate through the wealth transfer from oil-importing to oil-exporting countries, following an oil price rise. However, the effect for the oil-importing countries depend on whether it can expect a rise in exports and increased investments, caused by increased wealth of the oil-exporting countries, that more than outweighs the increased cost of imports.

Akram & Holter (1996) studied the relation between the USD and the oil price by proposing a theoretical model, tested empirically. The paper concludes that the oil price is affected by changes in the value of the USD, by that a depreciation of the USD will make the oil price in other oil exporting currencies fall. Over time this will lead to less production by oil exporters as well as an increased demand by oil importers, further leading to a higher dollar denominated oil price and therefore demand for US dollars. The resulting strengthening of the dollar, following the rise in demand, will partly or fully outweigh the fall of oil income for exporting countries.

Amano & Norden (1998) test empirically the hypothesis formulated by Krugman and Golub, and study whether the price of oil and the US real exchange rate are cointegrated. They find evidence suggesting that the persistent real exchange rate shocks in the post-Bretton Woods[2] period are dominantly caused by the oil price. Further evidence from their studies shows that causality runs from oil prices to exchange rate and not the opposite way, consistent with the results of Hamilton (1983).

Al-mulali & Sab (2012) investigate the impact of oil price shocks between 2000-2010 on the real exchange rate of multiple oil exporting countries located in Africa, South-East Asia, Middle East and South America using fixed and random effects models on panel data. Oil price increases caused the real exchange rate to appreciate in the 12 oil-exporting countries studied.

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[2] The Bretton Woods system was an international fixed exchange rate collaboration between 44 countries, established after World War II in order to avoid volatile exchange rates and international political conflicts (Thygesen, n.d.).

Using monthly data, Zhang (2013) investigates the cointegrating relation between the real effective exchange rate of the US dollar and the real price of oil, allowing for structural breaks. Zhang concludes that a significant cointegrating relation does not exist between the aforementioned variables, unless the structural breaks in November 1986 and February 2015 are controlled for.

Some researchers find bilateral causality. Fratzscher, Schneider, & Robays (2014) investigate the variables from a financial point of view, questioning whether the oil price reacts to other financial assets, and whether the oil price itself is financialised. The article finds evidence supporting Killian & Vega (2011) that in general, oil prices do not react to US macroeconomic news, but rather reflect changes in other financial assets such as exchange rates. They find that a 10% increase in the oil price leads to a 0.28% depreciation of the USD effective exchange rate, as well as that a 1% depreciation of the USD causes oil prices to rise by 0.73%. The article finds evidence of other financial asset price changes affecting both the USD and the oil price, such as stock market shocks, financialisation of oil markets and changes in risk aversion.

According to Brahmasrene, Huang, & Sissoko, (2014) the exchange rate Granger-causes crude oil in the short run, while the crude oil price Granger-cause exchange rates in the long run. The effect is stronger in the latter. Through the variance decomposition model, they provide evidence that oil price shocks significantly impact exchange rates in the medium and long run, but that the effect of exchange rates on oil prices is minimal. Further, conclusions from the impulse response model show that exchange rate shocks have significant negative impacts on crude oil prices. Additionally, when oil prices are stable, currency fluctuations and uncertainty can be minimized.

The evidence concerning the oil price and the value of the Norwegian krone is mixed. Some of the most influential studies on this relation have been conducted by the Norwegian central bank.

Akram (2000) investigated the relation between the oil price and the Norwegian exchange rate by testing for nonlinear effects within an equilibrium correction model, and found a negative relation. The strength of the relationship depends on whether the oil price is above, below or within the range of 14-20 USD per barrel, and if a falling or rising price trend is present. The relation is weak or non-existing when the oil price is within the range, yet relatively strong when the oil price is below 14 USD and falling. These findings were supported in his later work (Akram, 2002).

Bergvall (2004) explored the long term co-movements of real effective exchange rates[3], trade balance, terms of trade, and relative labor productivity in the Nordic countries. The author found the real price of oil (exogenous terms of trade shocks) to be the most influential determinant of the real exchange rate for Norway and Denmark using cointegration models and variance decomposition. The estimated cointegration relations show that a decrease in the real price of oil depreciates the Norwegian real exchange rate, while the opposite is true for the net oil importers Sweden, Denmark and Finland.

Habib & Kalamova (2007) studied the effect of changes in the real oil price on the real exchange rates of Norway, Russia and Saudi Arabia using a coherent single-equation time series approach. Contrary to aforementioned literature, the authors provide evidence of a non-existing impact of the real oil price on the real value of the NOK. They point to the recent changes in monetary policy in Norway, as well as the implementation of the fiscal rule for oil income spending as possible explanations, which will be discussed more in section 4.2.

Newer publications such as Ellen & Martinsen (2016) estimate a structural vector autoregressive (SVAR) model to investigate the effects of oil price changes on the nominal effective exchange rate, I44. They present empirical proof for that direct and indirect effects of oil price shocks on the I44 have increased over time. They argue and prove that long term interest rate differentials have become relatively more important in explaining movements in the value of the Norwegian effective exchange rate.

The wide range of conclusions prove that findings are sensitive to methodology choices such as data frequency, time period analysed, variable choices, and applied methods.

To our knowledge, there exists a limited amount of literature focusing on whether there exists a long run relationship between the oil price and the value of the Norwegian krone. The authors therefore seek to contribute to the literature by analysing the relation, using recent data on the variables of interest. Additionally, the subsample focus enables us to investigate the relation particularly after the 2014 oil price collapse. The contribution is intended to provide investors with a clearer understanding of the complex relationship, and add to the perspectives presented in financial media.

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[3] Note: The effective exchange rate discussed by (Bergvall, 2004) is defined the following way: *"The real exchange rate index (q) is a CPI-based effective real exchange rate constructed as a competition-weighted sum of exchange rate series for 10 OECD countries".*

3. Economic theory

The following section presents the theoretical frameworks on exchange rate and oil price determination. Fundamental theories on exchange rate formation is provided to explain the theoretically grounded mechanisms. With respect to the oil price the authors seek to give an overview of what are viewed as the most important factors for its determination.

3.1 Exchange rate determination

The foreign exchange (FX) market is the world's most traded and liquid market, with an average daily turnover of US$3.2 trillion. It is a decentralized, over-the-counter (OTC)[4] market. Currency turnover occurs from two sources, where foreign trade accounts for approximately 5% while speculation covers the remaining 95% (Forex, n.d.).

Law of One Price

The law of one price is the fundamental underlying theory of purchasing power parities. It states that the same good should be sold for the same price in different countries once prices are converted into a common currency, given by the following relationship (Rogoff, 1996):

$$P_i = EP_i^* \qquad (Eq. 3.1)$$

Where;

P_i is the price of the good in domestic currency

E is the nominal exchange rate, and

P_i^* is the price of the good in foreign currency

It is thus a theoretical no-arbitrage condition. Thus, if the parity is violated, market participants will be able to make an arbitrage profit consisting of a risk-free profit earned by a zero net investment. In practice, deviations from the law of one price will occur frequently due to, factors such as tariff agreements, transportation costs and non-tariff barriers.

[4] Financial markets are primarily organized in two ways: exchanges and over-the-counter (OTC). OTC is not a physical place, it is less formal, less transparent, and trading networks are centred around one or more dealers. Similar to exchanges, OTC markets are well-organized (Dodd, n.d.).

Purchasing Power Parity

Measures of purchasing power parities are designed to provide a broader measure of international price differentials. The absolute purchasing power parity is the relation containing a bundle of goods, rather than one single good, measured by the price indices such as the consumer price index (CPI) (Rogoff, 1996):

$$\sum P_i = E \sum P_i^* \qquad (Eq.\,3.2a)$$

The difficulties of comparing an internationally standardized bundle of goods, due to different constructions of CPIs, as well as differences in weights assigned to the goods, strengthens the relevance of using relative price measures, as the one presented below.

The relative purchasing power parity explains the relation between a percentage change in an exchange rate and the differential between the growth rate in foreign and home price indices, more commonly referred to as inflation differentials (Rogoff, 1996):

$$\frac{\sum P_{it}}{\sum P_{it-1}} = \frac{E_t}{E_{t-1}} \frac{\sum P_{it}^*}{\sum P_{it-1}^*} \qquad (Eq.\,3.2b)$$

Where;

t subscripts denote time

The long-term equilibrium state underlying the purchasing power parities is that the price level should be the same across countries when measured in one currency. An appreciation of a country's currency will theoretically lead to an increase in the price of the country's export goods and a reduction in the price of import goods, while the reverse is true given a currency depreciation (Rogoff, 1996).

Interest rate parities

The *Covered Interest Rate Parity* (CIP) explains the equilibrium relationship between interest rates and the spot and forward rates of two respective currencies. The theoretic model is based on a no-arbitrage condition, as discussed above. Multiples of violations of the parity, in the search for a risk-free profit, will force spot and future rates back to equilibrium where no possibilities of arbitrage exist. The relation is as follows (Sercu, 2009):

$$1 + r_{t,T} = (1 + r_{t,T}^*) * \frac{F_{t,T}}{S_t} \qquad (Eq. 3.3a)$$

Where;

$r_{t,T}$ is the domestic interest rate between time t and T

$r_{t,T}^*$ is the foreign interest rate between time t and T

S_t is the spot exchange rate at time t

$F_{t,T}$ is the forward exchange rate between time t and T (in units of home currency per unit of foreign currency)

The uncovered interest rate parity (UIP) presents the case where the above condition can be satisfied without the use of hedging exchange rate risk through forward contracts. The UIP is based on the assumption that the current forward rate is equal to the expected spot rate. The following equation illustrates the relationship (Sercu, 2009).

$$1 + r_{t,T} = (1 + r_{t,T}^*) * \frac{E(S_T)}{S_t} \qquad (Eq.\ 3.3b)$$

Where;

$E(S_T)$ is the expected spot rate at time T

The relation states that the difference in interest rates between two countries is equal to the expected change in the future spot rate. In other words, the return on deposits in the domestic currency should be equal to the return on foreign deposits, if the relation holds (Sercu, 2009).

Interest rate parities rest on the assumptions of mobile capital and perfect substitutability of assets. The first assumption entails that investors can exchange domestic assets to foreign assets with ease, whereas the second describes that the assets have to be perfect substitutes in terms of risk and liquidity.

Economic literature points to fundamental long-term equilibrium theories such as the law of one price (LOP) as well as the interest- and purchasing power parities (IP) and (PPP) to explain exchange rate relations. Empirical studies by Froot & Rogoff (1994), Rogoff (1996), Isard (1996) and Macdonal (1995) provide empirical proof of convergence towards the long-run PPP rate, with a slow speed of reversion.

In general, studies reject that PPP holds in countries affected by large real shocks, such as the Norwegian economy (Akram, 2002b).

Akram (2002) although presents evidence for fast convergence towards PPP for the Norwegian real and nominal exchange rates, despite large real shocks as in the post-Bretton Woods period.

3.1.1 Supply and demand of exchange rates

As discussed, the fundamental theories explained above do not hold in reality, due to strict assumptions and "all else equal" necessities. Rogoff, Froot, & Kim (2001) state that *"One of the most striking empirical regularities in international finance is the volatility and persistence of deviations from the law of one price across relatively homogenous classes of goods".* This suggests the need for an extended discussion of additional factors, presented in what follows.

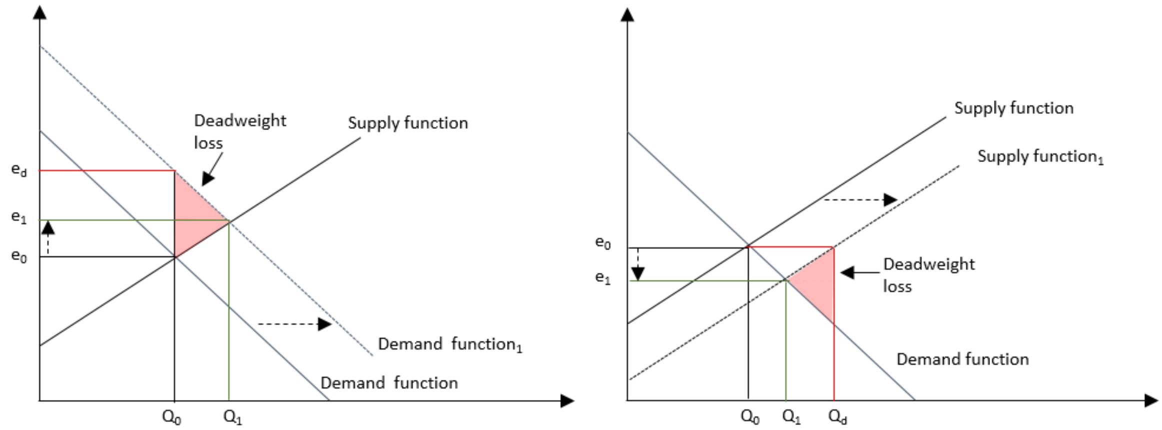
Like for any good or commodity, exchange rates are partly determined by supply and demand. For each possible currency price, there is a corresponding supply and demand to be exchanged with another currency in the money market. When demand for a currency equals its supply, the corresponding price at a specific time is said to be in equilibrium. Demand is affected by factors such as interest rates, inflation, government policy and expectations, while supply is primarily controlled by the central bank (Madura & Fox, 2011).

Given a floating exchange rate regime, shifts in demand (figure 1a) and supply (figure 1b) determine the exchange rate equilibrium. Rising demand for a currency causes a shift in the demand function to the right, as seen in figure (a). Holding currency supply constant, the exchange rate will rise to point e_d creating a deadweight loss[5], which subsequently causes supply to rise from Q_0 to Q_1, creating a new, higher equilibrium rate at point e_1. Similarly, if the market is recognised by excess currency supply (figure b), the supply function will shift to the right, creating a deadweight loss and pressure on the exchange rate to move from e_0 to a new, lower level at e_1 (Madura & Fox, 2011).

In both scenarios, the equilibrium quantity increases. However, an increase in demand would cause the exchange rate to appreciate in value, whereas an increase in supply would cause a depreciation ("Lession 4: Exchange Rates and Supply and Demand," n.d.).

[5] Deadweight loss represents inefficient allocation, i.e. economic inefficiency in terms of utility (The Economic Times, n.d.-a)

Figure 1 – How exchange rates change following shifts in supply and demand



(a) Exchange rate equilibrium following a demand shift

(b) Exchange rate equilibrium following a shift in supply

Source: Compiled by authors/Madura & Fox (2011)

Supply and demand levels, as well as the equilibrium price levels, change continuously. Madura & Fox (2011) argue that these variations can be explained by changes in five macroeconomic variables which can be summarized in the following function:

$$e = f(\Delta Inflation, \Delta Interest\ rate, \Delta Expetations, \Delta Income, \Delta Governement\ control\ )$$

Where;

e is the percentage change in the spot rate

$\Delta\ Inflation$ is the change in inflationary differential between two countries

$\Delta Interest\ rate$ is the change in interest rate differential between two countries

$\Delta Expectations$ is the change in the future currency value expectations

$\Delta Income$ is the change in the income level differential between two countries

$\Delta\ Government\ control$ is the change in government control

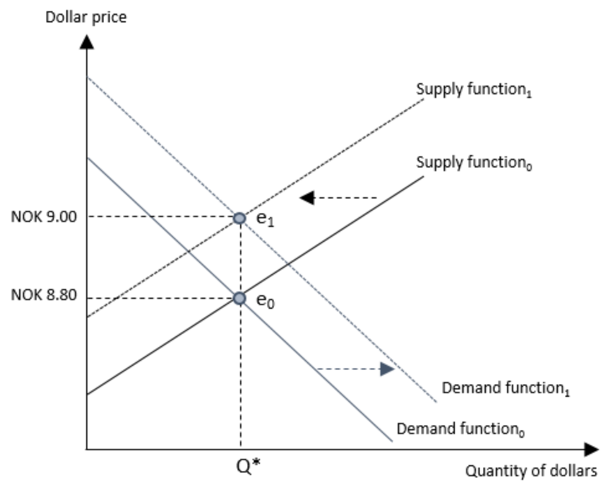
In the following, the above factors will be discussed, as a clear understanding of these macroeconomic variables is crucial going forward. Examples are provided for illustrative purposes, where each factor is analysed independently to demonstrate the impact on the exchange rate under the ceteris paribus assumption.

Inflation

As presented above, inflation is the foundation of the PPP. Inflation represents a sustained rise in the overall price level, i.e. a decline in the value of money (Norges Bank, 2007). General inflation is caused by a fall in the purchasing power (i.e. market value) of money within an economy, in contrast to currency devaluation which represents a fall of the market value of a currency relative to other currencies. Supply disruptions can be another source of inflation. Example of such disruptions can be crop failures driving up commodity prices, war or natural disasters which may restrict the supply of for example crude oil, resulting in higher energy prices (Credan, 2006).

If for example the inflation level in Norway suddenly was to jump relative to the US, the price of Norwegian goods would increase relative to those of the US, assuming goods are substitutes. The higher price level in Norway would cause Norwegian demand for US goods to rise, and consequently increase the demand for US dollars. On the contrary, the US would see Norwegian goods as less attractive due to the relatively higher price level, resulting in lower supply of USD to be exchanged for NOK. Continued rise in Norwegian inflation would cause demand for USD to increase, while supply continues to decrease, illustrated by shifts in both the demand and supply curves, as seen in figure 2 below. The outcome would be a new equilibrium exchange rate at point $e_{1,}$ in which the Norwegian krone has weakened against the US Dollar, from NOK/USD 8.80 to 9.00 (Madura & Fox, 2011).

Figure 2 - A rise in the domestic price level will isolated lead to a weakening of the currency

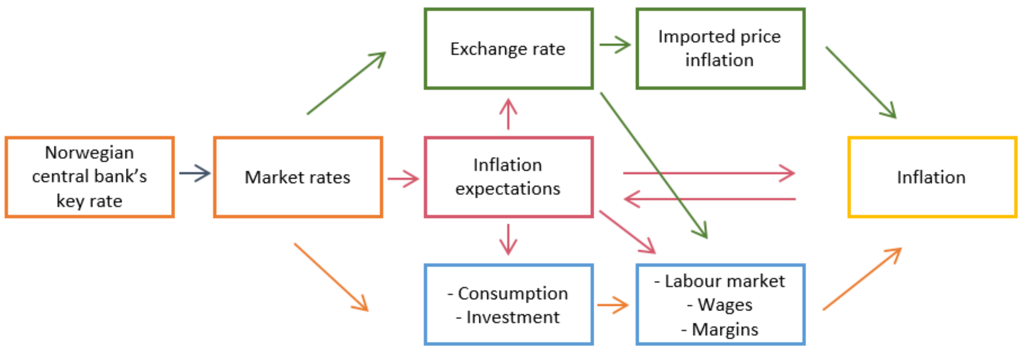


Source: Compiled by authors/Madura & Fox (2011)

Relative interest rates

The Norwegian central bank's main monetary policy instrument is the key interest rate, and the implications of this instrument is illustrated in figure 3. Economies recognized by having well-functioning money- and credit markets will generally experience that changes in the key policy rate[6] pass relatively fast through to money market rates[7] (Olsen, 2015). Further, changes in the key rate affect *expectations* concerning its future evolution which is decisive for lending rates, banks' deposits and bond yields. Monetary policy operates through three distinct channels: the demand channel, the exchange rate channel and the expectations channel, illustrated in figure 3 below (Norges Bank, 2004).

Figure 3 - Changes in the key rate, by the central bank, has widespread implications for economic variables



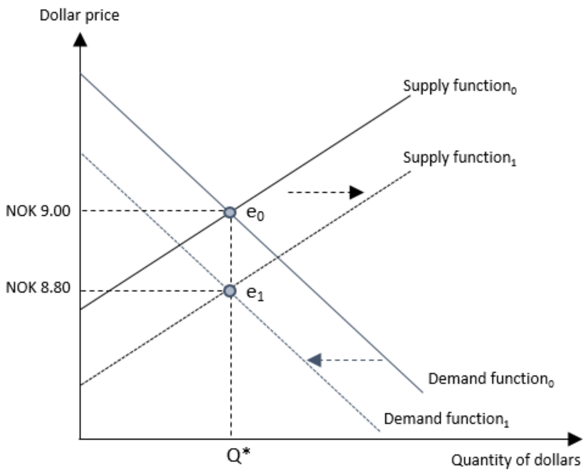
Source: Compiled by authors/Norges Bank(2004)

If Norwegian interest rates suddenly rise relatively to those of the US, investments in Norwegian interest-bearing securities would become relatively more attractive, both from a domestic and foreign investors' perspective. Norwegian investors would likely reduce their demand for US dollars, as domestic rates are seen as more attractive. At the same time US demand for NOK would increase, rising the supply of USD for sale by US investors. Similar to the inflation example presented in figure 2, both the supply and demand curves would shift as seen in figure 4, resulting in a new exchange rate equilibrium. However, in this case the Norwegian krone has strengthened against the USD, from NOK/USD 9.00 to 8.80 (Madura & Fox, 2011).

[6] The key policy rate is defined by the Norwegian central bank as "*[...] the interest rate on banks' reserves up to a specified quota in Norges Bank*" (Norges Bank, n.d.-b)

[7] Money market rates across different maturities are collectively defined as the Norwegian Interbank Offered Rate (NIBOR) (Finans Norge, n.d.)

Figure 4 - A rise in domestic interest rates will, in isolation, lead to an appreciation of the domestic currency



Source: Compiled by authors/Madura & Fox (2011)

It is important to emphasize that high interest rates alone cannot be the only factor in currency value determination. If this was the case, the currency offering the highest returns would attract all investments. Hence, other factors must exist that make portfolio managers refrain from investing funds solely in the currency offering the highest return. One such factor relates to the expectations of a potential greater offsetting effect over time, through a fall in the value of the currency with the higher interest rate (Madura & Fox, 2011). Following Irving Fisher, interest rates are a compensation for time, risk and inflation. Assuming that US and Norwegian interest rates have the same time and risk elements, Fisher argues that inflation is the only rational for differences in interest rates. Thus, a portfolio manager should only invest in the high interest currency if he or she expects that the *real interest rate* (interest rate less inflation) is going to be higher in the high interest currency compared to the low interest currency (Madura & Fox, 2011).

Expectations

Market expectations is a third factor influencing exchange rates. Common for efficient financial markets is that they react immediately to news that may affect the future demand and supply. In finance, news is defined as information that differs from expectations. Market expectations can complicate matters, as market reactions depend on whether announcements are in line with expectations or not. For example, an announcement of high inflation in the US can either have a positive, negative or no effect on the dollar value. If the announcement is unexpected, currency traders may start selling dollars, anticipating future depreciation. However, if the high inflation was lower than expected, traders may instead buy dollars as the situation turned out better than expected. Finally, if the announcement is in line with expectations the value of the dollar may remain unchanged (Madura & Fox, 2011).

Relative (national) income levels

Relative income levels between countries is a fourth factor affecting exchange rates. The reasoning behind is that a rising/falling income level generally result in higher/lower demand for foreign goods, which consequently has the potential of affecting exchange rates (Madura & Fox, 2011).

Government control

Governments can affect the equilibrium exchange rates through government control. The influence can take place in several ways, including imposing foreign exchange and trade barriers, intervening in the foreign exchange markets through buying and selling currencies, and by affecting macroeconomic variables such as inflation, interest rates and income levels (Madura & Fox, 2011).

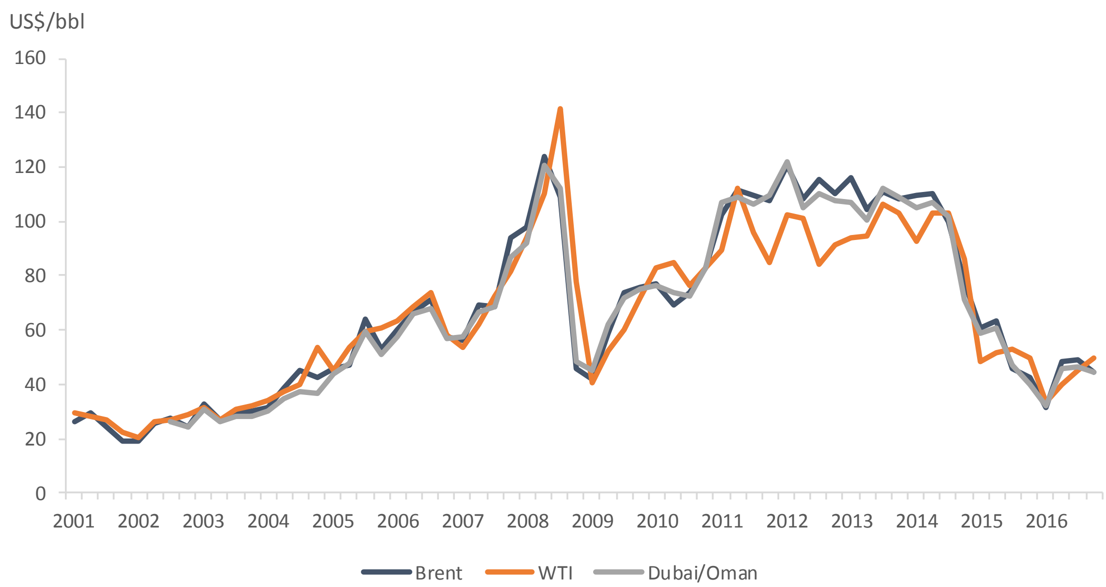
In summary, empirical evidence is not always consistent with the above theoretical frameworks on exchange rate determination. Hnatkovska and Lahiri (2008) present empirically that random walk models for exchange rate development usually outperform fundamental-based forecasting models. More specifically, most theories are built on assumptions different from what is experienced in reality, and work well under *ceteris paribus* conditions. This is one of the reasons why the authors seek to further analyse the relation between the oil price and the Norwegian krone. However, as Rogoff (2002) stated: *"No structural model can reliably explain major currency exchange-rate movements after the fact, much less predict them",* highlighting the empirical difficulties in estimating such a relationship.

3.2 Oil price determination

The development of the thesis' other main variable of interest, the oil price, is sought to be analysed in what follows. The international market for crude oil is complex, and multiple factors are important in the price determination.

Oil is not one single homogenous commodity. Crude oil is refined into petroleum products with various applications. The products are used to fuel vehicles, heat buildings, and produce electricity among others. In the petrochemical industry, petroleum is used to produce products such as plastics, polyurethane, solvents, and other intermediate and finished goods (U.S. Energy Information Administration, 2016a). Crudes have a wide range of densities, consistencies and colours, and are also differentiated by their sweetness, which depends on the total sulphate content in the oil[8]. There exist dozens of oil benchmarks, but the price is often pegged to one of three types, representing oil from different parts of the world; *Brent Blend, West Texas Intermediate (WTI)* and *Dubai/Oman* (The Intercontinental Exchange, n.d.) (Fattouh, 2006).

Figure 5 – The oil price benchmarks Brent Blend, WTI and Dubai/Oman have historically been closely related



Source: Compiled by authors/Datastream

Nearly all oil traded outside America and the Far East is priced using Brent Blend (further referred to as Brent Blend or simply Brent) as a benchmark. It is the largest of the well-known oil classifications, and includes numerous measures such as *Brent Crude, Brent Sweet Light Crude, Oseberg* and *Forties*

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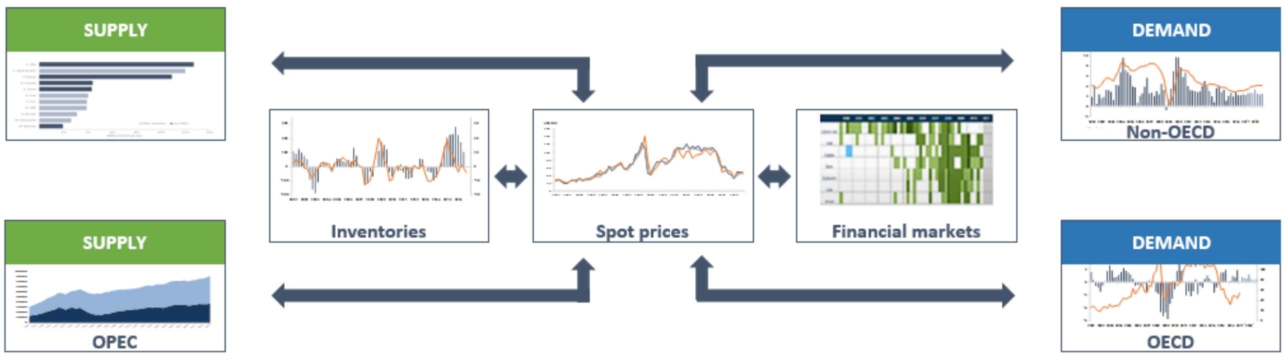
[8] In which a total sulfate content level less than 0.5% is considered sweet and the contrary is considered sour (Cummans, 2015)

(Bjørnland, 2008). Brent Blend is a sweet low density crude oil, yet considered to be more sour than WTI. The majority of Brent Blend is produced in the Northwest regions of Europe, especially in Scandinavia, and it originates from four oil fields in the North Sea (Brent, Forties, Oseberg and Ekofisk). WTI is the main benchmark used for oil extracted in the United States, also considered a sweet oil. Dubai/Oman is the benchmark referred to for Persian Gulf crudes sold in the Asia-Pacific market, and consists of heavier, more sour grades of crude oil (The Intercontinental Exchange, n.d.) (Fattouh, 2006). As seen in figure 5 above, the different benchmarks tend to follow each other closely, despite representing different underlying classifications.

The U.S. Energy Information Administration (EIA) present the six key factors they argue to be most important in oil price determination. These include supply by OPEC and non-OPEC members, demand by OECD and non-OECD members, inventories, and financial markets (U.S. Energy Information Administration, n.d.-a). Figure 6 illustrates how these six factors are interrelated in the price determination process.

Figure 6 - The six key factors influencing the oil price, according to The U.S. Energy Information Administration (EIA)

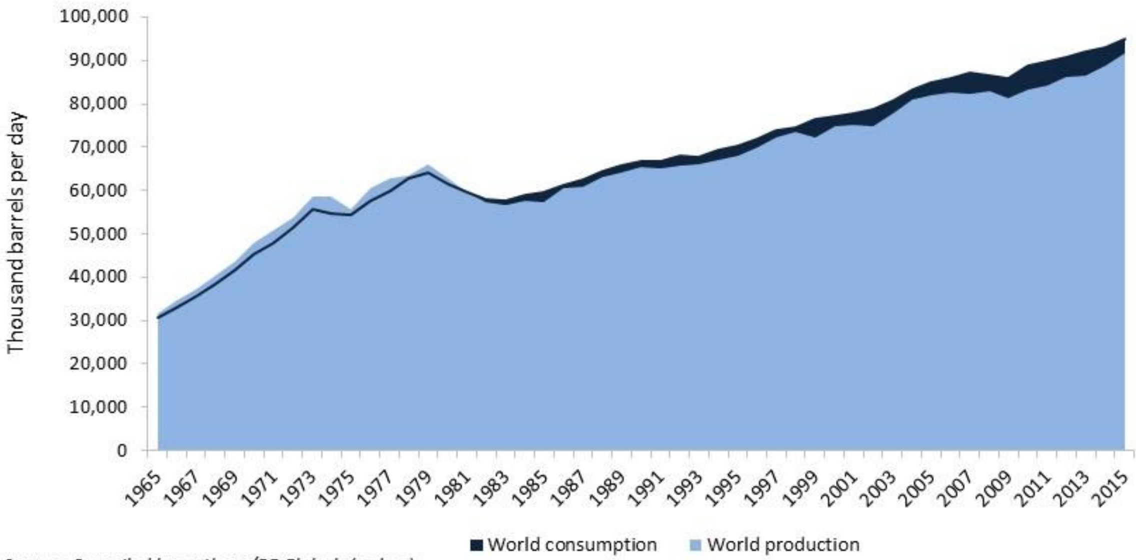


Source: Compiled by authors/U.S. Energy Information Administration, (n.d.-a)

3.2.1 Supply and demand of oil

As any other commodity, the equilibrium price of oil is fundamentally driven by the relation between supply and demand. Oil is as a high-demand global commodity, and its price fluctuations have widespread economic effects. The figure below presents the smooth uprising historical production and consumption of oil since 1965, and factors behind the development will be elaborated in what follows.

Figure 7 - Oil production and consumption has increased steadily since the 1960s



Source: Compiled by authors/BP Global, (n.d.-a)

3.2.1.1 Supply

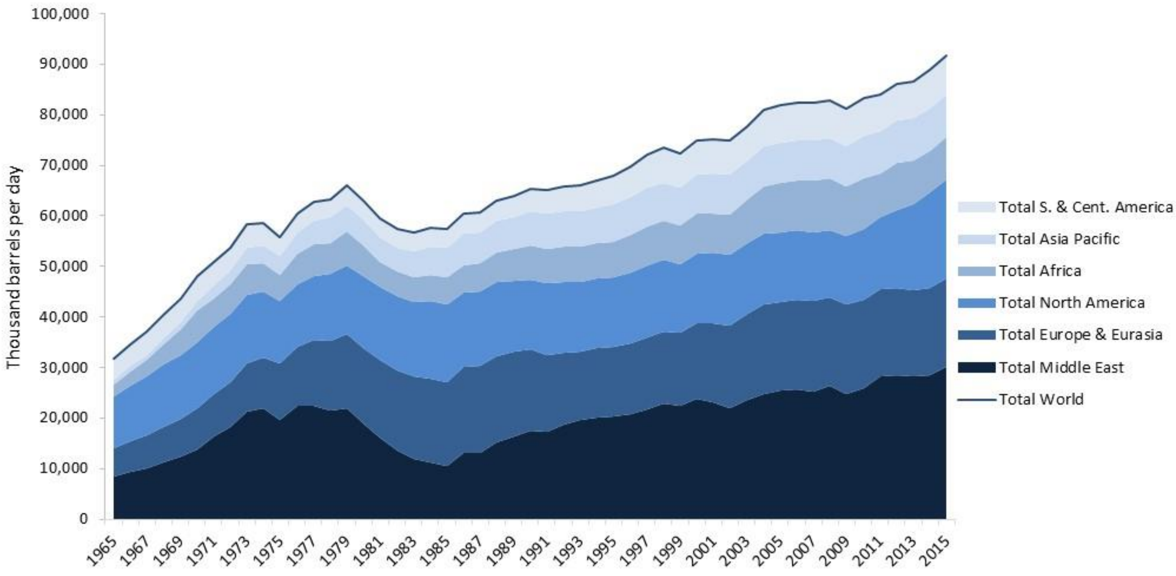
Nations with vast fossil fuel resources are located across the globe, and major oil producing countries may have a stand-alone impact on the supply of oil in the global market. According to British Petroleum (BP) Global, the global oil proved reserves[9] have increased by 24% the past decade, and suffice for 50.7 years of future production (BP Global, n.d.-c). Global availability of oil has an actual end date, which is likely to affect price formation in the future.

The largest oil producing region is the Middle East, with a 32.4% share of global production in 2015, as illustrated in figure 8 below. Over time, the Middle East has been the dominating production region, and has prior to 2015 produced between 18 and 30% of world oil output. North America, primarily the US,

[9] Defined as "*the estimated quantities of oil which geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under current economic and operating conditions*" (BP Global, n.d.-c)

has increased its share profoundly the past ten years, surpassing Europe and Eurasia in 2014 (BP Global, n.d.-a).

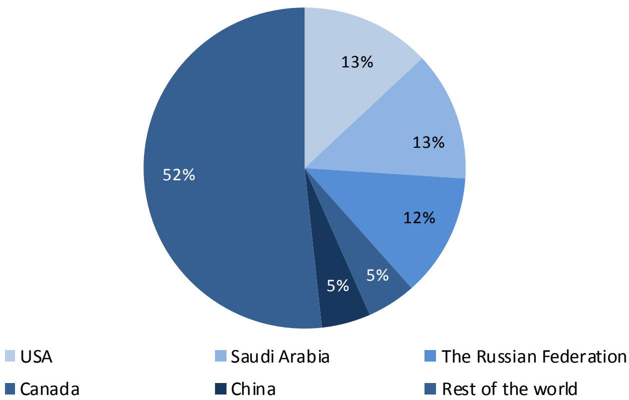
Figure 8 - The Middle East dominates as the world's largest oil producing region



Source: Compiled by authors/BP Global, (n.d.-a)

Top five producers by country in 2015 where USA and Saudi Arabia with a share of 13% each, the Russian Federation with a 12.4% share, followed by Canada and China with a share of 4.9% each, as seen in the chart below.

Figure 9 - The Unites States and Saudi Arabia are the world's largest oil producing countries

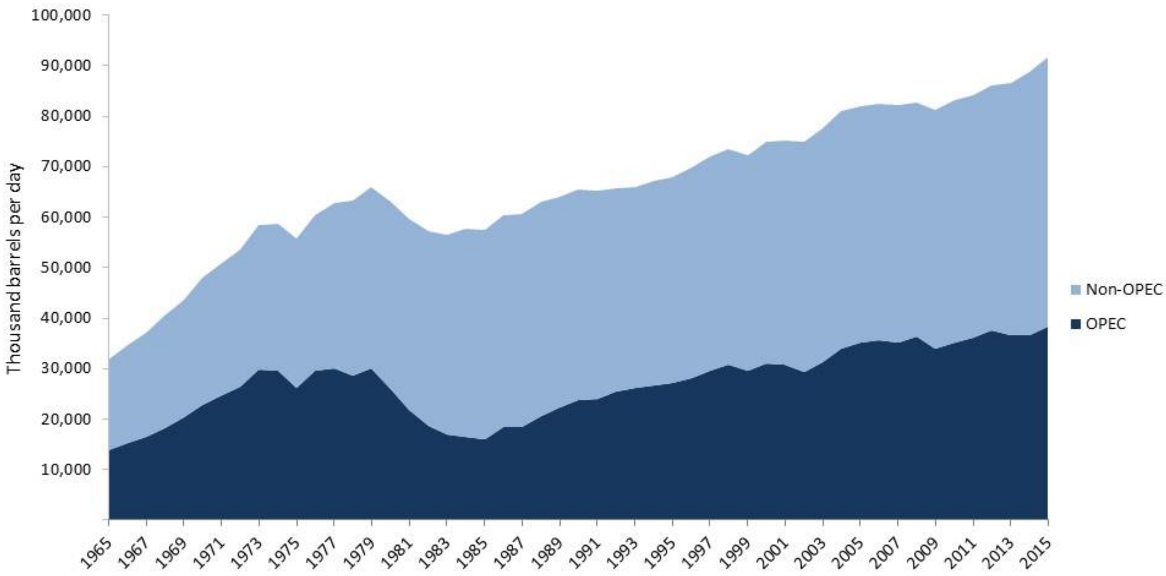


Source: Compiled by authors/BP Global, (n.d.-a)

3.2.1.1.1 Supply by OPEC

The supply of oil has popularly been described in terms of planned production by OPEC and non-OPEC countries. The Organization of the Petroleum Exporting Countries (OPEC) consists of large oil producing countries across the world, and was created in 1960 by the five founding members Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. Later it has been joined by nine other members, namely Qatar, Indonesia[10], Libya, United Arab Emirates, Algeria, Nigeria, Ecuador, Angola and Gabon. Their stated mission is to *"ensure the stabilization of oil markets [...]"* (Organization of the Petroleum Exporting Countries, 2017). The organization regularly sets production targets, which historically has affected crude oil prices, due to its strong impact on world supply. Below is an illustration of historical production figures by OPEC and non-OPEC countries. It is clear that OPEC, with above 40% of world production, influences prices (BP Global, n.d.-a). However, as seen in figure 10, OPECs share of production has declined, due to the US' production of shale oil, among other factors.

Figure 10 - OPEC has historically accounted for approximately 40% of world oil production



Source: Compiled by authors/BP Global, (n.d.-a)

[10] Suspended its membership in Nov 2016 (Organization of the Petroleum Exporting Countries, 2017).

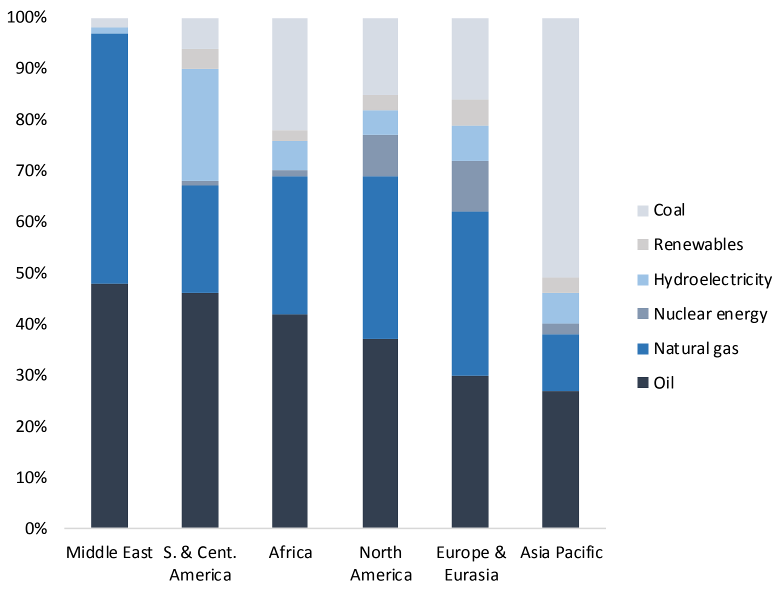
3.2.1.1.2 Supply by non-OPEC

The Economist argues that the economics of oil began to change around 2014, and state that *"[...] oil prices should be less vulnerable to shocks or manipulation"* (The Economist, 2014). The reasoning behind is the increased production of shale oil in the United States, making the US a "genuine rival" to Saudi Arabia. The high oil prices experienced after the financial crisis encouraged drillers in the United States to employ *hydraulic fracturing and horizontal drilling techniques (fracking),* to explore oil from shale formations in states such as North Dakota and Texas. The production of shale oil has been described as a game changer in the global oil markets in the recent past. The United States had a downwards spiralling trend in the amount of oil produced from the 1970s up until 2008, but after the recent revolutionary changes in the production methods, production costs have declined, lowering the breakeven point significantly. The impact of the boom has resulted in a doubling of US crude oil production between 2010 and 2016 (U.S. Energy Information Administration, n.d.-b). Shale oil drilling skyrocketed from having a few hundred productive wells before 2011, to more than 4,000 in 2012, which is more than the total number of oil and gas wells becoming productive the same year in the rest of the world. By year-end 2012, the boom brought about an overall production of over 1.5 million barrels of crude oil per day, starting from nearly zero in 2006 (Maugeri, 2013). *The International Energy Agency* (IEA) predicted an increase in American crude oil production by 45.000 barrels per day in 2012, however the actual increase turned out to be one million barrels per day. This represents one of IEA's biggest forecast mistakes in history, which was built on the perception that the resources were not economically recoverable (Qvale, 2014). Shale oil production has further been described as the key for the United States' ambition of becoming self-sufficient. Thus, the supply side of the equation is now less reliant on the previous dominating oil nation alone, namely Saudi Arabia.

3.2.1.2 Demand

The state of the global economy is an important determinant of oil demand, and it therefore largely influences the price. A higher economic activity leads to stronger demand for products fuelled by oil, which all else equal raises demand. Oil was overall the dominant fuel source in 2015, but the use of oil versus other energy inputs varies greatly across regions. As seen in the figure 11, oil is the dominant energy input in the Americas and Africa, while coal dominates in the Asia Pacific, and natural gas in Europe & Eurasia and the Middle East, according to 2015 figures.

Figure 11 - Oil is the dominant energy source in the Americas and Africa

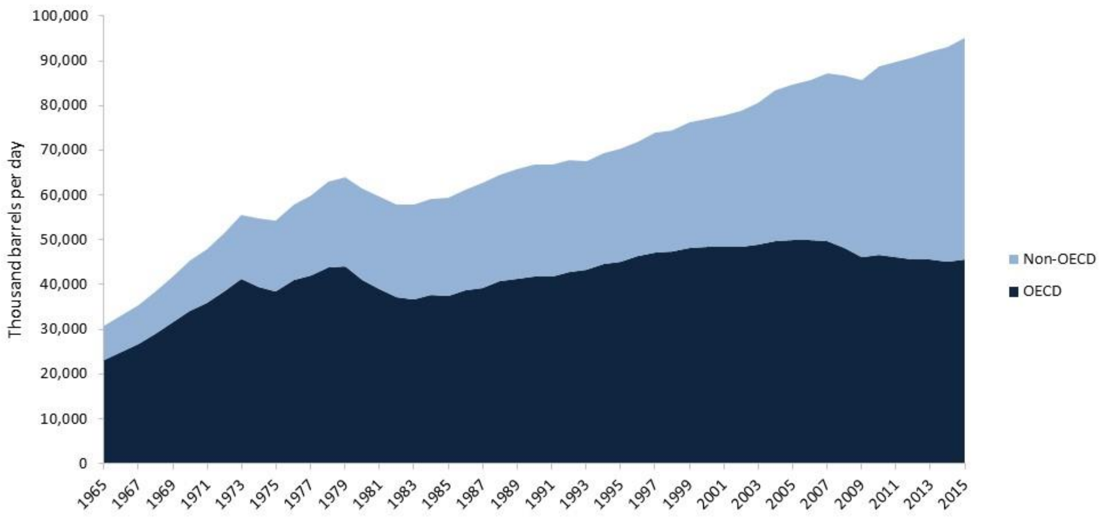


Source: Compiled by authors/BP Global, (n.d-d)

3.2.1.2.1 Demand by OECD

The *Organization of Economic Cooperation and Development (OECD)* consists of 35 member countries around the globe, and includes many of the most advanced countries in the world, and to some extent also emerging countries. The OECD countries dominated oil demand until around year 2008, when approximately half of the world's demand came from non-OECD countries, as seen in figure 12. However, the year-on-year consumption growth is much lower in the OECD countries (BP Global, n.d.-a).

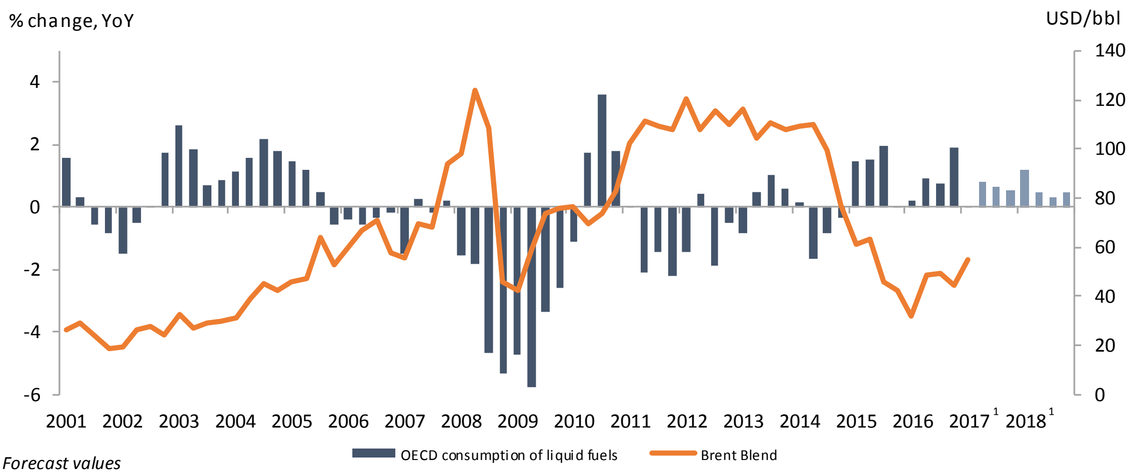
Figure 12 - Energy demand from non-OECD countries is growing at a faster pace than for OECD countries



Source: Compiled by authors/BP Global, (n.d.-a)

Figure 13 illustrates how OECD consumption has developed from 2001, and projection estimates for 2017 and 2018. We see that demand was low during the financial crisis, indicating the lower economic activity in the period. Furthermore, the graph illustrates that lower consumption historically has coincided with rises in the oil price. This price effect on consumption levels has been more prevalent for OECD than for non-OECD countries (U.S. Energy Information Administration, n.d.-a).

Figure 13 - Year-on-year OECD oil consumption change and the oil price development



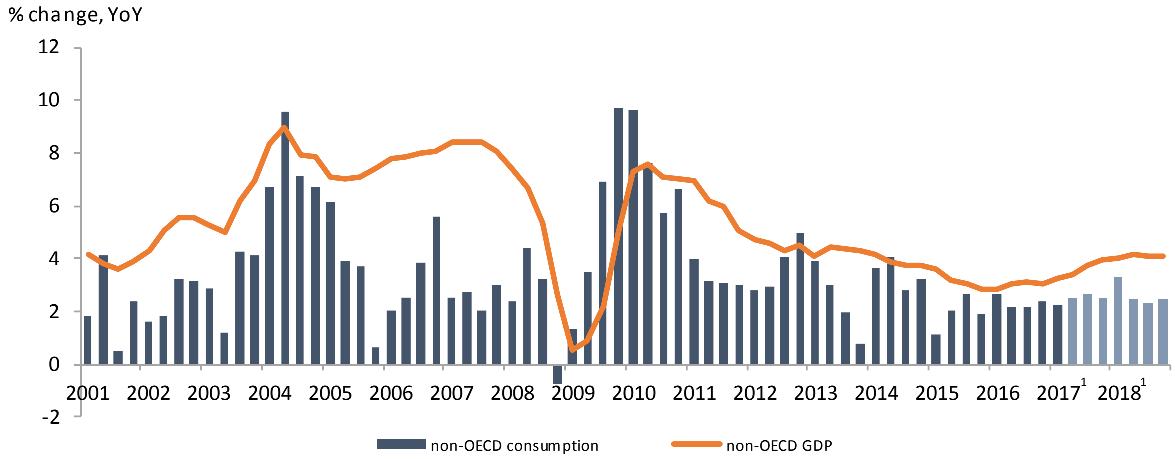
[1] Forecast values
Source: Compiled by authors/U.S. Energy Information Administration, (n.d.-a)/Datastream

3.2.1.2.2 Demand by non-OECD

Economic growth in non-OECD countries has a great impact on oil consumption. In figure 14, we see that periods recognized by positive year on year GDP growth is associated with rising consumption. Oil consumption has historically experienced positive year-on-year growth, with the exception of the fourth quarter of 2008, associated with the financial crisis (U.S. Energy Information Administration, n.d.-c)

Development of large economies can alone have a great impact, which has been evident with the recent rise of emerging markets. For instance, it has been predicted that China becomes the world's largest energy importer by 2035, with 25% share of global energy demand, up from 12.6% in 2015 (BP Global, n.d.-b).

Figure 14 - Year on year consumption of oil by non-OECD countries is closely related to GDP growth



[1] *Forecast values*

Source: Compiled by authors/U.S. Energy Information Administration, (n.d.-a)/Datastream

3.2.2 Other supply and demand factors

Geopolitical tensions and instability also have an impact, as this affects the relation between supplying countries as well as the relation between supplier and consumer countries, elaborated in the section 5.4.1 regarding the historical development of the oil price. Geopolitical concerns may spread reasoned or unreasoned fear of damaged oil supply from the relevant regions.

Further, natural disasters in oil producing areas may crimple supply as they can cause destruction of production and distribution. This has historically been seen for example in the aftermaths of natural disasters such as Hurricane Katrina (Cunningham, 2014) and Hurricane Ike (Nichols & Seba, 2008).

Highly relevant is the debate concerning the environmental threats posed by fossil fuels and its implications for ecosystems, human society and economic development. There is currently broad consensus among researchers that humans have played a significant role in global warming, specifically through burning fossil fuels (Cook et al., 2016). Leading researchers argue that renewable energy can replace crude oil as an energy source within a span of 50 to 130 years (Klare, 2015). As societies have gained increased knowledge of the potential environmental damage caused by production and consumption of fossil fuels, the increased demand of more environmentally sustainable energy resources has been evident. Of an overall increase in world energy consumption of 0.95%, there was an increase in the use of renewable sources of 15.24% in 2015 (BP Global, n.d.-a). Through the efforts of the United Nations, the world has reached its first comprehensive climate agreement[11], dealing with

[11] The Paris Agreement (United Nations, n.d.)

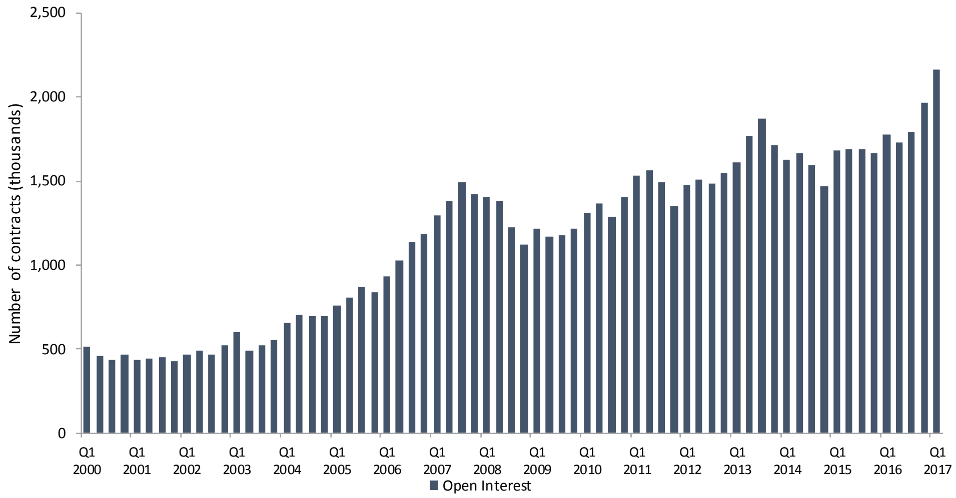
mitigation of greenhouse gas emissions. As the aim is to trigger a shift away from fossil fuels and encourage larger investments in renewable energy, this accordingly may have an impact on the demand for oil. Nevertheless, it is unneglectable that crude oil is an important energy input for the current era.

3.2.3 Additional factors

3.2.3.1 Financial markets

Further, as discussed by Fratzscher et al., (2014), among others, the oil price can be regarded as a financial asset, having the characteristic that its price reflects changes in other assets. It was found empirically that this has been evident since the early 2000s, when trading of oil futures[12] became more popular. More specifically, investors can buy oil futures without physically buying the oil as a commodity. Thus, the prices to be paid in the future are based on supply and demand for the relevant delivery date - and hence depend on expectations of future oil prices. One measure of movements in futures markets is open interest on exchanges, which is defined by IEA as *"[...] the number of contracts in a trading session that have not been settled or closed"* (U.S. Energy Information Administration, n.d.-a). An overview of the development of open market interest over time is seen in figure 15 below.

Figure 15 - Overview of open market interest



Source: Compiled by authors/U.S. Energy Information Administration, (n.d.-a)

Oil futures trading has gained increased interest from both commercial and non-commercial investors, the former being those with a direct interest in the physical oil production, consumption or trade, and the latter being money managers and funds trading for investment purposes. Additionally, investments

[12] Defined as "*A futures contract is a contract between two parties where both parties agree to buy and sell a particular asset of specific quantity and at a predetermined price, at a specified date in future.*" (The Economic Times, n.d.-b).

in crude oil can be done through options trading[13]. This allows the traders to limit their exposure as the potential loss is restricted, and hence functions like an insurance instrument in the case of adverse movements in the commodity prices. However, a lot of ongoing trading activity is not measured by official numbers, as it is done in the less transparent over-the-counter (OTC) market (U.S. Energy Information Administration, n.d.-a).

Market participants form their expectations based on observing market movements such as suppliers' expressed expectations about future production, inventory levels, possibilities of political instability in large consumer and/or producer countries, global demand for oil, as well as perception of changes in other macroeconomic variables thought to affect the availability or price of oil (U.S. Energy Information Administration, n.d.-a).

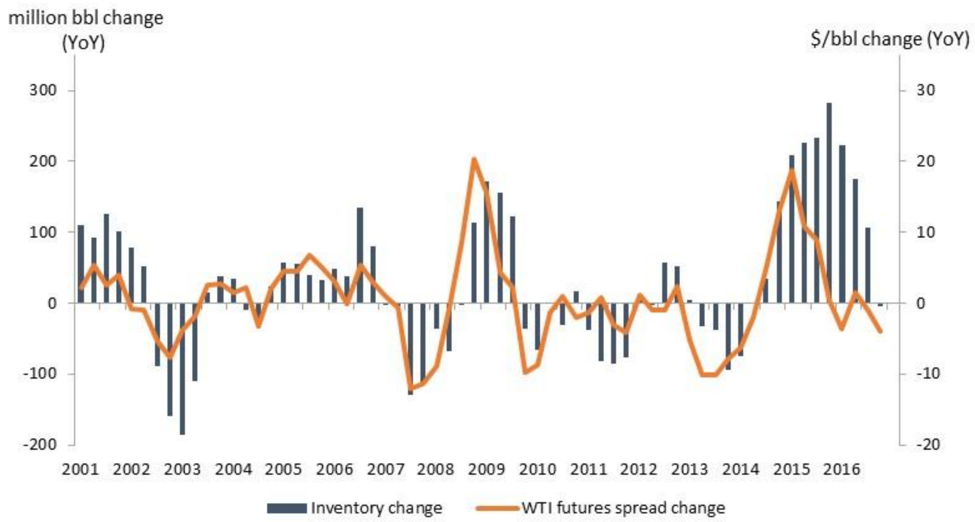
3.2.3.2 Inventories (balance)

During periods of overproduction, crude oil can be stored for expected future use, and hence increase inventories. On the contrary, in periods recognized by over-demand, inventories can be drawn on to supplement current production. In other words, inventories can be said to act as the balancing point between supply and demand (U.S. Energy Information Administration, 2016b). Information on inventory levels is needed for long-term planning by governments and larger companies, due to the necessity of ensuring adequate supplies to meet demand. The markets react rapidly to announcements of expected inventories, which is information provided by large energy bureaus such as the American Petroleum Institute, EIA, IEA and BP Global (U.S. Energy Information Administration, 2016b).

[13] Defined as *"A contract permitting the option buyer the right, without obligation, to buy or sell an underlying asset in the form of a commodity, such as precious metals, oil, or agricultural products, at a designated price until a designated date."* (Business Dictionary, n.d.)

Figure 16 below illustrates that declining inventory levels historically have tended to go hand-in-hand with rising one month futures prices, i.e. declining futures spread (U.S. Energy Information Administration, 2016b). The futures spread is defined as the price of twelve month's oil futures contract less the price of the next month's contracts. Generally, the more positive the spread, the higher the incentive to expand inventories.

Figure 16 - Increases in future relative to current oil prices tends to go hand-in-hand with inventory changes

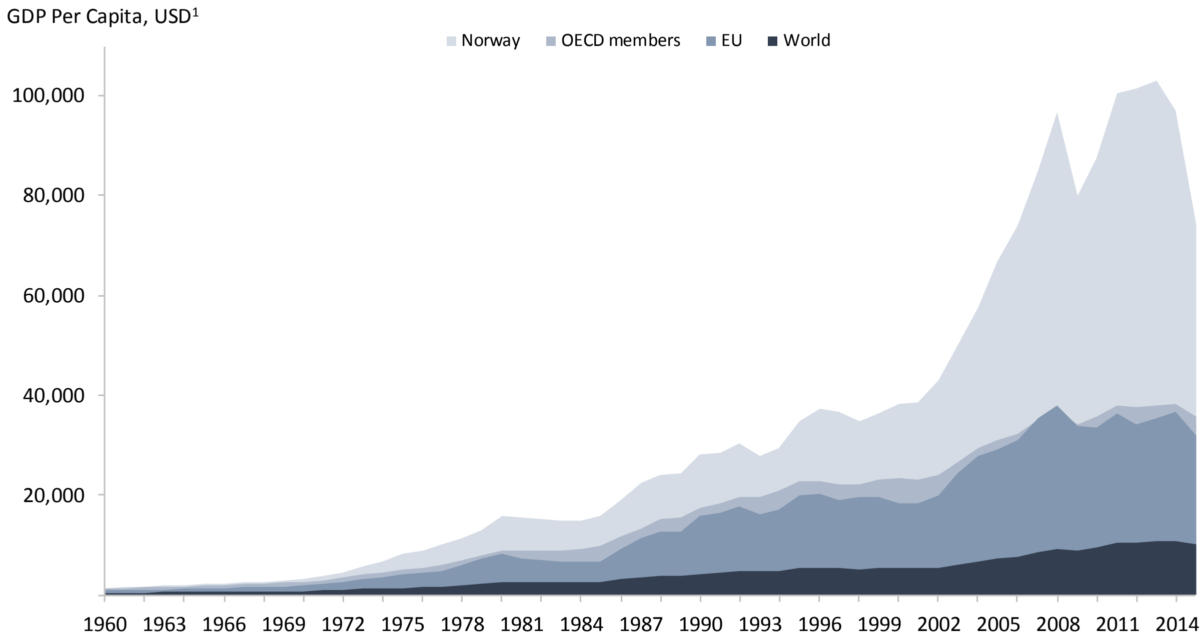


Source: Compiled by authors/U.S. International Energy Administration, (n.d.-a)

4. The Norwegian economy at a glance

The Norwegian economy is recognized by high GDP per capita and high standards of living (OECD, 2016). According to the World Bank, Norway was ranked as number four in the world in terms of GDP per capita in 2015 (World Bank, n.d.).

Figure 17 - Norwegian GDP per capita has steeply risen since the oil discoveries in the 1960s

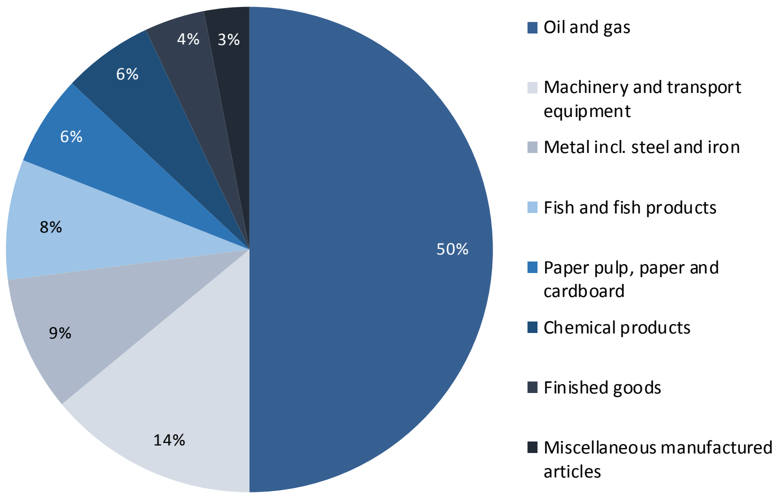


[1] *Current US Dollars*

Source: Compiled by authors/World Bank, (n.d.)

The structure of the Norwegian economy has changed radically the past 60 years. Prior to the discovery of commercially viable oil in the North Sea during the 1960s, Norway was primarily a shipping, fishery and agricultural nation, with the majority of the population employed within these industries. Since the discoveries and subsequent rise in oil prices in the world markets, the traditional sectors have withdrawn, and the oil industry has become the dominating industry in the Norwegian economy. Illustratively, before the first oil was extracted in Norway in 1971, the country's GDP per capita was lower than the average for western countries, as illustrated in the figure above. Oil and gas exports account for approximately 25% of GDP, and about 50% of total exports (OECD, 2016).

Figure 18 - Oil and gas dominates Norwegian exports



Source: Compiled by authors/Government.no (2015)

Impressive standards of living have further been achieved by thorough management of the oil revenues via the sovereign wealth fund and the associated fiscal rule, which will be described further in the following section. The Norwegian state has large ownership interests in various business sectors, although a trend towards privatization has been seen in recent years (Globalis, 2016). Being characterized as a small open economy, Norway is highly dependent on, as well as influenced by, its main trading partners. The economy has become more open to foreign labour, especially from other European Economic Area (EEA) countries[14], which has further supported economic activity and reduced the possibility of overheating (OECD, 2016). Despite the increased dependency on foreign economies, the global financial crisis that hit the world economy in 2008 affected the Norwegian Economy to a lower extent compared to most other advanced economies, and the contrast between the Norwegian and other European countries' economies has been more prevailing since the crisis (Norges Bank, 2017a). According to figures published by OECD, the fall in Norwegian GDP was less than 1.5% in 2009, compared to the Eurozone average of 4%. Employment was maintained at a healthy level, and it was evaluated that the crisis handling in Norway was particularly good (Gustavson, 2011).

[14] The EU member states and the three EEA European Free Trade Organization (EFTA) states; Iceland, Liechtenstein, and Norway (EFTA, n.d.)

4.1 Fiscal framework

The nature of the Norwegian economy's dependence on oil revenues could in theory present challenges to ensure stable economic development. In many countries, temporary large natural resource incomes have produced short run booms followed by adjustment difficulties and diminishing revenues. In Norway, the establishment of *The Government Pension Fund Global* (the sovereign wealth fund), and the implementation of *The Government Pension Fund Act* (the fiscal rule), are two crucial factors contributing to stable public sector revenues (Government.no, 2015). The former is a government handled fund, administered by *Norges Bank Investment Management* on behalf of the Ministry of Finance, in which public petroleum revenues have been accumulated since 1990. Despite its name, it has no formal pension liabilities, and it was constructed to provide the government with room for manoeuvre in its fiscal policy in a presence of a contraction of the mainland economy or a drop in oil prices. The current size of the fund is approximately double the size of Norwegian mainland GDP (Akram & Mumtaz, 2016), and it has had a yearly return since 1998 of 5.6%[15] (Norges Bank Investment Management (NBIM), n.d.-b). The fund is managed such that investments are made up of a diversified mixture of international equity, fixed income and real estate (Norges Bank Investment Management (NBIM), n.d.-a). The Government Pension Fund Act is an operational fiscal policy rule established in 2001, stating that all oil revenues are transferred to the sovereign wealth fund. An annual average of the expected real return of the fund, estimated at 4%, is to be invested abroad, with the purpose of leaving the fund capital untouched (Alstadheim, 2016). The purpose of the fiscal rule is to ensure that the petroleum wealth will benefit future generations, and to even out economic fluctuations (Government.no, 2015).

4.2 Monetary policy regimes

Norway joined the Bretton Woods system of fixed exchange rates in 1946, which entailed that the NOK was to maintain a par value in terms of gold towards the pound and the US dollar. The system collapsed in 1971, and was followed by a new fixed exchange rate system known as the Smithsonian Agreement. In 1972, Norway joined the European "snake in the tunnel" monetary cooperation[16], which further limited the fluctuations of the NOK relative to the European currencies. The Smithsonian Agreement broke down in 1973, but the commitment to the "snake" continued until 1978. At this time, the krone was linked to a trade weighted basket of currencies, with various adjustments of the target introduced until the decision was made to peg the krone to the European currency unit (ECU) in October 1990. The

[15] Measured in the fund's basket of currencies. The return was 3.7% after subtraction of administrative costs and inflation.
[16] A monetary cooperation that attempted to "*[...] limit fluctuations between various European currencies and eventually, create a single currency band for the European Economic Community*" (Kilic, 2013)

link of the krone to the European Monetary System (EMS) through the ECU peg was maintained until the krone underwent such pressure that the fixed scheme was abandoned in December 1992. A *managed* float was maintained until the introduction of the Euro in 1999, when the Norwegian central bank started to use the new currency as an indicator for European currencies. The central bank although describes that the *real* floating exchange rate period did not begin until 1997 (Bernhardsen & Røisland, 2000).

From January 1999, the Norwegian central bank employed *de facto*[17] inflation targeting parallel to the takeover of Svein Gjedrem as the governor of the bank. In March 2001 two important changes were introduced; de jure[18] inflation targeting with a floating exchange rate regime replacing the managed float, and the introduction of the fiscal rule, as discussed in section 4.1. (Alstadheim, 2016). According to prominent monetary policy researchers, the flexible inflation regime has been characterized as close to if not the best practice (Akram & Mumtaz, 2016).

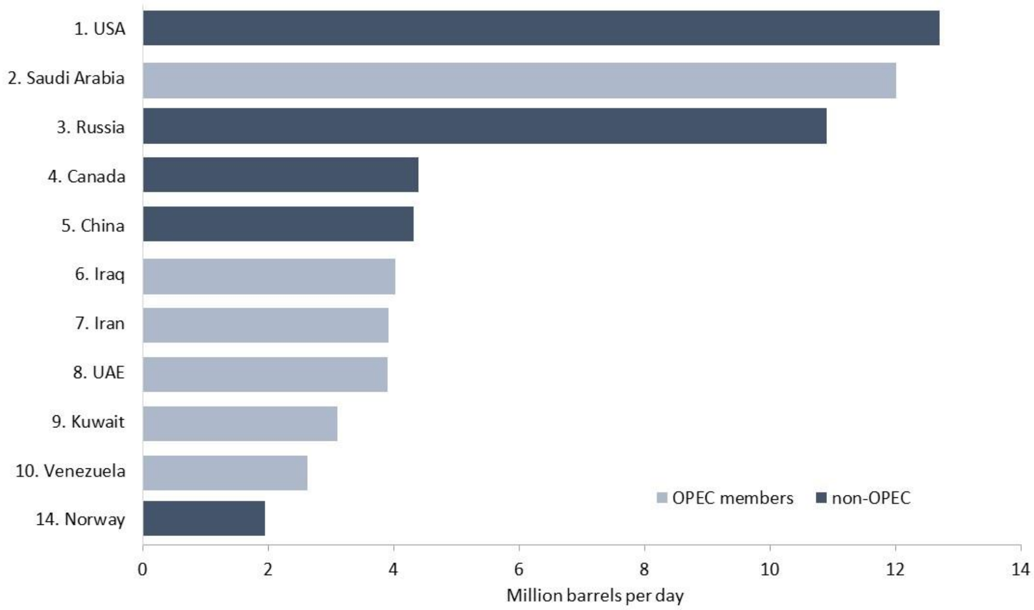
4.3 Effects of oil price changes for the Norwegian economy

As oil has become a major influencer in the world economy, it has been prevalent how significant changes in the oil price alters the wealth of nations. The positive oil price development prevailing from the beginning of the millennium until pre-financial crisis times provided oil exporters with large current account surpluses, raised the interest in these countries, and thus the demand for the respective currencies (Habib & Kalamova, 2007). The effect of changes in the oil price for different economies depend on factors such as the dependency of the oil, the amount of imports and exports, and the cost of exploring different fields for producing countries.

The petroleum production is currently Norway's largest industry measured in value creation, state income, investments and export value (Norwegian Petroleum, 2017b). According to the Norwegian Petroleum Directorate, Norway was ranked as the 14th largest oil producing country in the world in 2015, ranging below large economies such as the US, Saudi Arabia, Russia, Canada and China, as seen in figure 19. Norway supplies approximately 2% of global crude oil consumption, and the value of exported crude oil was NOK 186bn in 2016 (Norwegian Petroleum, 2017a).

[17] Exchange rate regime in operation by the central bank (Bermúdez, n.d.)
[18] Exchange rate regime officially declared by central banks to the IMF (Bermúdez, n.d.)

Figure 19 - USA has recently taken the lead as the largest oil producer, whilst Norway is ranked as number 14



Source: Compiled by authors/Norwegian Petroleum (2017a)

The krone exchange rate development and the oil price are of high importance in the interest rate setting due to its influence on inflation and output (Norges Bank, 2017a). Simplified, the relationship between the variables is as follows in the short run; a decline in the oil price may give rise to expectations of a weaker economy, and lower interest rates. This leads to lower demand for the Norwegian krone, and thus a weakening of its value, as foreign investors are not incentivized to keep their holdings in NOK denominated securities. As the krone weakens, imported goods become more expensive than national goods, which further leads to imported inflation (Lie, 2016). Since the inflation targeting regime was introduced in 2001, the Norwegian economy has been exposed to several shocks, being both large and persistent (Norges Bank, 2017a). These include the financial crisis starting in 2008 and the significant oil price drop in 2014, among others.

Bjørnland (1998) investigated whether the so called "Dutch disease"[19] affected the Norwegian economy as was the case with the Dutch economy after its natural gas discoveries in the 1960s. In the Netherlands, the gas discoveries had adverse effects on the manufacturing sector through an appreciation of the real exchange rate, and thus made it a less competitive sector in terms of exports. According to Bjørnland, the manufacturing industry in Norway actually benefited from the Norwegian natural resource discoveries and subsequent rising oil prices. Bjørnland explains that the conduction of macroeconomic

[19] A discovery of a natural resource that has harmful consequences for traditional industries in the country (Rutherford, 1992)

policy affects the result of an oil price shock to an oil exporting country. In Norway, cautious subsidies were made to maintain output from the manufacturing industry regardless of the changes in the oil sector, which resulted in maintaining low unemployment, as compared to for example the UK where the oil revenues were spent on paying off existing external debt and social security (Bjørnland, 1998).

In newer times, research has been conducted on the effect of the 2014 oil price drop for the Norwegian economy. The Norwegian government income fell by 30% from 2014 to 2015, mainly related to the fall in the oil price during the same period. Output growth slowed, following the depression of oil-related activity. Investments related to the petroleum sector started decreasing already in 2012, but showed a continuing downward trend from mid-2014. The initial investment downfall stemmed from the fact that multiple large projects were completed, as well as cost-reduction campaigns were carried out. Unemployment rose to above 4% in early 2015, compared to average of 3.34% the preceding 12 quarters (OECD, n.d.-c). However, declining interest rates, an expansionary fiscal policy, as well as rising housing wealth boosted consumption, and the resulting depreciation of the exchange rate strengthened Norway's competitive position. There was a rising trend in mainland exports[20], and better prospects for exports within manufacturing. A report from OECD summarises the above in the following manner *"[...] the substantial oil-price falls since 2014 have been a reminder of Norway's exposure to external risks and consequently the importance of a flexible and competitive mainland economy"* (OECD, 2016).

For Western oil companies, the effect of a price drop is large, as the North Sea inhabits expensive and maturing fields (Oil and Gas UK, 2016), through high-cost drillings projects such as deep water drilling or drilling in the Arctic. This is seen in comparison to countries such as Saudi Arabia where the cost of drilling is much lower, and thus also the vulnerability (The Economist Explains, 2014). Data presented by Rystad Energy shows that the total cost of producing one barrel of crude oil is almost four times higher for Norway compared to Saudi Arabia, equalling $36.10 and $9.90, respectively (Kristopher, 2016a).

[20] Exports, excluding oil and shipping (OECD, n.d.-a)

5. Data presentation

5.1 Variable choices

For the purpose of this thesis, daily observations are the desired frequency for all variables, as fluctuations in the variables of interest may occur from one day to another. Also, a large number of observations would be lost if the analyses were to be conducted on monthly, quarterly or yearly data, which potentially could make the results less robust, all else equal. The authors' choice of nominal exchange rates in favour of real exchange rates stems from the fact that the analysed exchange rates are intended to be directly relatable to those discussed in the media. Furthermore, the desired use of daily data restricts the availability of variables necessary to deflate nominal variables, such as inflation measures, which are published on monthly basis.

5.1.1 Exchange rates

No single exchange rate exists as it depends on the currency against which it is measured. For the purpose of the thesis it has been chosen to analyse the nominal effective krone exchange rate, I44, as well as exchange rate pair NOK/USD. The relevance of the I44 stems from the fact that it represents the value of the Norwegian krone relative to the currencies of Norway's 44 most important trading partners, calculated as a geometric average weighted by the amount of imports from the respective trading partners (Norges Bank, 2003). The Norwegian krone can appreciate against the dollar and depreciate against the Euro simultaneously. Due to this, I44 can be used as representation of the international value of the krone, as it is a measure of the value of the krone against a basket of currencies (Bernhardsen & Røisland, 2000). An increase in the I44 index equals a depreciation of the nominal effective krone exchange rate, also referred to as a depreciation of the Norwegian krone. The USD has been chosen due to its relevance as the most traded currency in the world (Desjardins, 2016)) and due to the fact that the price of Brent Blend is quoted in USD. A rise in the NOK/USD exchange rate implies a depreciation of the NOK.

5.1.2 Oil price

The thesis makes use of the Brent Blend as representative for the oil price. As discussed in section 3.2, the Brent Blend oil price represents the price of oil from the North Sea and is therefore viewed as the most relevant price for Norwegian oil (Finansdepartementet, n.d.). This is also in accordance to previous literature published by the Norwegian central bank (Akram, 2002a; Bjørnland, 2008). Some research finds that there exist seasonal aspects in the oil price, as prices have historically tended to rise during the summer season and fall with some consistency towards mid-September and October (Kristopher, 2016b). According to econometric theory, the ignorance of any calendar phenomena in the model building can potentially lead to a miss-specified model (Brooks, 2008). Due to the daily nature of the data, leading to the inclusion of more than 3500 observations, as well as technical limitations of statistical programming software, the authors believe that the ability to capture these effects are limited, and entails ignorance of this aspect.

5.1.3 Control variables

According to the economic theories presented in the theory section, as well as the research presented in the literature review, a vast number of variables may have an influence on the relation between exchange rates and the price of oil. Variables of interest in modelling exchange rates may include, the consumer price index, interest rates, GDP growth and government control, expenditures and deficits, among others.

Certain control variables have been omitted from the main analyses as they are most frequently reported on a monthly or quarterly basis. To account for this, a robustness check will be conducted in section 7, in order to include variables that occur on a monthly basis. For the main part of the empirical analyses we have included interest rates and interest rate differentials, as commonly used in exchange rate literature, see (Akram, 2002a), (Bernhardsen & Røisland, 2000) and (Ellen & Martinsen, 2016). These variables also correspond to the theory of Madura & Fox (2011) described in section 3.1.1.

As a representative for the interest rate level, the thesis makes use of three month money market rates for the relevant currencies; NIBOR and LIBOR USD (Bjørnstad & Jansen, 2007). The money market rates are adopted due to their characteristic as the key policy rate plus a risk premium added according to the individual credit ratings of the countries. Thus, the rate will capture the individual economic uncertainty for the relevant geographic areas. The three month maturity is adopted due to its characteristic as being the most commonly quoted (Investopedia, n.d.). NIBOR (Norwegian Interbank Offered Rate) is a collective term for Norwegian money market rates with different maturities, based on an average of the rates at which a panel of banks are willing to lend to each other. The rates should reflect the interest rate level a lender demands for an unsecured loan in NOK with delivery in two days (spot) (Oslo Børs, 2014). LIBOR (London Interbank Offered Rates) is the similar rate based on some of the world's leading banks, and is based on five currencies; USD, EUR, GBP, JPY and CHF[21]. LIBOR and EURIBOR are the primary benchmarks of short-term interest rates around the world (Zibel, 2008).

[21] USD = Unites States Dollar, GBP = Great Britain Pounds, JPY = Japanese Yen, CHF = Swiss Franc (Norges Bank, 2017b).

Interest rates in relation to the I44 variable should ideally be computed as the weighted average of the trading partners interest rates, with identical countries and weights as those contained in the I44 index. However, in practice this entails difficulties due to availability of data. For simplicity and feasibility, an aggregated interest rate has therefore been calculated as a weighted average of the most important trading partners, following the Norwegian central bank (Ellen & Martinsen, 2016). Annually, the central bank publishes an overview of the weights used to calculate the I44 index. The top seven countries in this list make up around 80% of the weights in the I44 index, which is why these countries have been chosen. The relevant annual weights have been rescaled such that the relative importance of each country remains the same, which can be seen in appendix 1. Countries included yearly vary somewhat, resulting in a long list of currencies including: EUR, SEK, USD, GBP, DKK, JPY, CAD, PLN and KRW[22]. It should be noted that Chinese interest rate has been excluded due to the lack of data availability. China has become one of Norway most important trading partners in later years, however, inclusion of Chinese interest rates would imply a loss of 1996 observations. We view this cost higher than the benefit of inclusion.

The price of Brent Blend is retrieved from Thomson Reuters Datastream, all exchange rates are retrieved from the Norwegian central bank, while interest rates are retrieved from Bloomberg.

5.2 Logarithmic transformation and treatment of extreme values

The use of natural logarithmic transformation is common in economic time series. Firstly, log-transformation makes variance more constant by rescaling the variables (Brooks, 2008). Secondly, transformed data is more likely to satisfy linearity assumptions. Thirdly, log-transformation provide results which are easy to interpret (Koop, 2005). The following provides an example:

$$\ln(Y) = \alpha + \beta \ln(X) + \varepsilon \qquad (Eq. 5.1)$$

Where $\ln(Y)$ is the natural logarithm of the random variable Y, α is a constant, β is the coefficient on the explanatory variable X, and $\ln(X)$ is the natural logarithm of X. In equation 5.1 above, β can be interpreted as the elasticity of Y with respect to X. When working with the logarithm of both the dependent and the independent variables, we can say that *"Y tends to change by β% following a one percent change in X",* in contrast to *unit* changes when working with non-log-transformed variables. Hence, issues related to unit measurement is ignored, all results can now be interpreted as elasticities.

[22] EUR = Euro, SEK = Swedish Krona, DKK = Danish Krone, CAD = Canadian Dollar, PLN = Polish Zloty, KRW = South Korean Won (Norges Bank, 2017b).

An additional beneficial feature of working with logs is in relation to time series data, where a percentage change in a variable is approximately $100 * [ln(Y_t\ ) - ln(Y_{t-1})]$. The latter part of the fraction is defined as the first difference of Y. This transformation enables us to interpret results as percentage changes[23] (Koop, 2005).

Mathematical difficulties arise in log-transformation when variables contain negative values (Sydsæther, Hammond, & Strøm, 2012). The I44 and EURIBOR[24] interest rate variables exhibit negative values in the time period from June 2016 and April 2015 respectively. There exist solutions such as translating and transforming the data, or treating negative observations as missing values. The former method has been criticized by practicing statisticians, as the method entails adding an arbitrary constant to the data. The latter is also avoided as it would yield missing observations for a highly relevant period in the time series (Wicklin, 2011).

In what follows, the expression "level" will be used to characterise variables that are both on logarithmic and non-logarithmic form, in contrast to variables that are transformed by first-differencing. Additionally, the description *log* is used to characterize the natural logarithm. For example, the natural logarithm of the price of Brent is presented as logBrent.

5.3 Choice of analysis period

The thesis is based on daily data covering the period 01-01-2001 to 31-12-2016. The start date is set to include the Norwegian economy's monetary regime shift towards the current, as well as the introduction of the Euro as a currency. The dataset contains 3595 observations, as all weekends and non-trading days are excluded. The number of trading days varies somewhat in different countries. Therefore, the variable with the fewest observations serves as the upper limit, and all other observations are matched accordingly.

5.3.1 Subsamples

As expressed in the problem statement, the authors have an interest in investigating whether the relation between the exchange rates and oil price has changed in recent years. To be more explicit, the time series will be split in subsamples to investigate whether the results are robust across different periods.

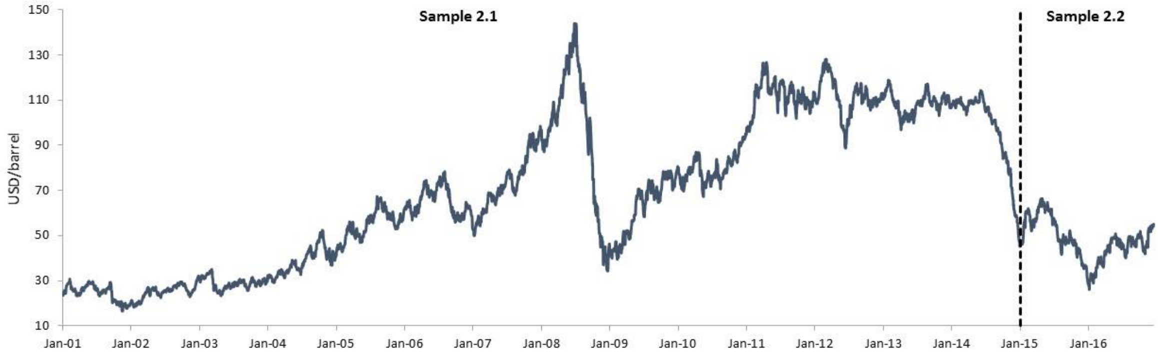
---

[23] Note that in section 6.4 and 6.5, the first differencing and logarithm transformation is conducted without multiplying by 100 in order to avoid imbalance in the first step of the two-step Engle-Granger estimation.

[24] This also applies for the CPI variables introduced in robustness analysis presented in section 7.

The chosen subsets are first of all the following two; sample 2.1 (01-01-2001 until 13-01-2015) and sample 2.2 (14-01-2015 until 30-12-2016). The reason for this split is the interest of seeing whether the relation between the oil price and the exchange rates have changed after the major downturn in the price of Brent during 2014. The split implies that sample 2.1 represents the longer period before and including the oil price downfall, while sample 2.2 represents the short period after the price stabilized in 2015, illustrated in figure 20.

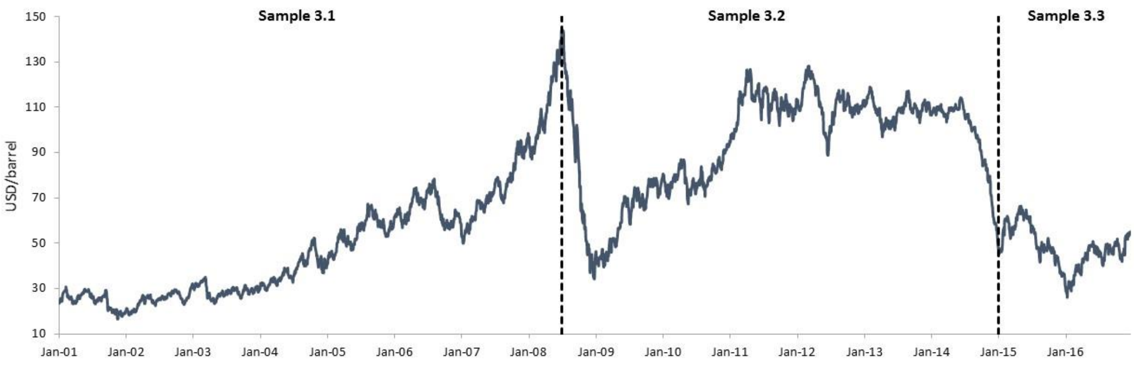
Figure 20 - Sample 2.1 and 2.2 distinguishes between the period before and after the 2014 oil price collapse



Source: Compiled by authors/Datastream

Furthermore, the analysis will be conducted on a three-part subset; sample 3.1 (01-01-2001 until 03-07-2008), sample 3.2 (4-7-2008 until 13-01-2015) and sample 3.3 (14-01-2015 until 30-12-2016). The latter is identical to sample 2.2, and is hereafter referred to as sample 2.2. This split will allow for investigation of two stable subsets, 3.1 and 3.3, and 3.2 which is more volatile. Thus, it will be used as a method for eliminating noise and volatility in the data, and checking the robustness of the analysis across subsamples which exhibit very different characteristics.

Figure 21 - Sample 3.1, 3.2 and 3.3 divide between pre-and post-financial crisis, as well as pre and post oil price collapse



Source: Compiled by authors/Datastream

The following table summarizes all samples to be analysed:

Table 1 – The thesis is split in five subsamples to analyse for changes over time

Sample	Start date	End date	# of obs.	Brent oil price characteristics during the period
Full	01-01-2001	31-12-2016	3595	Includes all observations
2.1	01-01-2001	13-01-2015	3150	Covers period until the bottom was reached following the 2014 oil price drop
2.2 *(Identical to 3.3)*	14-01-2015	31-12-2016	445	Stable period after bottom was reached following the 2014 oil price drop
3.1	01-01-2001	03-07-2008	1676	Period until the oil price peaked in July 2008
3.2	04-07-2008	13-01-2015	1474	Volatile period including financial crisis and 2014 oil price drop

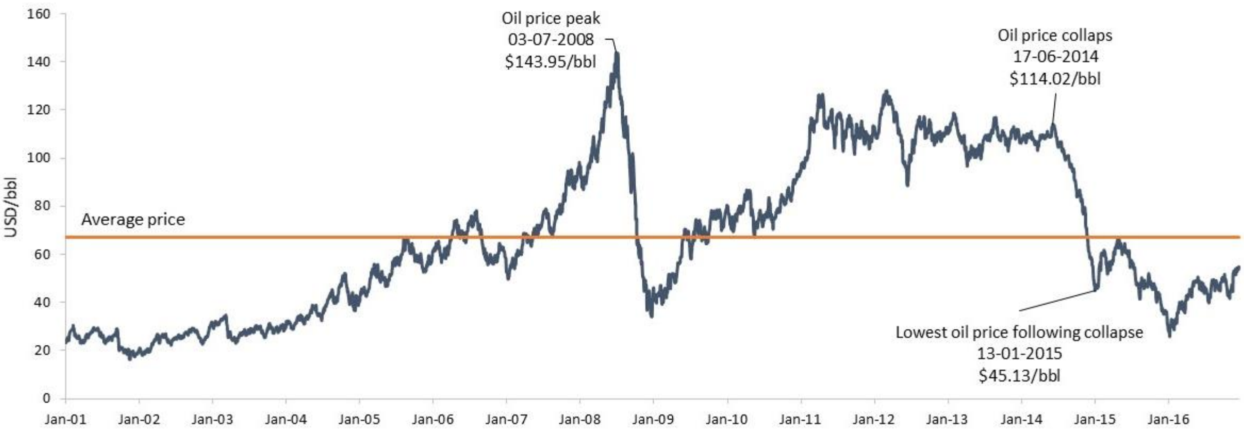
5.4 Historical development of key variables

In what follows, the historic development of the oil price as well as the chosen exchange rates will be explored, with the purpose of highlighting possible reasons for the prevalent movements. It is important to emphasize that relations that may appear obvious in the charts may not always have been as clear-cut in reality. Further, the description of correlation and possible causality between variables is not based on statistical methods, but rather a comprehensive research of second hand sources.

5.4.1 Historical development of the oil price

As portrayed in the time series plot of the oil price development the past 16 years, presented in figure 22.

Figure 22 - Historical development of Brent Blend



Source: Compiled by authors/Datastream

The rising price between 2001 and 2006 was most likely mainly driven by the world's increasing demand for oil as an energy resource, cf. section 3.2.1.2. In August 2006 the price broke the prior psychological barrier of $60 per barrel, and by mid-2006 the oil price reached an all-time record of $79/bbl. Geopolitically, global tensions from North Korea’s missile launch (Schienberg, 2006), the ongoing Iraq war as well as unrest between Israel and Lebanon, spread fears of disturbances in supply, which may have driven the prices upwards.

The decline in crude oil prices from mid-2006 until year-end were among other factors caused by overflowing oil inventories, milder weather conditions in the winter season as well as disbelief in OPECs statement of cutting production (Hargreaves, 2006).

From the end of 2006 until prior financial crisis times, the prices saw a sharper rise. Dominating factors were assessed to be geopolitical tensions in Turkey, generating fears that supplies could be threatened, as well as a weakening of the dollar caused by distress over the strength of the US economy (BBC News, 2007). In June 2008, specific events were among others the possibility of an Israeli attack on Iran due do Iran's lack of abandonment of its nuclear program. This was highly important as Iran was, and still is, among the top three producers within OPEC (Mouawad, 2008). Crude prices reached an all-time high on the 3rd of July 2008, at the price of $143.95 per barrel. However, the price rise was described as puzzling to investors as there was oversupply in the market and evidence of lower demand in industrialized countries.

Following the surge was the massive collapse in financial markets after Lehman Brothers declaration of bankruptcy in September 2008. Crude oil prices hit a seven-month low due to the fear of slowdown in demand as the recession became deeper (Saefong & Lesova, 2008). In December 2008, the prices hit a low point at $34 per barrel, which had not been experienced since end July 2004. Between July and December 2008, the price fell by almost $110 per barrel, an equivalent of 75.5 percent.

Primary causes of price rises in January 2009 were increased tension at the Gaza strip (BBC News, 2009). This was followed by concerns about the future of the European economy, high oil inventories and a strong dollar, causing temporary lower prices in May 2010.

A volatile price development is seen until the major drop in June 2014. Contributing factors were such as political turmoil in the Middle East and North Africa, inhabiting large oil reserves (Rooney, 2011). In 2012, prices saw an uprising trend after the approval of a bailout plan for Greece, a rise in money supply in China as well as Iran's announcement to end petroleum sales to British and French companies.

The first six months of 2014, prices were pushed upwards by the dispute in Crimea, further troubles in the Middle East, and lower supplies of US petroleum (Gorondi, 2014a). In October, Brent dropped due to a strong dollar, as well as decreased overall demand, and the hitting effects of the surge in US production from shale oil reserves. In January 2015, the oil price hit its lowest since 2009, at $45/bbl (Isidore, 2014).

During 2015, the prices saw a rise following troubling geopolitical situations in the Middle East and Ukraine, which again caused risk of reduced oil supplies (Gorondi, 2014b). These movements were followed by prices surging to record lows that had not been experienced since the financial crisis. Contributing factors were the IEA's pronounced predictions of high future oil supplies, Middle Eastern countries oversupplying the market, the expectation of Iran to increase their supply as a result of the nuclear agreement[25] and slow growth in China (Krishnan & Samanta, 2015). In December 2015, OPECs president expressed that OPEC would take a "wait and watch approach", and that OPEC members would keep current production levels stable (CNBC, 2015).

During 2016, the price has seen a slight recovery to mid-2015 levels, at around $50 per barrel. At the beginning of the year, prices dropped as supplies rose, due to increased shale production and rising production by OPEC. Prices saw a recovery after OPEC tried to work together with non-OPEC members on a plan to freeze production, although the initial talks never led through. Cuts from North American producers also had a positive effect on the price. Although, as prices saw sharper recoveries, North American companies regained confidence to increase well investments, resulting in a stabilisation of the price. In November, prices saw an upswing, as OPEC members agreed on production cuts, as well as persuaded non-OPEC members to reduce their output as well (DiLallo, 2016). Nevertheless, such announcements need to be followed through for the agreement to work, although the market expectations alone manifested in price reactions.

5.4.2 Historical development of the currency pairs

The most important drivers for the value of the NOK are argued to be the oil price, interest rate expectations, volatility in financial markets as well as Norwegian macroeconomic development relative to expectations (Hovde, 2016).

5.4.2.1 Description of NOK against USD

By looking at the time series plot of the NOK/USD exchange rate, we can see that the NOK strengthened against the USD between 2001-2008. The interest rate differential between NIBOR and LIBOR USD increased from 2001 until it peaked in November 2002, due to the NIBOR rate fluctuating around 7% while the LIBOR USD dropped from below 6% to 2%. Following this, the differential exhibited a falling trend towards March 2006, as Norwegian interest rate cuts were made to boost the economy. Between December 2002 and March 2004, the Norwegian key rate was reduced by a total of 5.25 percentage points, landing at 1.75 % (Norges Bank, n.d.-a). As discussed, changes in the key rate are proven to have substantial spill over effects on money market rates, which further affect the foreign exchange market (Bernhardsen, 2012). Lower interest rates make it more attractive to borrow and less favourable to invest in the Norwegian krone, resulting in a depreciation of the currency, all else equal.

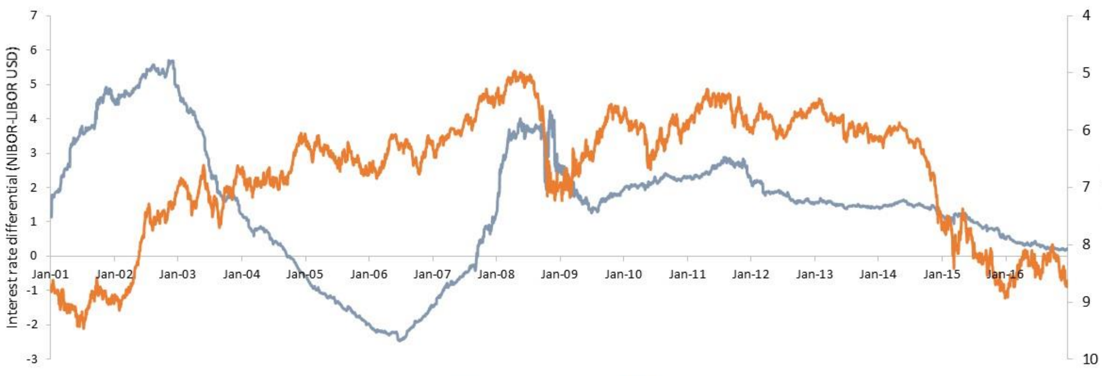
[25] On April 2nd 2015 Iran and world powers reached an agreement that would lift most sanctions in exchange for Iran limiting its nuclear program (Charbonneau & Nebehaym, 2017).

Figure 23 - Historical development of the NOK/USD exchange rate and Brent Blend

Source: Compiled by authors/Datastream

Falling stock market prices from 2000-2002 led investors to become more cautious and less optimistic about positive stock market returns. As stock market prices dropped, investors wished to invest a higher fraction of their portfolios in interest-bearing securities. The Norwegian krone was perceived as attractive due to a positive, and occasionally high, interest rate differential (Naug, 2003). Accordingly, the Norwegian krone strengthened relative to the dollar. From 1999 until 2006, USA experienced increasing trade deficits[26], which may have led to an increase in the demand for other currencies than USD, and thus a weakening of their currency (World Bank, 2017). The price of oil has, as discussed, exhibited an upwards rising trend until the financial crisis, which may have caused increasing demand for NOK.

Figure 24 - Historical development of the NOK/USD exchange rate and interest rate differential (NIBOR-LIBORUSD)



Source: Compiled by authors/Datastream

In April 2008, the NOK reached its strongest value since the 1970s, quoted at 4.96 NOK/USD. The NOK experienced a drop in value relative to the USD during the financial crisis and a more stable development was evident between 2009-2014, followed by depreciation from the beginning of 2014 and onwards.

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26 In terms of Balance of Payment (BoP) (World Bank, 2017).

The development in the Brent price followed a similar pattern, substantiating the frequently stated theoretical and empirical relationship between the two variables. During the summer of 2014, the oil price began to drop substantially due to the unexpected high supply, particularly by the US, as discussed in section 3.2.1.1. The USD appreciated against the NOK and other currencies, and at year-end 2014 it was speculated whether the Euro and USD would experience a one-to-one relationship (Norges Bank, 2017b). During this period, the US experienced lower interest rates than Norway, although the interest rate differential showed a downward trend since November 2008, which contributed to the strengthening of the NOK until 2014.

5.4.2.2 Description of the nominal effective krone exchange rate, I44

Describing the specific events that has impacted the development in the I44 effective exchange rate is not straight forward, as there are multiple currency pairs underlying the index value. Further, an explanation of the I44 development should include a consideration of the main events affecting the currency pair NOK/EUR[27], as the Euro countries have been Norway's most important trading partners throughout the investigated sample period, accounting for between approximately 32% and 39% of the weighted I44 index. It should also be noted that the USD historically has accounted for between 5% and 7% of the weights, and that the events described for this currency pair also influence the value of the I44 index.

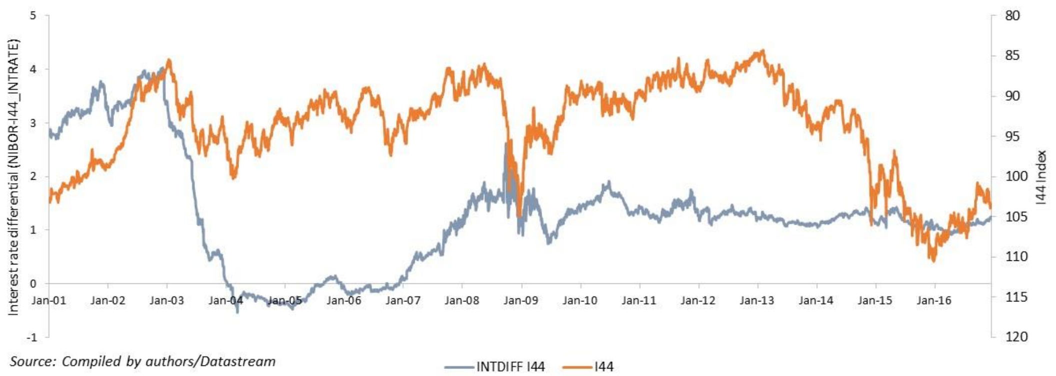
Figure 25 - Historical development of the effective krone exchange rate, I44, and Brent Blend

[1]A rising I44 index value indicates a depreciation of the NOK. Note that the axsis is in reverse order
Source: Compiled by authors/Datastream

[27] The Euro was launched as a common currency within the EU Economic and Monetary Union January 1st 1999 as a virtual currency for accounting purposes and cash-less payments. January 1st 2002 banknotes and coins were taken into use. It is the official currency of 19 out of 28 EU member countries collectively known as the Eurozone. The Euro is the second most important international currency after the US dollar, and is managed by the independent European central Bank (Europa.eu, n.d.).

In the years prior to the financial crisis, the nominal effective krone exchange rate strengthened gradually[28]. Specifically, the value of the NOK against the Euro reached a historical high in January 2003 after appreciating since the introduction of the Euro in 1999. The stronger NOK can among other factors be explained by the increasing interest rate differential between the NIBOR and EURIBOR until early 2003. From January 2003 the NOK began to depreciate, which can be partly explained by the narrowed interest rate differential resulting from monetary policy easing. As mentioned above, the interest rate differential between NIBOR and foreign money market rates dropped substantially between December 2002 and March 2004, due to the significant cuts carried out by the Norwegian central bank.

Figure 26 - Historical development of the effective krone exchange rate, I44, and the interest rate differential (NIBOR-I44 interest rate)



When the oil price dropped in July 2008, the NOK depreciated substantially against the currencies of Norway's major trading partners. The lowest value of the NOK was reached on December 22nd the same year, when the I44 index was quoted at 104.95[29]. In the same period the Norwegian krone depreciated strongly against the Euro, at its highest quoted at 9.95 NOK/EUR on December 29th 2008. As previously described, the global financial crisis affected the Norwegian economy to a lower extent compared to most other advanced economies. Several reasons contributed to this; Norway's economy was in an upturn when the crisis hit, unemployment was at an all-time low, inflation was slightly above target and the key interest was somewhat higher than its normal levels. Additionally, the depreciation of the NOK during 2008 supported inflation and improved competitiveness through rising exports (Norges Bank, 2017a).

In the aftermath of the financial crisis, the NOK appreciated steadily with an associated development in the oil price as a possible part of the explanation. The Euro countries suffered from a severe debt crisis,

[28] An increase in the index equals a depreciation of the nominal effective krone exchange rate, also referred to as a depreciation of the NOK or the Norwegian krone.

[29] Its highest value

high unemployment, and plunging credit ratings, possibly explaining a lower trust in the EUR (Gustavson, 2011).

During the winter of 2013, the I44 exchange rate reached its strongest level since before 1986, resulting from a gradual appreciation following the crisis years. The Norwegian central bank explains the strengthening by improved terms of trade as well as a positive interest rate differential against other countries, seen in figure 24 (Norges Bank, 2017a).

In 2014, the krone again depreciated, a weakening the central bank links to falling oil prices in the period (Norges Bank, 2017a). The trend reversed somewhat during first half of 2015, before the effective krone exchange rate again weakened until the lowest level since 2001 was reached in early January 2016. At that point, the I44 exchange rate had weakened nearly 21% since the oil price started surging in mid-2014.

During 2016, the NOK appreciated, partly due to a strengthened price of oil and a rebuilt belief in the Norwegian economy. Further, the interest rate differential between NIBOR and the I44 interest rate increased. This is due to the fact that the EURIBOR, LIBOR SEK and LIBOR DKK have developed towards negative rates, while NIBOR is still above zero.

5.4.3 Summary of key statistics and correlations

The following table provides an overview of the variables in the dataset, with an explanation of its definition, as well as the mean, standard deviation, minimum and maximum value in the respective samples.

Table 2 - Key statistics for all variables across all subsamples

Variable name (SAS)	Explanation	Mean	Standard deviation	Variance	Minimum	Maximum
Full sample Number of observations = 3595						
Brent	Oil price (USD/bbl)	67.19	31.85	1014.33	16.51	143.95
I44	Nominal effective exchange rate (1995=100)	93.53	5.70	32.49	84.30	110.51
USD	NOK/USD exchange rate	6.71	1.09	1.18	4.96	9.46
I44_INTRATE	Interest rate (%)	2.01	1.50	2.26	-0.06	5.40
LIBOR_USD	Interest rate (%)	1.79	1.78	3.16	0.22	6.37
NIBOR	Interest rate (%)	3.27	1.97	3.89	0.94	7.91
INTDIFF_I44	Interest rate differential, NIBOR - I44_INTRATE (%)	1.26	1.05	1.09	-0.53	4.04
INTDIFF_LIBORUSD	Interest rate differential, NIBOR-LIBORUSD (%)	1.48	1.86	3.47	-2.48	5.70
Sample 2.1 Number of observations = 3150						
Variable name (SAS)	Explanation	Mean	Standard deviation	Variance	Minimum	Maximum
Brent	Oil price (USD/bbl)	69.92	32.97	1087.19	16.51	143.95
I44	Nominal effective exchange rate (1995=100)	91.99	4.08	16.66	84.30	106.03
USD	NOK/USD exchange rate	6.50	0.97	0.95	4.96	9.46
I44_INTRATE	Interest rate (%)	2.28	1.40	1.95	0.28	5.40
LIBOR_USD	Interest rate (%)	1.97	1.83	3.34	0.22	6.37
NIBOR	Interest rate (%)	3.57	1.93	3.72	1.41	7.91
INTDIFF_I44	Interest rate differential, NIBOR - I44_INTRATE (%)	1.28	1.12	1.24	-0.53	4.04
INTDIFF_LIBORUSD	Interest rate differential, NIBOR-LIBORUSD (%)	1.59	1.96	3.83	-2.48	5.70
Sample 2.2/3.3 Number of observations = 445						
Variable name (SAS)	Explanation	Mean	Standard deviation	Variance	Minimum	Maximum
Brent	Oil price (USD/bbl)	47.84	8.47	71.68	26.01	66.33
I44	Nominal effective exchange rate (1995=100)	104.44	2.97	8.81	96.76	110.51
USD	NOK/USD exchange rate	8.25	0.34	0.11	7.37	8.92
I44_INTRATE	Interest rate (%)	0.05	0.07	0.01	-0.06	0.28
LIBOR_USD	Interest rate (%)	0.53	0.24	0.06	0.25	1.00
NIBOR	Interest rate (%)	1.17	0.15	0.02	0.94	1.53
INTDIFF_I44	Interest rate differential, NIBOR - I44_INTRATE (%)	1.13	0.11	0.01	0.92	1.43
INTDIFF_LIBORUSD	Interest rate differential, NIBOR-LIBORUSD (%)	0.64	0.36	0.13	0.16	1.25
Sample 3.1 Number of observations = 1676						
Variable name (SAS)	Explanation	Mean	Standard deviation	Variance	Minimum	Maximum
Brent	Oil price (USD/bbl)	48.76	25.21	635.47	16.51	143.95
I44	Nominal effective exchange rate (1995=100)	93.14	3.97	15.79	85.47	103.22
USD	NOK/USD exchange rate	6.93	1.10	1.21	4.96	9.46
I44_INTRATE	Interest rate (%)	3.22	0.87	0.75	2.10	4.93
LIBOR_USD	Interest rate (%)	3.20	1.61	2.60	1.00	6.37
NIBOR	Interest rate (%)	4.44	2.01	4.05	1.69	7.59
INTDIFF_I44	Interest rate differential, NIBOR - I44_INTRATE (%)	1.22	1.51	2.29	-0.53	4.04
INTDIFF_LIBORUSD	Interest rate differential, NIBOR-LIBORUSD (%)	1.24	2.57	6.61	-2.48	5.70
Sample 3.2 Number of observations = 1474						
Variable name (SAS)	Explanation	Mean	Standard deviation	Variance	Minimum	Maximum
Brent	Oil price (USD/bbl)	93.99	22.64	512.53	34.16	143.95
I44	Nominal effective exchange rate (1995=100)	90.69	3.80	14.45	84.30	106.03
USD	NOK/USD exchange rate	6.01	0.45	0.20	5.03	7.74
I44_INTRATE	Interest rate (%)	1.22	1.09	1.19	0.28	5.40
LIBOR_USD	Interest rate (%)	0.58	0.73	0.54	0.22	4.82
NIBOR	Interest rate (%)	2.57	1.23	1.50	1.41	7.91
INTDIFF_I44	Interest rate differential, NIBOR - I44_INTRATE (%)	1.35	0.22	0.05	0.75	2.62
INTDIFF_LIBORUSD	Interest rate differential, NIBOR-LIBORUSD (%)	1.99	0.61	0.37	1.16	4.22

Below is an overview of the correlation between pairs of variables, which is conducted to measure the degree of the linear association between them. Correlation is measured by the correlation coefficient, and a further theoretical definition is found in appendix 2. It shall be noted that the correlation analysis does not distinguish between regressor and regressand, and the underlying assumption is that both variables are stochastic (Gujarati & Porter, 2009). Correlation does not imply that changes in one variable causes changes in another, rather it suggests that movements in the variables are related to a given extent, measured by the correlation coefficient (Brooks, 2008). As seen below there is a negative correlation between the oil price and the currencies. The negative correlation is stronger for the USD, -0.79, than for the I44 exchange rate, -0.23.

Table 3 – Correlation matrix

Correlation coefficients, full sample Number of observations = 3595								
	I44	USD	Brent	I44_INTRATE	LIBOR_USD	NIBOR	INTDIFF_I44	INTDIFF_LIBORUSD
I44	1.0000	0.8142	-0.5985	-0.2169	-0.0423	-0.1739	-0.0165	-0.1438
P-value		*<.0001*	*<.0001*	*<.0001*	*0.0112*	*<.0001*	*0.3224*	*<.0001*
USD		1.0000	-0.7869	-0.0368	0.0192	0.1813	0.3944	0.1736
P-value			*<.0001*	*0.0275*	*0.25*	*<.0001*	*<.0001*	*<.0001*
Brent			1.0000	-0.2294	-0.2467	-0.2756	-0.1899	-0.0564
P-value				*<.0001*	*<.0001*	*<.0001*	*<.0001*	*0.0007*
I44_INTRATE				1.0000	0.8060	0.8524	0.1709	0.1336
P-value					*<.0001*	*<.0001*	*<.0001*	*<.0001*
LIBOR_USD					1.0000	0.5100	-0.1958	-0.4138
P-value						*<.0001*	*<.0001*	*<.0001*
NIBOR						1.0000	0.6609	0.5720
P-value							*<.0001*	*<.0001*
INTDIFF_I44							1.0000	0.8862
P-value								*<.0001*
INTDIFF_LIBORUSD								1.0000
P-value								

5.5 Treatment of extreme observations

As the figures in section 5.4 illustrate, all the variables include some periods of more extreme values, among others in relation to the financial crisis in the late 2000s. Such events may move the mean of the series up or down during the sample, and in an ideal world we would be able to model these events. More often, econometricians are forced to leave the shifts unexplained, or to adjust for this by imposing a dummy variable. Imposing a dummy for the extreme observations may make the model fit better with the data, and help it pass tests of stationarity. In time series data it is not possible to remove variables from the data, as is often done in cross-sectional data to account for outliers. Further, the definition of what actually accounts for an outlier or an extreme observation is relative and subjective. To account for this in the stationarity analysis procedure, the researchers employed the method of *step dummies*[30] as a remedy (Sjo, 2010). Although, the method did not change the conclusions of the analyses, which resulted in the choice of eliminating the use of dummies.

[30] The method implies that all observations take the value of 0 except for the outlier observations which take the value of one, followed by one observation of minus one (Sjo, 2010).

6. Econometric theory and empirical estimation

In what follows, econometric theory, estimation methods and empirical findings will be presented. The objective is to investigate the possibility of a causal relationship between the price of Brent Blend and the exchange rates, both in the short and long term. Firstly, the variables are subjected to the Dickey-Fuller test for stationarity and the Breusch-Godfrey test for autocorrelation. As non-stationary variables cannot be modelled by *Ordinary Least Squares* (OLS) unless a cointegrating relationship exists, the two-step Engle-Granger procedure will be applied to test for such a relation. In cases where a cointegrating relationship is evident, the analysis will be extended to test for short and long term Granger causality through error correction models. Lastly, Granger causality is tested where no cointegration is found.

Results will be reported according to the significance level of the relevant tests with stars as symbols. ***, **, and * correspond to significance at a 1%, 5%, and 10% level respectively.

6.1 Stationarity

Stationarity analysis can be conducted in several ways and a combination of methods are recommended. The methods applied in the following analysis are based on the those prominently discussed in prior literature.

6.1.1 Theory

A key assumption when working with time series is stationarity of the underlying variables. A time series can be defined as *stationary* if its probability distribution does not change over time, meaning that in a probabilistic sense, it requires the future to be like the past. A stationary time series will revert to its long-term mean, implying that any shock to the series will cancel out over time.

Formally, the properties underlying a stationary time series are the following, where Y_t is a stochastic series (Gujarati and Porter, 2009):

Mean: $$E(Y_t) = \mu \qquad (Eq. 6.1a)$$

Variance： $$var\ (Y_t) = E(Y_t - \mu)^2 = \sigma^2 \qquad (Eq. 6.1b)$$

Covariance： $$\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)] \qquad (Eq. 6.1c)$$

Where;

E denotes expectation

μ is the mean of Y

σ^2 is the variance of Y

γ_k is the covariance (or autocovariance) of Y. γ_k, at lag k represents the covariance between the values of Y_t and Y_{t+k}

If a series is nonstationary, it implies that classical regression results are invalid. Some of the implications are that hypothesis tests, confidence intervals and forecasting can be unreliable. Further, non-stationarity implies that generalization of regressions results to other time periods cannot be done (Brooks, 2008).

A variable can exhibit a persistent long-term movement, known as a *trend*, or a change in the population regression function, known as a *break*, or both. Trends can either be characterized as *deterministic* or *stochastic* (unit root), in which the former is a function of time and the latter is random and non-predictable (Stock & Watson, 2011).

A **pure random walk (RW) model** is the simplest version of a nonstationary stochastic process. If a time series follows a random walk, the series is nonstationary, meaning that over time the variance of a random walk increases, leading the distribution of Y_t to change. This model is a difference stationary process, as a first difference transformation leads it to become stationary. Formally we have (Gujarati & Porter, 2009):

$$Y_t = \beta_1 Y_{t-1} + u_t \qquad (Eq. 6.2a)$$

Where;

Y_{t-1} is the one period lag of Y

u_t is a white noise error term

Secondly, a nonstationary process may follow a **random walk with drift**. Such a model has a tendency to move in one direction or the other, depending on whether the drift is positive or negative. In equation 6.2b below, β_1 represents the drift in the random walk, also known as the drift parameter or the constant.

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t \qquad (Eq. 6.2b)$$

Thirdly, a series might exhibit a **deterministic trend** which is a *trend stationary process*, meaning that it can become stationary by subtracting the expected value of Y_t from Y_t, so called detrending:

$$Y_t = \beta_0 + \beta_1 t + u_t \qquad (Eq. 6.2c)$$

Where;

t is time measured chronologically

Lastly, a nonstationary process may follow a **random walk with drift and trend:**

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 t + u_t \qquad (Eq. 6.2d)$$

Non-stationarity is common for economic time series. Thus, it is important to determine its proper specification prior to conducting further analyses. In order to determine whether a series exhibits stationarity, a variety of tests can be conducted, such as examining the ACF correlogram and line-plots, and applying the Dickey-Fuller and Breusch-Godfrey tests. This enables the determination of whether the variables should be first differenced or regressed on deterministic functions of time - in order to fulfil the stationarity requirement (Gujarati & Porter, 2009).

If the first difference of a variable is stationary, it is defined as an integrated variable of order one, or I(1) (Gujarati & Porter, 2009).

6.1.1.1 Autocorrelation function (ACF) and correlogram

Stationarity can be investigated by analysing the *autocorrelation function* (ACF).

Autocorrelation function at lag k denoted by ρ_k is defined in the following way (Gujarati & Porter, 2009):

$$\rho_k = \frac{\gamma_k}{\gamma_0} = \frac{covariance\ at\ lag\ k}{variance} \qquad (Eq. 6.3a)$$

Plotting the sample autocorrelation of order k, $\hat{\rho}_k$, against k yields a graph known as the population correlogram. The graph will display if lags of the ACF have significant values outside the confidence bans. Time series behave differently, and their nature can be identified by how the autocorrelation function move over time. Generally, a stationary time series can be recognized by a correlogram with values close to zero. Additionally, a stationary process can also be characterised by ACF plots with high initial values that decay rapidly towards zero. On the contrary, nonstationary time series are typically recognized by having high autocorrelation coefficients at different lags that decay slowly towards zero as the lag length increases (Gujarati & Porter, 2009).

Additionally, the null hypothesis of independent residuals is tested up to lag *m,* by the so-called portmanteau statistics*.* The classical portmanteau test statistic is proposed by Box and Pierce:

$$Q_{BP} = n \sum_{k=1}^{m} \hat{\rho}_k^2 \qquad (Eq. 6.3b)$$

Under the null hypothesis of no autocorrelation, the test statistic, Q_{BP}, is distributed as a chi-square, χ^2, with $(m - p - q)$ degrees of freedom (Arranz, 2005).

6.1.1.2 The Dickey-Fuller unit root test

The unit root test has become, out of many, a popular test of stationarity. A unit root is present if $\beta_1 = 1$ in the above equations, 6.2a-6.2d. General OLS hypothesis and test-statistics will be strongly biased if a unit root is present. For the practical application to be feasible for statistical software, a simple algebraic transformation of the regression function is needed. Using the pure random walk in equation 6.2a as an example, the transformation is as follows:

$$Y_t - Y_{t-1} = \beta_1 Y_{t-1} - Y_{t-1} + u_t \qquad (Eq. 6.4a)$$

$$\Delta Y_t = Y_{t-1}(\beta_1 - 1) + u_t \qquad (Eq. 6.4b)$$

By denoting $\delta = (\beta_1 - 1)$, we test the null hypothesis of whether $\delta = 0$ (identical to testing $\beta_1 = 1$), in which a unit root is present. The test allows for various specifications and can be estimated under three different null hypotheses, namely random walk, random walk with drift and random walk with drift and deterministic trend (Gujarati & Porter, 2009).

Thus,

Y_t is a random walk: $\Delta Y_t = \delta Y_{t-1} + u_t$ $(Eq. 6.5a)$

Y_t is a random walk with drift: $\Delta Y_t = \beta_0 + \delta Y_{t-1} + u_t$ $(Eq. 6.5b)$

Y_t is a random walk with drift and deterministic trend: $\Delta Y_t = \beta_0 + \delta Y_{t-1} + \beta_2 t + u_t$ $(Eq. 6.5c)$

The critical values are the so-called Dickey Fuller critical values (see appendix 4), which differ depending on the specifications of the test. If the absolute value of the computed test statistic (tau) exceeds the absolute value of the DF critical values, we reject the hypothesis that $\delta = 0$.

In the unit root test it is assumed that the error term, u_t, is uncorrelated. As for most macroeconomic time series, autocorrelation is likely to be present (Gujarati & Porter, 2009), which is why additional testing by the Breuch-Godfrey test and the augmented Dickey Fuller is conducted.

6.1.1.2 The Breusch-Godfrey test

The Breusch-Godfrey (BG) test is a stepwise general test of autocorrelation. Multiple regressors and lagged values of the dependent variable can be added to the model. The model tests autoregressive schemes up to the p^{th} order, and is here illustrated by a two-variable regression model (Gujarati & Porter, 2009):

$$Y_t = \beta_0 + \beta_1 X_t + u_t \qquad (Eq. 6.6a)$$

Assume the error term u_t follows the pth autoregressive, AR(p) as follows:

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \cdots + \rho_p u_{t-p} + \varepsilon_t \qquad (Eq. 6.6b)$$

Where;

ε_t is a white noise error term

u_{t-p} represent the lagged values of the error term

The null hypothesis tests whether the ρ's equal zero, in which there is no autocorrelation, against the alternative of autocorrelation (Gujarati & Porter, 2009). Formally we have;

H_0: $\rho_1 = \rho_2 = \rho_3 = \cdots = \rho_p = 0$ No autocorrelation

H_1: $At\ least\ one\ \rho_p \neq 0$ Autocorrelation

The test statistics is calculated as $(n-p) * R^2 \sim X_p^2$, where R^2 is the coefficient of determination from the auxiliary regression (Eq. 6.6b), p is the number of lags of residuals and n is the number of observations. The test follows a chi-square distribution, and if this calculated test statistic exceeds the critical chi-square value, the null hypothesis of no autocorrelation is rejected. This indicates that at least one ρ is statistically significantly different from zero (Gujarati & Porter, 2009).

6.1.1.3 The Augmented Dickey-Fuller unit root test

If the error term, u_t, exhibits autocorrelation, the Augmented Dickey-Fuller test can be conducted. It is done by "augmenting" equation 6.5a-6.5c by adding lagged values of the dependent variable, ΔY_t. The critical values from the DF-test are still applicable, and the null hypothesis still test whether $\delta = 0$. The number of lags of the dependent variable to include depends on the nature of the data, and should be enough for the error term to be serially uncorrelated (Gujarati & Porter, 2009). The results of the Breusch-Godrey test can be used as an indicator when determining how many lags to include in the ADF test (Hall & Asteriou, 2015).

The ADF test can be carried out using one of the following three model specifications;

Y_t is a random walk: $\Delta \mathrm{Y_t} = \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$ $(Eq. 6.7a)$

Y_t is a random walk with drift: $\Delta \mathrm{Y_t} = \beta_0 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$ $(Eq. 6.7b)$

Y_t is a random walk with drift and deterministic trend: $\Delta Y_t = \beta_0 + \beta_1\, t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$ $(Eq. 6.7c)$

Which of the three model specifications presented in equation 6.7a-6.7c to apply is questionable unless the data generating process is known. The graphical line-plot analysis is however useful in determining the appropriate specification.

6.1.2 Estimation method

In the following stationarity analysis, the Breusch-Godfrey test is used to indicate the number of lags to include in the Augmented Dickey-Fuller unit root rest. A time series can exhibit autocorrelation without violating the stationarity condition, as long the autocorrelation is not too high. The ADF test will primarily be conducted including the number of lags suggested by the BG test. However, for all variables, lag 1 to 5 is included to capture autocorrelation during a week (excluding weekends). If the BG test indicates autocorrelation up to lag 10, the ADF test will be conducted with a default number of lags equal to lag 1 to 5, 10 and 20, where 10 and 20 to check for autocorrelation of higher lags. The time series variables in the sample is not believed to exhibit any particular seasonality, with the exception of the oil price as discussed in section 5.1.2. As these variations are summer and winter based we do not expect to be able to capture this with the daily nature of the data, hence we do not find reasons for including a high number of lags in the ADF test. The authors feel confident that this methodology will ensure fair stationarity conclusions, as the test is supplemented by line- and ACF plots from the sample which provide relatively clear indication on the nature of the time series in question. Based on the results from the graphical inspection, the ADF test will be conducted assuming that all relevant time-series exhibit a stochastic trend, meaning that equation 6.7b (random walk with drift) is viewed to be the correct specification.

The stationarity analysis is not conducted on INTDIFF_LIBORUSD and INTDIFF_I44[31], as linearly transformed series are expected to have the same characteristics as the time series itself (Koop, 2007). Thus, given that LIBOR, NIBOR and I44 interest rates are stationary, the differential between them is also expected to be.

[31] This also apply for the CPI_DIFF introduced in the robustness section

6.1.3 Empirical findings

Through the example of the variable logBrent, the following explains the application of the discussed tests. The line plot presented to the left in figure 27 below yields an initial clue about the nature of the time series, as it illustrates the behaviour of the variable over time. Line plots are useful to reveal if the variable exhibits any trending behaviour (Gujarati & Porter, 2009).

Figure 27 – Line and ACF plot for logBrent

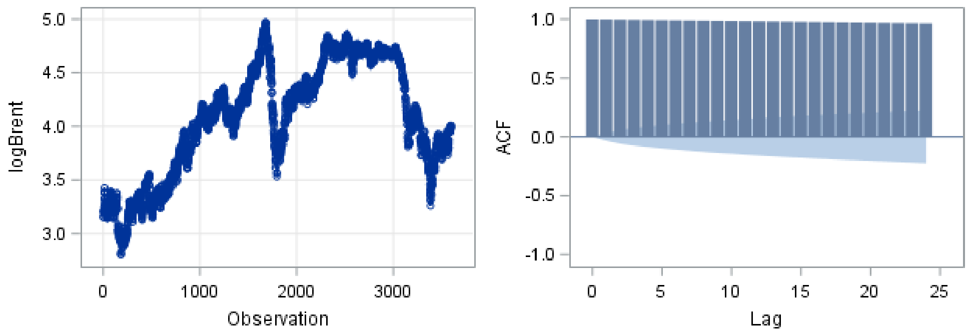


Table 4 – Autocorrelation analysis for logBrent

Lag	Chi-Square test statistic	P-value	Autocorrelations coefficients					
1-6	9999.99	<.0001	0.9990	0.9970	0.9960	0.9940	0.9930	0.9910
7-12	9999.99	<.0001	0.9900	0.9890	0.9870	0.9860	0.9840	0.9830
13-18	9999.99	<.0001	0.9820	0.9800	0.9790	0.9770	0.9760	0.9740
19-24	9999.99	<.0001	0.9730	0.9720	0.9700	0.9680	0.9670	0.9650

P-value indicates the significane level of the chi-square test statistic: <.0001 indicates significane at 0.01%.

The plot demonstrates what can be argued to look like a random walk. Over time, the series has both rising and falling behaviour, and has experienced changes in the level over the sample period, suggesting that is exhibits a stochastic trend (unit root) rather than a deterministic time trend.

In the ACF plot to the right in figure 27 above, we see what is described as general for nonstationary time series. Autocorrelation coefficients are high and decline slowly towards 0. The χ^2 (Chi-square) test statistic presented in table 4 above shows that coefficients are highly significant at 1% level, leading us to reject the null hypothesis, implying that there is severe autocorrelation in the time series. The above is general for *all* the economic time series analysed in the sample, see summary table 8 in the end of the section 6.1.3.1

The BG test indicates that zero lags are necessary to correct for autocorrelation, hence we are back to the Dickey-fuller unit root test[32] specified in equation 6.5b. The absolute value of the test-statistic (tau-value) is 1.91 which is below the Dickey-fuller critical value of 3.43 at a 10% significance level, as seen in table 5. The null hypothesis of a unit root can therefore not be rejected against the alternative of stationarity. The same conclusions are reached for *all* variables analysed, with few exceptions.

In subsample 3.2, the ADF test concluded that the interest rate variables are stationary. However, respective correlograms (see table 8) indicates the opposite. These variables exhibited high volatility in the period examined, which includes both the financial crisis and the 2014 oil-price drop. The validity of statistical tests can suffer when variables exhibit large variations, which is why the authors have chosen to emphasize the ACF plots, and conclude that the variables in fact are non-stationary.

A summary of the unit root tests for all variables, in all samples, can be seen in table 5 below. The full SAS[33] output is presented in appendix 6.

[32] Random walk with drift, as established for all variables

[33] The applied Statistical Analysis Software (SAS)

Table 5 - Stationarity analysis for all samples, variables in level form

Variables in level form					
Name	Model specification	BG-test conclusion	Lag(s) in ADF-test	Test statistic (tau-value)	Conclusion (significance)
			Full Sample		
logBrent	RW with drift	0	0	-1.91	Unit root
log I44	RW with drift	6	6	-2.14	Unit root
log USD	RW with drift	0	0	-1.66	Unit root
I44_INTRATE	RW with drift	>10	10/20	-1.26/-1.61	Unit root
LIBORUSD	RW with drift	>10	10/20	-2.01/-2.05	Unit root
NIBOR	RW with drift	>10	10/20	-1.83/-1.84	Unit root
			Sample 2.1		
logBrent	RW with drift	0	0	-1.75	Unit root
log I44	RW with drift	3	3	-2.76	*Stationarity
log USD	RW with drift	0	0	-2.14	Unit root
I44_INTRATE	RW with drift	>10	10/20	-1.21/-1.63	Unit root
LIBORUSD	RW with drift	>10	10/20	-1.74/-1.71	Unit root
NIBOR	RW with drift	>10	10/20	-1.68/-1.72	Unit root
			Sample 2.2[1]		
logBrent	RW with drift	0	0	-1.54	Unit root
log I44	RW with drift	4	4	-1.85	Unit root
log USD	RW with drift	4	4	-2.29	Unit root
I44_INTRATE	RW with drift	>10	10/20	-1.95/-1.46	Unit root
LIBORUSD	RW with drift	>10	10/20	0.18/0.33	Unit root
NIBOR	RW with drift	0	0	-2.07	Unit root
			Sample 3.1		
logBrent	RW with drift	0	0	0.16	Unit root
log I44	RW with drift	5	5	-2.45	Unit root
log USD	RW with drift	5	5	-0.63	Unit root
I44_INTRATE	RW with drift	>10	10/20	-0.42/-0.53	Unit root
LIBORUSD	RW with drift	>10	10/20	-1.42/1-.47	Unit root
NIBOR	RW with drift	>10	10/20	-1.03/-1.04	Unit root
			Sample 3.2		
logBrent	RW with drift	6	6	-0.99	Unit root
log I44	RW with drift	0	0	-1.53	Unit root
log USD	RW with drift	0	0	-1.71	Unit root
I44_INTRATE	RW with drift	>10	10/20	-3.82/-3.98	***Stationarity
LIBORUSD	RW with drift	>10	10/20	-3.43/-3.28	***Stationarity
NIBOR	RW with drift	>10	10/20	-3.46/-3.32	***Stationarity

[1] *Identical to sample 3.3*

Critical values applicable for RW with drift: 10% = -2.57, 5% = -2.86, 1% = -3.43

6.1.3.1 Correcting for non-stationarity

Proper transformation is required for nonstationary series before further analysis can be conducted. By definition, a time series that exhibits a unit root becomes stationary by taking the first difference of the variable. This has been done for the logarithm of Brent, and its line plot in figure 28 presents a development which now looks like a stationary process. The observations vary around a constant mean, and the series' variance and auto covariance seem fairly constant. Similar characteristics are achieved for *all* variables, indicating that they are integrated of order one, I(1), as summarized in table 8 presented in the end on this section.

Figure 28 - Trend and correlation analysis for ΔlogBrent

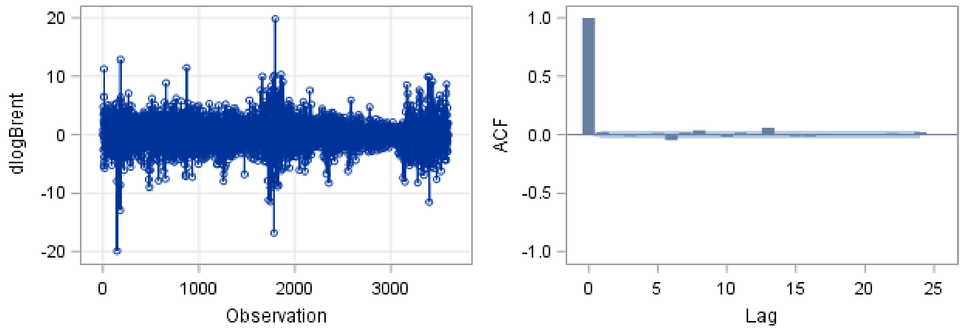


Table 6 – Autocorrelation analysis for ΔlogBrent

Lag	Chi-Square test statistic	P-value	Autocorrelations coefficients					
1-6	11.7800	0.0671	0.0230	0.0030	-0.0120	-0.0050	0.0140	-0.0490
7-12	21.1200	0.0487	0.0190	0.0390	0.0030	-0.0190	0.0180	0.0080
13-18	36.5700	0.0060	0.0610	-0.0020	-0.0140	-0.0150	0.0090	-0.0010
19-24	39.1000	0.0266	0.0000	0.0000	0.0030	0.0120	-0.0060	0.0220

P-value indicates the significane level of the chi-square test statistic

The ACF plot to the right in figure 28 shows few and very limited significant spikes outside the confidence bans[34] indicating that the time series is stationary and white noise is achieved. Additionally, the autocorrelation coefficients in table 6 are low and insignificant.

It should be noted that although a series in level form is recognized as a "random walk with drift", the model specification will change when we operate with the first difference of the variable. This is because the drift term, β_0, is mathematically removed, which can be shown by the following calculation:

We have:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t \qquad (Eq. 6.8a)$$

$$Y_{t-1} = \beta_0 + \beta_1 Y_{t-2} + u_{t-1} \qquad (Eq. 6.8b)$$

Taking the difference implies subtracting equation 6.8b from equation 6.8a:

$$Y_t - Y_{t-1} = \beta_0 + \beta_1 Y_{t-1} + u_t - (\beta_0 + \beta_1 Y_{t-2} + u_{t-1}) \qquad (Eq. 6.8c)$$

$$Y_t - Y_{t-1} = \beta_1 (Y_{t-1} - Y_{t-2}) + (u_t - u_{t-1}) \qquad (Eq. 6.8d)$$

[34] If $k = 0, \rho_0 = 1$ (Gujarati & Porter, 2009)

The Breusch-Godfrey test on the $\Delta logBrent$ variable indicates that there is autocorrelation at lag 10, see table 7. The absolute tau-values on lag 10 and 20 are 17.81 and 12.49 respectively, much higher than the ADF-critical value of 2.58 at a 1% significance level. The null hypothesis of a unit root can therefore be rejected against the alternative of stationarity. The above conclusion is drawn on the first difference of the *all* variables, for all sub-samples, see summary table 7 below as well as full SAS output in appendix 6.

Table 7 - Stationarity analysis for all samples, variables in differenced form

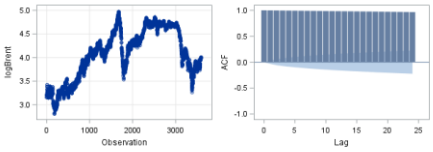
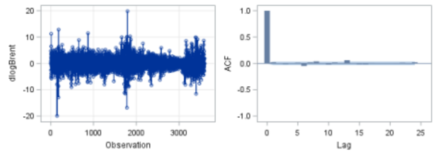
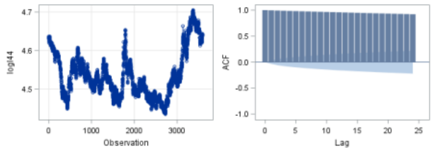
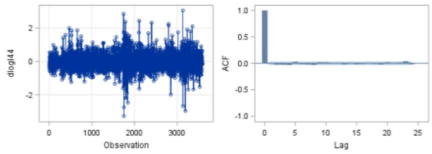
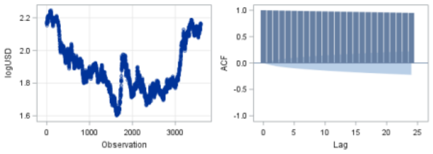
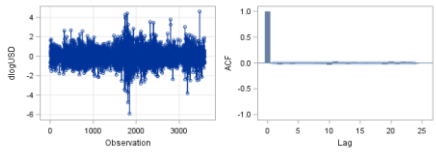
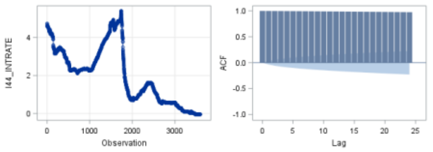
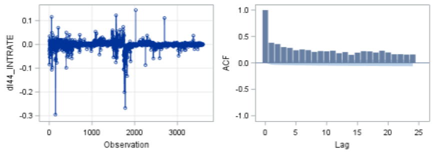
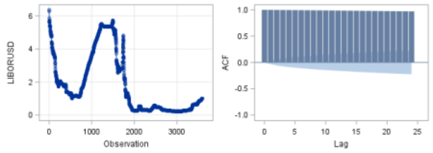
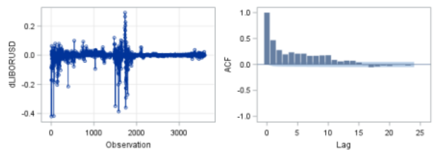
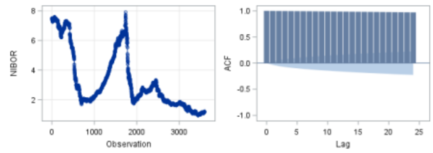
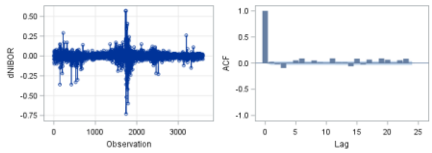
Variables in first differences, Δ					
Name	Model specification	BG-test conclusion	Lag(s) in ADF-test	Test statistic (tau-value)	Conclusion (significance)
			Full Sample		
ΔlogBrent	Pure RW	>10	10/20	-17.81/-12.49	***Stationarity
ΔlogI44	Pure RW	1	1	-43.44	***Stationarity
ΔlogUSD	Pure RW	1	1	-60.01	***Stationarity
ΔI44_INTRATE	Pure RW	>10	10/20	-9.95/-6.85	***Stationarity
ΔLIBORUSD	Pure RW	>10	10/20	-13.14/-11.93	***Stationarity
ΔNIBOR	Pure RW	>10	10/20	-14.37/-9.33	***Stationarity
			Sample 2.1		
ΔlogBrent	Pure RW	10	10/20	-16.23/-11.19	***Stationarity
ΔlogI44	Pure RW	2	2	-34.13	***Stationarity
ΔlogUSD	Pure RW	0	0	-56.07	***Stationarity
ΔI44_INTRATE	Pure RW	>10	10/20	-9.30/-6.39	***Stationarity
ΔLIBORUSD	Pure RW	>10	10/20	-12.32/-11.18	***Stationarity
ΔNIBOR	Pure RW	>10	10/20	-13.29/-8.67	***Stationarity
			Sample 2.2		
ΔlogBrent	Pure RW	0	0	-20.36	***Stationarity
ΔlogI44	Pure RW	3	3	-11.91	***Stationarity
ΔlogUSD	Pure RW	3	3	-11.77	***Stationarity
ΔI44_INTRATE	Pure RW	>10	10/20	-4.30/-5.57	***Stationarity
ΔLIBORUSD	Pure RW	9	9	-3.23	***Stationarity
ΔNIBOR	Pure RW	0	0	-22.28	***Stationarity
			Sample 3.1		
ΔlogBrent	Pure RW	10	10/20	-12.49/-9.25	***Stationarity
ΔlogI44	Pure RW	4	4	-17.38	***Stationarity
ΔlogUSD	Pure RW	4	4	-17.59	***Stationarity
ΔI44_INTRATE	Pure RW	>10	10/20	-8.35/-6.39	***Stationarity
ΔLIBORUSD	Pure RW	>10	10/20	-8.64/-5.67	***Stationarity
ΔNIBOR	Pure RW	>10	10/20	-9.30/-5.59	***Stationarity
			Sample 3.2		
ΔlogBrent	Pure RW	10	10/20	-10.24/-6.29	***Stationarity
ΔlogI44	Pure RW	0	0	-39.02	***Stationarity
ΔlogUSD	Pure RW	>10	10/20	-11.42	***Stationarity
ΔI44_INTRATE	Pure RW	>10	10/20	-5.38/-3.63	***Stationarity
ΔLIBORUSD	Pure RW	>10	10/20	-8.24/-9.46	***Stationarity
ΔNIBOR	Pure RW	>10	10/20	-9.05/-6.20	***Stationarity

[1] *Identical to sample 3.3*

Critical values applicable for simple RW 10% = -1.61, 5% = -1.95, 1% = -2.58

The following table summarises the time-series properties and autocorrelation functions for the variables in level form and in first differences in the full sample analysis.

Table 8 - Summary of stationarity analysis*:* Line and ACF plots, full sample

Overview of line and ACF plots Full Sample		
Variable	Undifferenced variable	First difference of variable
logBrent		
log I44		
log USD		
I44_INTRATE		
LIBORUSD		
NIBOR		

The above illustrations are relatively general for the other sub-samples in question and their respective summary tables can therefore be found in appendix 7.

As mentioned in section 5.5, step dummies were applied to take care of extreme values. This was done for the interest rate variables, as they were found to exhibit moist noise, without functioning as desired. Conclusions were unchanged, and the method was therefore not applied. As seen above, all ACF plots indicate stationarity of first differenced variables.

6.4 Cointegration

As a limited amount of published literature focuses on the whether there exists a cointegrating relationship between the value of the *Norwegian krone* and the oil price, the following section is carried out with the purpose of investigating whether such a relationship exists. An investigation of a long-term relation will be done between the following variable pairs: Brent and the I44, as well as the NOK/USD exchange rates, respectively. Economic theory concerning oil exporting countries yields reasons to expect a long-term relation between the analysed exchange rates and Brent. It is anticipated that a rise in the price of oil will result in more favourable terms of trade, and a subsequent strengthening of the exchange rate, as presented in the literature review. Further, the belief of a cointegrating relation between the NOK/USD exchange rate and Brent is explained throughout literature by the fact that crude oil is quoted in USD, and that a depreciation of the USD against other currencies has tended to be followed by a rise in the price of oil. Thus, the depreciation of the dollar makes oil relatively cheaper in the currencies that the USD is quoted against. This sparks the authors interest of investigating whether there exists a long-run co-movement.

As all variables were found to be nonstationary, one could expect spurious regressions, as discovered by Yule (1926). Spurious regressions can carry on in nonstationary time series even in large samples. The possibility although exists that the two series share the same stochastic trend, implying that regression is not spurious, as the shared stochastic trend represents a long-run equilibrium relationship. Engle and Granger presented their theory of cointegration in their paper *Co-Integration and Error Correction: Representation, Estimation and Testing* from 1987, but the concept of cointegration was introduced by Granger (1981) and Granger and Weiss (1983). Engle and Granger (1987) find cointegration between variables such as income and consumption, short and long-term interest rates, and nominal GNP[35] and M2[36] (Engle & Granger, 1987). Brooks (2008) further presents examples of financial variables which may exhibit cointegration, such as spot and future prices for given commodities as well as equity prices and dividends. As presented in the *Granger Representation Theorem*, cointegration further infers that at least one of the two variables must Granger-cause the other, while bilateral causality is also a possibility. Also, cointegration implies that there exists a valid error correction representation of the data (Engle & Granger, 1987).

[35] Gross national product. Measures the production by any person or company from a specific country, regardless of where the production is taken place (Amadeo, 2017).
[36] A measure of money supply. M1 (coins and notes in circulation and other money equivalents that are easily convertible to cash) plus short-term deposits in banks and 24-hour money market funds (Financial Times, 2017).

A vast amount of previous research has been carried out with the interest of investigating the long-term relationship between the oil prices and various currencies. In addition to causality analyses, such as the before mentioned paper by Krugman (1980) and Golub (1983), several researches have employed cointegration tests and error correction models to explore the causality direction over time. Amano & Norden (1998a, 1998b), Benassy-Quere, Mignon, & Penot (2007) and Chaudhuri & Daniel B.C. (1997) among others, find that the oil price and the US dollar exchange rate are cointegrated, and that causation runs from the oil price to the dollar exchange rate.

6.4.1 Theory

According to Brooks (2008), nonstationary variables were usually modelled by taking the first differences when the concept of nonstationarity was introduced in the 1970s. The problem with first difference-based models is that they have no long-run solution. Consider the two series Y_t and X_t, which are both I(1)[37]. One may consider modelling the series by estimating a model on their first differences:

$$\Delta Y_t = \beta_0 \Delta X_t + u_t \qquad (Eq. 6.9)$$

A long-run variable is defined as a variable that is no longer changing, and has hence converged upon its long-term value. This yields that: $Y_t = Y_{t-1} = Y$ and $X_t = X_{t-1} = X$. As $\Delta Y_t = Y_t - Y_{t-1}$, and $\Delta X_t = X_t - X_{t-1}$, the equation above cancels out, and the model has no long-term solution (Brooks, 2008).

Cointegration refers to the special case where two I(1)-series have a stochastic trend in common, or more specifically when Y and X are I(1)[38] but the error term in the relationship between them is stationary. Time series which are non-stationary can still "move together" over time, implying that there might exist some forces causing the two series to be bound by some relationship in the long run. Two cointegrated series can also be viewed as a long-term or equilibrium phenomenon, as deviations from the variable-relationship might occur in the short run, while in the long-run their association will return. Thus, the difference between the two series will return to a stable, constant value after being disturbed by a shock (Brooks, 2008).

A simplified cointegration regression with one coefficient and no trend is expressed as follows (Gujarati & Porter, 2009):

$$Y_t = \beta_1 X_t + u_t \qquad (Eq. 6.10)$$

[37] Integrated variable of order one, cf. section 6.1
[38] Higher order of integration is possible.
However, it is important to remember that the order of integration of Y and X must match for the regression to make economic sense (REED College, 2015).

Suppose both Y_t and X_t are integrated of order one, hence are nonstationary. If, for some coefficient β_1, (the cointegration coefficient) $Y_t - \beta_1 X_t$ is integrated of order zero, then X_t and Y_t are said to be cointegrated, and share a stochastic trend. Isolating u_t, implies that the residuals from the cointegration regression, $Y_t - \beta_1 X_t$, are obtained (Stock & Watson, 2011).

To decide whether a set of time series contain cointegrated variables, several methods should be applied. These include expert knowledge, applying economic theory, graphical analysis as well as statistical tests (Gujarati & Porter, 2009). Decisions also need to be made on whether to include and intercept and/or a time trend in the cointegration regression. Including an intercept implies that we allow for the long-term relationship among the variables to have a mean different from zero[39], while the inclusion of a time trend will imply constant growth (Kennedy, 2008).

6.4.1.1 Engle-Granger Test for cointegration

The test for cointegration is conducted by obtaining the residuals from the cointegration regression of interest, and test whether the residuals exhibit stationarity by the DF- or ADF tests. Since the unit root tests are carried out on the residuals, they should have mean zero, and an intercept is therefore often not included. Additionally, it is important to notice that since the estimated residuals are based on the estimated cointegrating parameter, the relevant critical values should be the specific values calculated by Engle and Granger (1987) presented in appendix 5. Formally, from the estimated cointegration regression (equation 6.11a), we obtain the residuals (equation 6.11b):

$$Y_t = \hat{\beta}_0 + \hat{\beta}_1 X_t + \hat{u}_t \qquad (Eq.\ 6.11a)$$
$$\hat{u}_t = Y_t - \hat{\beta}_0 - \hat{\beta}_1 X_t \qquad (Eq.\ 6.11b)$$

The DF test takes the following form (Gujarati & Porter, 2009):

$$\Delta\hat{u}_t = \delta\hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.12)$$

Where:

ε_t is a white noise distributed error term

The hypothesis tested is the following:

$H_0: \delta = 0$ No cointegration

$H_1: \delta < 0$ Cointegration

[39] Random walk with drift, cf. section 6.1.1

The above cointegration regression 6.11a was represented as a bivariate relation. However, several variables might be of interest, and the model can accordingly be expanded to allow for several explanatory variables, resulting in a multiple regression model. The Engle-Granger test presented above can still be carried out in the same manner, but when three or more variables are included, new difficulties arise. Namely the possibility of having more than one cointegrating relationship. If *K* variables are included, at most *K-1* cointegrating relationships can exist. In this case, one option is to use Johansen's multivariate Vector Autoregression (VAR) method. Alternatively, one can carry out multiple Engle-Granger tests and include different combinations of the variables in question (Koop, 2007).

6.4.1.2 The Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) unit root test and Shin cointegration test

For many time series, standard unit root tests fail to reject the null hypothesis of a unit root. This is due to the fact that classical hypothesis tends to favour the acceptance of the null hypothesis unless there is strong evidence against it. Thus, the explanation for frequent failure to reject a unit root is a combination of the low power of among others the Dickey-Fuller test, and the fact that most economic time series *"are not very informative about whether or not there is a unit root […]"* (Kwiatkowski, Phillips, Schmidt, & Shin, 1992). For this reason, there have been developed tests favouring stationarity (in comparison to unit root tests), like the KPSS test. The joint use of stationarity and unit root tests is known as *confirmatory data analysis* (Brooks, 2008). For the results to be robust, both types of tests should yield the same results.

The null hypothesis of the KPSS test states that the time series is stationary, in contrast to the Dickey-Fuller and Augmented Dickey-Fuller test. The former therefore tends to discard a random walk more often. The null hypothesis depends on whether or not an intercept is included. If an intercept is excluded, the KPSS tests three null hypotheses: zero mean, single mean, and deterministic trend (Kwiatkowski et al., 1992).

The Shin cointegration test works as a multivariate extension of the KPSS. Kwiatkowski, Phillips, Schmidt and Shin (1992) developed the stationarity test for the univariate case, using the component model. Shin extended this method to test the cointegration regression where non-stationary, I(1), regressors are added (Shin, 1994).

The underlying assumption is that the series is expressed as the sum of the deterministic trend, random walk and stationary error, also known as the random walk with drift around a deterministic trend:

$$Y_t = \beta_0 + \beta_1 t + r_t + u_t \qquad (Eq. 6.13a)$$
$$r_t = r_{t-1} + e_t \qquad (Eq. 6.13b)$$

Where

β_0 is an intercept

$\beta_1 t$ is a deterministic trend component

r_t is a random walk component

u_t is a stationary error

$e_t \sim iid(0, \sigma_e^2)$

The hypothesis is formulated as follows:

$H_0: \sigma_e^2 = 0$ Trend stationarity
$H_1: \sigma_e^2 \neq 0$ Random walk

The main hypothesis is that $\sigma_e^2 = 0$. If the $\beta_1 = 0$ restriction is added, the process is specified as level stationary. If both $\beta_1 = 0$ and $\beta_0 = 0$, we test for zero-mean stationarity. The test is thus extended to test the joint hypothesis of zero mean stationarity or level stationarity (Hobijn, Franses, & Ooms, 1998).

6.4.2 Estimation method

If the dependent variable is determined by other factors than those associated with the included independent variable(s), then the omission of these factors should theoretically prevent findings of statistically significant cointegrating relationships (Amano & Norden, 1998b). Evidence of cointegration on the other hand, indicates that the included variables are able to capture the dominant source of persistent innovations in the dependent variable over the sample period (Amano & Norden, 1998).

To the potential cointegration relations, relevant control variables have therefore been added to review the robustness of the results as well as account for the potential necessity of these to establish a cointegrating relationship. When testing for cointegration between the I44 exchange rate and the Brent Blend oil price, the interest rate differential between NIBOR and the I44 interest rate is considered relevant. This is to capture any deviation between the respective interest rates and thus potential depreciation/appreciation pressure on the exchange rates, cf. the interest rate parities.

Similar argumentation is used when testing for cointegration between the NOK/USD exchange rate and the oil price. However, the interest rate differential applied in this case is represented by the difference between LIBOR USD and NIBOR interest rates.

The interest rate level in the US is represented by LIBOR USD, which is included due to the desire of capturing the close relation between US interest level, the value of the dollar, and the oil price. Interest rates are set by the central bank to impact the economic activity and cuts are often done to stimulate the economy. Higher economic activity is often seen by rising production levels. As energy is an essential input in industrial production, the demand for oil and other energy sources is therefore expected to rise, which subsequently is expected to impact the oil price (Bayar & Kilic, 2014).

When control variables are added, we run into the aforementioned potential problem of having more than one cointegrating relationship. One potential solution is to apply the Johansen test, however, this analysis is beyond the authors main interest.

If cointegration is established, there is no need to worry about spurious regressions. One important limitation is although still present. One cannot draw inference about the significance of parameters using resulting test statistics and P-values, because the variables independently are non-stationary (Brooks, 2008). Hence, we cannot with certainty say whether the estimated coefficients are significantly different from zero, implying the one should be cautious in interpreting the estimated coefficients. However, in the proceeding, the authors will interpret the coefficients under the assumption of statistical significance. Due to the unreliability of the significance levels obtained, they will not be reported in what follows.

As discussed, the determination of whether to include an intercept or time trend should reflect the nature the underlying variables, established in the stationarity analysis. All variables analysed in the sample have previously been established independently to follow a "random walk with drift", leading us to include an intercept in the respective cointegration models.

In practical application, the KPSS gives the option to choose the applied kernel used in the test. This can either be *Newey-West/Bartlett* or *quadratic spectral (QS).* The equations behind the QS specification yields a lag length that the authors find to be too low for the expected autocorrelation in the series. The KPSS specification applied in the following therefore includes the kernel specified as Newey-West/Bartlett, as this gives room for the expected autocorrelation by including more lags.

Financial theory may suggest whether regressions should be estimated using the levels or the logarithms of the variables. It should be noted that if a series is cointegrated in levels, it will also be cointegrated in logarithmic form (Brooks, 2008). In all proceeding models, the variables will be in logarithm form if this is allowed by their nature[40], due to the benefits described in section 5.2.

An overview of the models tested is found in table 9. The models have also been tested in the reverse specification, by having $logBrent$ as the dependent variable. This is done to verify the strength of the results. An elaboration of the reverse model specification will only follow in cases where the two models yield contradicting results.

Table 9 - Overview of cointegration model specifications

Overview of cointegration models tested (applicable in all samples)	
Model specification	
I44 and Brent	
Model 1	$\log I44_t = \beta_0 + \beta_1 \log Brent_t + u_t$
Model 2	$\log I44_t = \beta_0 + \beta_1 \log Brent_t + \beta_2 INTDIFF\_I44_t + \beta_3 LIBOR\_USD_t + u_t$
NOK/USD and Brent	
Model 3	$\log USD_t = \beta_0 + \beta_1 logBrent_t + u_t$
Model 4	$\log USD_t = \beta_0 + \beta_1 \log Brent_t + \beta_2 INTDIFF\_LIBORUSD_t + \beta_3 LIBOR\_USD_t + u_t$

[40] Variables that exhibit periods of negative values cannot be log-transformed, cf. section 5.2

6.4.3 Empirical findings

Table 10 below presents an overview of the cointegration findings. Each model specification has been tested in all sub-samples with, the interest of analysing if cointegrating relationships exist and whether the relations possibly have changed over time. Cointegration is only found in subsample 2.2[41], and will be further analysed in the following. As previously described, subsample 2.2 represents the relatively stable period after the oil price hit bottom in early 2015, until December 2016. During this period, the oil price rose steadily and interest rates stabilized.

It should be noted that there might exist cointegrating relations in the subsamples preceding 2.2 which is not detected due to noise in the data, as this makes statistical modelling relatively more challenging. The phenomenon coincides with the findings of Zhang (2013), who explains that a significant cointegrating relation is only found when controlling for structural breaks. Brahmasrene et al., (2014) argue that currency fluctuations can be minimized when oil prices are stabilized. During periods of uncertainty, financial variables often possess above normal volatility, which may lead market participants to act irrationally.

Table 10 - Overview of stationarity analysis on regressions residuals, sample 2.2

Overview of models where cointegration was established Sample 2.2				
Model	Model specification	# of lags to ensure no sign. autocorr[1]	Test statistic (tau-value)	Stationarity conclusion on regression residuals
	I44 and Brent			
Model 1	$\log I44_t = \beta_0 + \beta_1 \log Brent_t + u_t$	1	*-3.14	Stationarity
Model 2	$\log I44_t = \beta_0 + \beta_1 \log Brent_t + \beta_2 INTDIFF\_I44_t + \beta_3 LIBOR\_USD_t + u_t$	2	*-3.16	Stationarity
	NOK/USD and Brent			
Model 3	$\log USD_t = \beta_0 + \beta_1 logBrent_t + u_t$	9	*-2.98	Stationarity
Model 4	$\log USD_t = \beta_0 + \beta_1 \log Brent_t + \beta_2 INTDIFF\_LIBORUSD_t + \beta_3 LIBOR\_USD_t + u_t$	9	*-3.16	Stationarity

[1] *The number of lags of the models residuals included in the ADF test*

Engle-Granger critical values (applicable to ADF test): 10% = -2.84, 5% = -3.17,1% = -3.77

6.4.3.1 The relation between the I44 exchange rate and the oil price

Model 1

Model 1 tests whether the underlying hypothesis of a cointegrating relationship between the effective krone exchange rate I44 and the oil price can be confirmed. Formally we have:

$$logI44_t = \beta_0 + \beta_1 logBrent_t + u_t \qquad (Eq. 6.14a)$$

[41] Identical to subsample 3.3

Due to Norway's high dependency on oil, we can contemplate if it is reasonable to believe that the exchange rate and the oil price can drift apart over longer time horizons. As previously discussed, economic theory suggests that for oil-exporting nations as Norway, rising (falling) oil prices will in isolation lead to an appreciation (depreciation) of the exchange rate because of improved (deteriorated) terms of trade (Bernhardsen & Røisland, 2000).

The estimation yields the following results:

Table 11 - Cointegration coefficient estimates, model 1

Dependent variable = logI44		
Variable	Estimate	Std. Error
Intercept	5.1247	0.0168
logBrent	-0.1237	0.0044

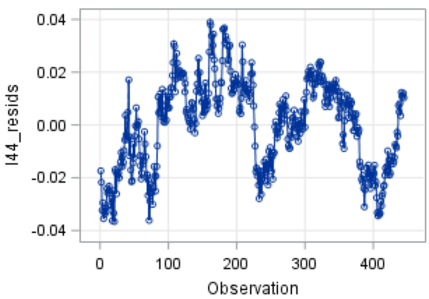
Based on the Breusch-Godfrey analysis, the ADF test is carried out including one lag of the dependent variable. The subsequent unit root test on the residuals, $\hat{u}_t$, from the regression (Eq. 6.14a) indicates stationarity, as the null hypothesis of a unit root is rejected at 10%, seen in table 12 below. The ACF plot in figure 29 shows that autocorrelation coefficients fall relatively fast towards zero. It should be noted that the speed of deterioration towards zero could have been higher, and the results are therefore evaluated as borderline. The KPSS-test fails to reject the null hypothesis of stationarity at a 5% significance level, indicating again that the stationarity result is somewhat borderline.

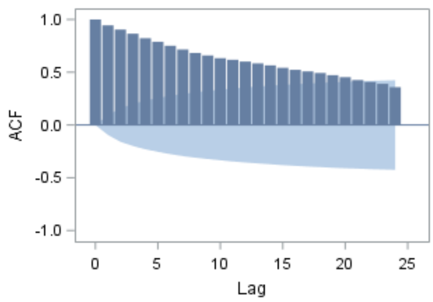
Table 12 - Stationarity analysis on regression residuals, model 1

Stationarity analysis on regression residuals		
	ADF test	KPSS test
# of lags to ensure no sign. autocorr	1	17
Test statistic	*-3.14	*0.29
Conclusion	Stationarity	Stationarity

Engle-Granger critical values (applicable to the ADF test): 10% = -2.84, 5% = -3.17, 1% = -3.77

Figure 29 - Line and ACF plot on regression residuals, model 1





The estimated model is presented in equation 6.14b:

$$\widehat{logI44}_t = 5.12 - 0.12logBrent_t \qquad (Eq. 6.14b)$$

The estimated coefficient on $logBrent$, $\hat{\beta}_1$, represents the long-run multiplier. Assuming coefficients are significant, we can say that a 1% rise in the oil price is associated with a 0.12% decrease in the I44 index, implying an appreciation of the NOK, in line with expectations.

Model 2

Model 2 is represented by the following, which is an extension of model 1 above. The model is tested to investigate whether the cointegrating relationship found in model 1 is stronger when control variables are included.

$$logI44_t = \beta_0 + \beta_1 logBrent_t + \beta_2 INTDIFF\_I44_t + \beta_3 LIBOR\_USD_t + u_t \qquad (Eq. 6.15a)$$

The underlying hypothesis is that we expect a long-run equilibrium between the I44 exchange rate and the oil price, when controlling for the interest rate LIBOR USD as well as the interest rate differential between the I44 interest rate and NIBOR. In addition to the economic theories on the association between the value of the Norwegian krone and the oil price presented in section 3.1, economic theory presents explanation for how exchange rates are expected to move given deviations between the respective interest rates. As explained, the interest rate differential is equal to the expected change in the spot exchange rate. When market participants act on this arbitrage opportunity, spot and futures rates will be forced back to equilibrium (Isard, 1996).

The resulting estimates from the regression model in equation 6.15a are:

Table 13 - Cointegration coefficient estimates, model 2

Dependent variable = logI44		
Variable	Estimate	Std. Error
Intercept	5.1189	0.0161
logBrent	-0.0885	0.0050
INTDIFF_I44	-0.1083	0.0082
LIBORUSD	-0.0142	0.0031

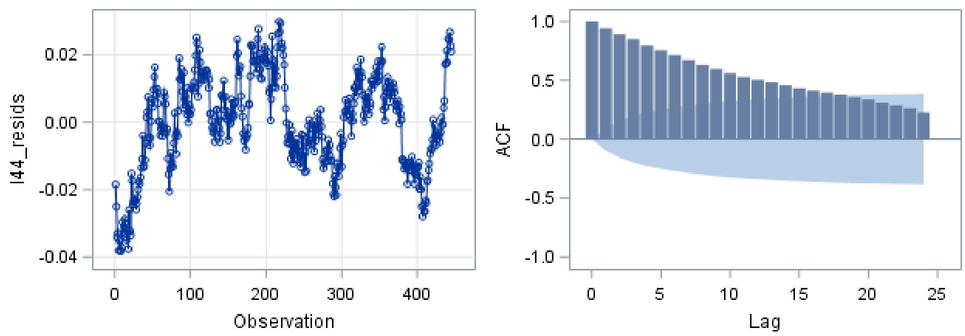
The Breusch-Godfrey analysis indicated the necessity of two lags to ensure no significant autocorrelation. The unit root test in table 14 indicates stationarity, as the null hypothesis of a unit root is rejected at 10%. The ACF plot below shows that autocorrelation coefficients exhibit some persistence, but decline relatively fast towards zero. The KPSS-test for stationarity fails to reject the null hypothesis at a 5% significance level, indicating again that residuals are stationary while somewhat borderline. The stationarity conclusion is somewhat stronger compared to model 1, as the ADF test here rejects the null hypothesis at a 5% level.

Table 14 - Stationarity analysis on regression residuals, model 2

Stationarity analysis on regression residuals		
	ADF test	KPSS test
# of lags to ensure no sign. autocorr	2	17
Test statistic	*-3.16	**0.23
Conclusion	Stationarity	Stationarity

Engle-Granger critical values (applicable to the ADF test): 10% = -2.84, 5% = -3.17, 1% = -3.77

Figure 30 - Line and ACF plot on regression residuals, model 2



The results show the following relationship:

$$\widehat{logI44}_t = 5.12 - 0.09logBrent_t - 0.11INDIFF_{I44_t} - 0.01LIBORUSD_t \qquad (Eq.6.15b)$$

The coefficient on logBrent, $\hat{\beta}_1$, reflects the elasticity of the Brent with respect to the I44 exchange rate. Stated otherwise, in the long run, a 1% increase in the price of Brent is associated with a 0.09% decline in the I44 index, all else equal. Hence, when the oil price rises, the index declines, representing an appreciation of NOK.

The coefficient on the interest rate differential between the I44 interest rate and NIBOR[42], $\hat{\beta}_2$, equals -0.11. The regression coefficient, $\hat{\beta}_2$, is approximately the percentage change in I44 given a one unit change in INTDIFF_I44. A one percentage point increase in the interest rate differential[43] yields an

[42] NIBOR minus I44 interest rate

[43] Interest rate variables included in the dataset are in percent and not in decimal form, implying that a change from 1.00 to 2.00 equals a 1% increase

expected decrease of the I44 index equal to 0.11%, thus an appreciation of the NOK, ceteris paribus. As the cointegrating relation is a long-term association, the above result in fact contradicts the interest rate parity, as an increase in the differential theoretically implies depreciation pressure on the high interest currency, while the above results indicate an appreciation of the value of NOK. In the short term, the regression estimate is believed to present an accurate picture of the market movements, as the high-interest currency is seen as more attractive.

LIBOR USD was included as the interest rate level in the US is expected to influence the value of the dollar, which again is expected to affect the dollar denominated Brent Blend oil price. The LIBOR USD coefficient, $\hat{\beta}_3$, equals -0.01. If the LIBOR USD interest rate increases by one unit, results imply that the NOK appreciates by 0.01%, all else equal. In line with the interest rate parity, higher interest rates in the US over time implies depreciation pressure on the dollar compared to other currencies, assuming corresponding interest rates are held constant. A potential explanation for the appreciation of the NOK is that the value of the US dollar is captured within the I44 index, as it makes up between 5-7% of the trade weighted exchange rate, I44.

6.4.3.2 The relation between the NOK/USD exchange rate and the oil price

Model 3

Model 3 investigates whether a cointegrating relationship exists between the NOK/USD exchange rate and the Brent Blend oil price. The hypothesis is similar to the one presented in model 1 and 2, with respect to how the oil price is expected to affect the exchange rate for an oil exporting nation as Norway.

Model 3 is formulated in the following way:

$$logUSD_t = \beta_0 + \beta_1 logBrent_t + u_t \qquad (Eq. 6.16a)$$

Table 15 - Cointegration coefficient estimates, model 3

Dependent variable = logUSD		
Variable	Estimate	Std. Error
Intercept	2.7542	0.0271
logBrent	-0.1674	0.0070

Formally we have:

$$\widehat{logUSD}_t = 2.75 - 0.17 logBrent_t \qquad (Eq. 6.16b)$$

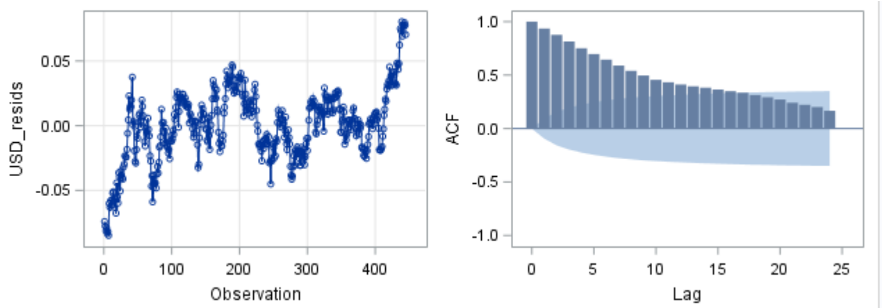
Residuals from the above regression are stationary, as the ADF test in table 16 rejects the null hypothesis of a unit root at a 5% level. Again, the ACF plot shows that autocorrelation coefficients fall relatively fast towards zero, although some persistence is present. The KPSS test rejects stationarity at a 1% level, which contradicts the results from the ADF test. The authors have chosen to emphasize the ADF test in conjunction with the ACF plot, as the KPSS was included for confirmatory purposes, and thus conclude that cointegration is present.

Table 16 - Stationarity analysis on regression residuals, model 3

Stationarity analysis on regression residuals		
	ADF test	KPSS test
# of lags to ensure no sign. autocorr	7	17
Test statistic	**-3.21	***0.68
Conclusion	Stationarity	Unit root

Engle-Granger critical values (applicable to the ADF test): 10% = -2.84, 5% = -3.17, 1% = -3.77

Figure 31 – Line and ACF plot on regression residuals, model 3



The coefficient on logBrent, $\hat{\beta}_1$, reflects the long-run multiplier, implying that in the long run, a 1% rise in the price of Brent is associated with a 0.17% decline in the NOK/USD exchange rate, holding all else equal. In other words, when the oil price rises, the NOK/USD declines, representing an appreciation of the Norwegian krone, in line with expectations.

Note that the results from the reverse specification 3R[44] did not provide proof of a cointegrating relationship. Theoretically, the two specifications should yield a similar cointegration conclusion. Hence, the conclusion for model 3R is questionable, due to the lack of cointegration in the reverse specification.

[44] Model 3R: $logBrent_t = \beta_0 + \beta_1 logUSD_t + u_t$

Model 4

The following model is an expansion of model 3 above, conducted to establish whether the results are robust when controlling for the interest rate differential between NIBOR and LIBOR USD, as well as the interest rate level in the US.

Formally, we test the following model:

$$logUSD_t = \beta_0 + \beta_1 logBrent_t + \beta_2 INTDIFF\_LIBORUSD_t + \beta_3 LIBORUSD_t + u_t \qquad (Eq.17a)$$

Table 17 - Cointegration coefficient estimates, model 4

Dependent variable = logUSD		
Variable	Estimate	Std. Error
Intercept	2.6489	0.0275
logBrent	-0.1240	0.0078
INTDIFF_LIBORUSD	-0.0645	0.0120
LIBORUSD	-0.0386	0.0167

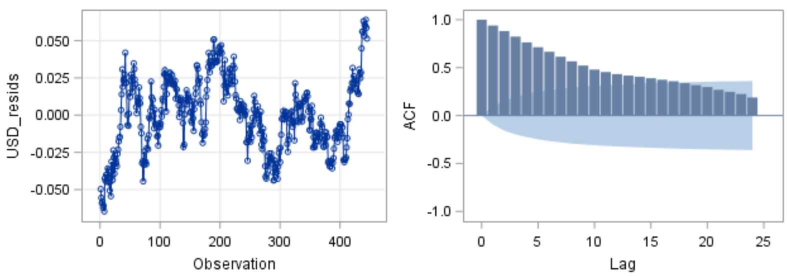
The unit root test on the residuals, $\hat{u}_t$, from the above regression indicates that residuals are stationary, as the null hypothesis of a unit root is rejected at 10%, as seen in table 18. The ACF plot in figure 32 is similar to those seen in previous models. The KPSS-test presented below rejects the null hypothesis of stationarity at a 5% level, which is an indication that the results from the ADF test may be subject to certain weaknesses. As in model 3, the authors accentuate the ADF test in conjunction with the ACF plot, and thus conclude that cointegration is present, although questionable.

Table 18 - Stationarity analysis on regression residuals, model 4

Stationarity analysis on regression residuals		
	ADF test	KPSS test
# of lags to ensure no sign. autocorr	8	17
Test statistic	*-3.16	**0.18
Conclusion	Stationarity	Stationarity

Engle-Granger critical values (applicable to the ADF test): 10% = -2.84, 5% = -3.17, 1% = -3.77

Figure 32 – Line and ACF plots on regression residuals, model 4



The estimated model yields the following:

$$\widehat{logUSD}_t = 2.65 - 0.12logBrent_t - 0.06INTDIFF\ LIBORUSD_t - 0.04LIBORUSD_t \qquad (Eq. 6.17b)$$

The estimated coefficient on logBrent equals -0.12 implying that a 1% rise in the oil price is associated with a decline of the NOK/USD exchange rate by of 0.12%, all else equal. This is again in line with economic theory, which states that a rise in the oil price is expected to strengthen the currency value for nations highly dependent on oil exports, and depreciate the currency value for oil importers.

Furthermore, we see that a rise by one percentage point of the interest rate differential between NIBOR and LIBOR USD is expected to strengthen the NOK by 0.06%, all else equal. As for the interest rate differential in model 2, the sign is opposite of what is expected from the interest rate parity, given the long term perspective underlying the cointegration methodology.

On the contrary, the coefficient on LIBOR USD equals -0.04, meaning that if LIBOR USD rises by one percentage point, the NOK/USD exchange rate will decline by 0.04%, implying a strengthening of the NOK, in line with expectations. In the long run, higher interest rates in the US compared to Norway, implies depreciation pressure on the dollar given that Norwegian interest rates remain constant, c.f. the interest rate parity.

6.4.4 Conclusion cointegration

Cointegration analyses were carried out in all subsamples, and results indicated that cointegration is only established in subsample 2.2[45], representing the period after the oil price hit bottom in January 2015 and until end the of 2016. A cointegrating relationship was found between the I44 exchange rate and the oil price, and results were robust when interest rates variables were added to the model. The same applies for the relationship between the NOK/USD exchange rate and the oil price. In other words, we found indication of a long-term relationship between the exchange rates and Brent Blend. Results are although slightly borderline, as the applied stationary tests occasionally yield mixed results.

6.5 Error correction models

According to the Granger Representation theorem, if a cointegrating relationship is found in a system of variables, there exists a valid error correction representation of the data (Engle & Granger, 1987). We therefore estimate an e*rror correction model* (ECM) in order to investigate the short and long-run dynamics between the variables of interest simultaneously. In the short-run, the relation may exhibit a disequilibrium, in which the error correction models are useful in estimating the speed at which the dependent variable will return to the equilibrium value after a change in the explanatory variables. Further, tests for cointegration do not propose the direction of causality. Granger causality analyses are therefore applied within the ECM to investigate which variable Granger causes the other.

6.5.1 Theory

6.5.1.1 Error correction models

The *error correction mechanism* was introduced by Sargan (1964), and was later interpreted by Engle and Granger (1987). The error term in the cointegration equation relating the two variables of interest can be treated as the *equilibrium error*, and can be used to tie the short-run behaviour of the Y variable to its long-run value. The following equation, a linear transformation of the cointegration equation 6.11a, defines the error correction term (Gujarati & Porter, 2009):

$$u_t = Y_t - \beta_0 - \beta_1 X_t \qquad (Eq. 6.18a)$$

The following represents an error correction model:

$$\Delta Y_t = \alpha_0 + \theta_1 \Delta X_t + \varphi u_{t-1} + \varepsilon_t \qquad (Eq. 6.18b)$$

[45] Identical to subsample 3.3

Where;

u_{t-1} is the lagged value of the error term in Eq. 6.18a

ε_t is a white noise error term

The equation states that the change in Y, ΔY, depends on the change in X, ΔX, and the equilibrium error term from the previous period, u_{t-1}. If the equilibrium error term (hereafter also referred to as the EC-term) is nonzero, the model is in disequilibrium.

For example, if ΔX is zero and $u_{t-1} > 0$, Y_{t-1} is above its equilibrium value of $\alpha_0 + \theta_1 X_{t-1}$. As we expect φ to be negative, φu_{t-1} is negative and ΔY_t will be negative to re-enter into equilibrium. Thus, if Y_t is larger than its equilibrium value, it will exhibit a downwards trend to correct the equilibrium error, and vice versa. By this, we understand that the absolute value of φ describes how quickly the equilibrium is reinstated, or stated otherwise, the speed of the movement towards the equilibrium. θ_1 shows how quickly changes in the independent variable are reflected in the dependent variable (Gujarati & Porter, 2009). If φ is above 0, the equilibrium errors will be magnified instead of corrected, which is inconsistent with cointegration (Koop, 2007).

The introduction of the equilibrium error from the preceding period as an explanatory variable in this representation allows us to move towards a new equilibrium, while the term ε_t is a stationary disturbance that leads temporary deviations from the equilibrium path. More generally, the β_j coefficients above will capture the long-term relation between the variables of interest through the cointegration relation, while θ_1 and φ will estimate the short-run relationships through the error correction model (Gujarati & Porter, 2009).

6.5.1.2. Granger causality with cointegrated variables

Within the error correction models, the authors have conducted Granger-causality tests to investigate the direction of causality.

Granger (1969) specifies that Granger's concept of causality is based on *forecast ability* or *predictability* rather than causality in the sense of a cause and effect relationship. The idea behind Granger causality is to exploit the fact that time does not run backwards. Thus, if event 1 happens before event 2, it may be possible that event 1 causes event 2, but not the other way around. However, if Granger causality is found, it does not *guarantee* that event 1 causes event 2. Yet, if past values of one variable has explanatory power for another, it suggests there *may* be some causality (Koop, 2007).

The Granger test assumes that the time series data on the variables of interest contains *all* relevant information to predict the dependent variable (Gujarati & Porter, 2009). If Y_t and X_t are two series, X_t is said to Granger cause Y_t if lagged values of X_t has statistically important information about the future values of Y_t. The test may yield either *unidirectional causality* from X to Y or from Y to X, meaning that for example in a regression of Y on lagged values of X, the latter corresponding coefficients are statistically different from zero as a group, or vice versa. There may exist *bilateral causality*, in which the sets of lagged Y's or X's are statistically significantly different from zero in both regressions. Lastly, the results may yield *independence,* in which the lagged explanatory variables are not statistically significant in any of the regressions. A limitation of this test is that it can only be applied to pairs of variables. Thus, if the true relation encompasses three or more variables, the test may yield misleading results (Brahmasrene et al., 2014). The two variable relation could be expanded to contain multivariate causality through the vector autoregression (VAR) (Gujarati & Porter, 2009). This is however regarded as beyond the main interest of this thesis.

The Granger causality method tests the null hypothesis that the coefficients on the explanatory variables in a time series regression with multiple predictors are zero. In other words, the null hypothesis is that the tested regressors have no predictive content for the dependent variable beyond that contained in other regressors. The critical values are based on the F-distribution (Koop, 2007).

Consider the following autoregressive distributed lag (ADL) model[46]:

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta Y_{t-1} + \cdots + \alpha_m \Delta Y_{t-m} + \theta_1 \Delta X_{t-1} + \cdots + \theta_j \Delta X_{t-j} + \varepsilon_t \qquad (Eq. 6.19a)$$

The Granger causality hypothesis would formally be stated the following way:

$$H_0\colon \theta_1 = \theta_2 = \theta_3 = \cdots = \theta_q = 0$$

$$H_1\colon At\ least\ one\ \theta_q \neq 0$$

In the case of cointegrated variables, the ADL model from above is extended to include the error correction term, φu_{t-1}. As explained above, past values of X also appear in this term, as $u_{t-1} = Y_{t-1} - \beta_0 - \beta_1 X_{t-1}$ (Koop, 2007). The augmented model from above can be written as:

[46] This is defined as a regression model which includes "[…] lagged values of the dependent variable and current and lagged values of one or more explanatory variables" (Chen, n.d.). Note that current values of the explanatory variables are not included, as we do not allow for *contemporaneous causality* (Koop, 2007)

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta Y_{t-1} + \cdots + \alpha_m \Delta Y_{t-m} + \theta_1 \Delta X_{t-1} + \cdots + \theta_j \Delta X_{t-j} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.19b)$$

The hypothesis test is extended to:

$$H_0: \theta_1 = \theta_2 = \theta_3 = \cdots = \theta_j = 0 \; and \; \varphi = 0$$

$$H_1: At\ least\ one\ of\ the\ above\ \neq 0$$

The first part of the null hypothesis can be referred to as the "short run non-causality", and the second as the "long-run non-causality". If the null hypothesis is rejected, there exists a causal relationship between Y and X at least once, either in the short or long term, or both (Lee, Lin, & Wu, 2002).

6.5.2 Estimation method

As the authors are not interested in contemporaneous causality, the contemporaneous value of X is not included. Consequently, we seek only to estimate the effect of the past values of the explanatory variables, and not the current (Koop, 2007).

The inclusion of the particular control variables in the specific relations is done following the same argumentation as in the test for cointegration presented in section 6.4.2.

Some important assumptions and characteristics behind the test are to be mentioned. In the process of determining the number of lags to include in the ECM, thorough analysis has been carried out to ensure that autocorrelation is removed, and that the residuals exhibit white noise. The direction and acceptance of causality may depend critically on the number of lagged terms included (Gujarati & Porter, 2009), as seen in the comprehensive Granger causality results overview in appendix 10. Each model has been tested with the inclusion of 1 to 15 lags of all included variables, and the corresponding Breusch-Godfrey tests and ACF plots have been analysed in conjunction (Gujarati & Porter, 2009). The maximum lag length examined is 15, which implies a cut-off equal to three business weeks. This is found to be reasonable, as an effect exceeding three weeks is not expected, in accordance with efficiency of financial markets, as discussed in section 3.1.1. All variables in a specific model were restricted to have identical lag lengths, to reduce the number of possible model specifications, following Amano & Norden (1998b) and Brahmasrene et al. (2014). The potential drawback of applying the identical lag length method is a quick increase in the number of parameters to be estimated, and the risk of having an over parametrized system relative to the total number of observations. The latter can potentially lead to poor and inefficient estimates (Hoover, 1995). However, in this specific case, the authors believe that the number of observations are sufficient to avoid the problem.

As the models partly investigate short-term relations, the first difference of the variables are analysed. Additionally, the Granger causality test assumes that the variables are stationary, which is satisfied by the first-difference specification.

Table 19 below presents the error correction models based on the cointegration findings in section 6.4.3. The models are also tested in the reverse specification, in order to analyse whether causality exists in the opposite direction.

Table 19 - Overview of error correction model specifications to be tested for Granger causality

Overview of error correction models tested for Granger causality	
Model	Model specification
	Does the oil price Granger cause the exchange rates?
Model 1.1	$\Delta \log I44_t = \alpha_0 + \alpha_1 \Delta logI44_{t-1} + \cdots + \alpha_m \Delta logI44_{t-m} + \theta_1 \Delta \log Brent_{t-1} + \cdots + \theta_j \Delta logBrent_{t-j} + \varphi u_{t-1} + \varepsilon_t$
Model 2.1	$\Delta \log I44_t = \alpha_0 + \alpha_1 \Delta logI44_{t-1} + \cdots + \alpha_m \Delta log44_{t-m} + \theta_1 \Delta \log Brent_{t-1} + \cdots + \theta_j \Delta logBrent_{t-j} + \vartheta_1 \Delta INTDIFF\_I44_{t-1} + \ldots + \vartheta_p \Delta INTDIFF\_I44_{t-p} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots + \tau_n \Delta LIBOR\_USD_{t-n} + \varphi u_{t-1} + \varepsilon_t$
Model 3.1	$\Delta \log USD_t = \alpha_0 + \alpha_1 \Delta logUSD_{t-1} + \cdots + \alpha_m \Delta logUSD_{t-m} + \theta_1 \Delta \log Brent_{t-1} + \cdots + \theta_j \Delta logBrent_{t-j} + \varphi u_{t-1} + \varepsilon_t$
Model 4.1	$\Delta \log USD_t = \alpha_0 + \alpha_1 \Delta logUSD_{t-1} + \cdots + \alpha_m \Delta logUSD_{t-m} + \theta_1 \Delta \log Brent_{t-1} + \cdots + \theta_j \Delta logBrent_{t-j} + \vartheta_1 \Delta INTDIFF\_LIBORUSD_{t-1} + \ldots + \vartheta_p \Delta INTDIFF\_LIBORUSD_{t-p} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots + \tau_n \Delta LIBOR\_USD_{t-n} + \varphi u_{t-1} + \varepsilon_t$
	Does the exchange rate Granger cause the oil price?
Model 1.1R[1]	$\Delta \log Brent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \cdots + \alpha_m \Delta logBrent_{t-m} + \theta_1 \Delta \log I44_{t-1} + \cdots + \theta_j \Delta logI44_{t-j} + \varphi u_{t-1} + \varepsilon_t$
Model 2.1R	$\Delta \log Brent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \cdots + \alpha_m \Delta logBrent_{t-m} + \theta_1 \Delta \log I44_{t-1} + \cdots + \theta_j \Delta logI44_{t-j} + \vartheta_1 \Delta INTDIFF\_I44_{t-1} + \ldots + \vartheta_p \Delta INTDIFF\_I44_{t-p} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots + \tau_n \Delta LIBOR\_USD_{t-n} + \varphi u_{t-1} + \varepsilon_t$
Model 3.1R	$\Delta \log Brent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \cdots + \alpha_m \Delta logBrent_{t-m} + \theta_1 \Delta \log USD_{t-1} + \cdots + \theta_j \Delta logUSD_{t-j} + \varphi u_{t-1} + \varepsilon_t$
Model 4.1R	$\Delta \log Brent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \cdots + \alpha_m \Delta logBrent_{t-m} + \theta_1 \Delta \log USD_{t-1} + \cdots + \theta_j \Delta logUSD_{t-j} + \vartheta_1 \Delta INTDIFF\_LIBORUSD_{t-1} + \ldots + \vartheta_p \Delta INTDIFF\_LIBORUSD_{t-p} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots + \tau_n \Delta LIBOR\_USD_{t-n} + \varphi u_{t-1} + \varepsilon_t$

[1] *R represents the reverse model specification. Models are conversely specified to check for causality in the oppsite direction*

6.5.3 Empirical findings

Table 20 below summarizes the error correction models and Granger causality findings. Granger causality is found in all models in sample 2.2, and all specifications exhibit equilibrium correcting properties, with the exception of model 1.1, where the error correction term is insignificant. The error correction models are presented one by one in what follows. Following literature, emphasis and analysis on day-to-day fluctuations in dynamic models is not common, which is why the coefficients will not be interpreted extensively. Table 29 in the end of this section presents the models' corresponding ACF plots, confirming that no significant autocorrelation is present.

Table 20 – Overview of Granger causality test results for cointegrated variables, sample 2.2

Granger causality for cointegrated variables Sample 2.2							
Model	Granger causality from X → Y	Control variables	# of lags to ensure no sign. autocorr.	F-value	Error correction term	Coefficient on lag of ΔX	Conclusion
Does the oil price Granger cause the exchange rates?							
Model 1.1	ΔlogBrent → ΔlogI44	-	4	***4.97	-0.0189	***-0.0411	GC in SR[1]
Model 2.1	ΔlogBrent → ΔlogI44	ΔINTDIFF_I44, ΔLIBORUSD	4	***5.37	*-0.0372	***-0.0406	GC in SR and LR[2]
Model 3.1	ΔlogBrent → ΔlogUSD	-	4	***3.61	*-0.0314	***-0.0466	GC in SR and LR
Model 4.1	ΔlogBrent → ΔlogUSD	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	6	***3.98	***-0.0569	***-0.0536	GC in SR and LR
Does the exchange rate Granger cause the oil price?							
Model 1.1R	ΔlogI44 → ΔlogBrent	-	1	***4.70	***-0.2451	0.2941	GC in LR
Model 2.1R	ΔlogI44 → ΔlogBrent	ΔINTDIFF_I44, ΔLIBORUSD	1	*2.32	*-0.1687	0.4656	GC in LR
Model 3.1R	ΔlogUSD → ΔlogBrent	-	1	*2.40	**-0.1123	0.0955	GC in LR
Model 4.1R	ΔlogUSD → ΔlogBrent	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	1	1.46	-0.0857	0.1927	No GC

[1] SR = Short run

[2] LR = Long run

6.5.2.1 The relation between the I44 exchange rate and the oil price

Model 1.1 – Does Brent Granger cause the I44 exchange rate?

Based on the autocorrelation analysis, it is established that four lags were necessary make the error term uncorrelated, leading us to estimate the model presented in equation 6.20 below:

$$\Delta logI44_t = \alpha_0 + \alpha_1\, \Delta logI44_{t-1} + \cdots + \alpha_4 \Delta \mathrm{logI44}_{\mathrm{t-4}} + \theta_1 \Delta logBrent_{t-1} + \cdots + \theta_4 \Delta logBrent_{t-4} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.20)$$

Table 21 - Error correction model coefficient estimates and Granger causality test, model 1.1

Dependent variable = ΔlogI44				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	0.0001	0.0003	0.3000	0.7625
$\Delta logI44_{t-1}$	-0.1103	0.0505	-2.1900	0.0294
$\Delta logI44_{t-2}$	-0.0375	0.0507	-0.7400	0.4604
$\Delta logI44_{t-3}$	0.0863	0.0504	1.7100	0.0877
$\Delta logI44_{t-4}$	-0.1103	0.0492	-2.2400	0.0255
$\Delta logBrent_{t-1}$	**-0.0411**	**0.0091**	**-4.5400**	**<.0001**
$\Delta logBrent_{t-2}$	0.0011	0.0092	0.1200	0.9042
$\Delta logBrent_{t-3}$	0.0090	0.0092	0.9700	0.3319
$\Delta logBrent_{t-4}$	0.0084	0.0093	0.9100	0.3624
$\hat{u}_{t-1}$	**-0.0189**	**0.0158**	**-1.2000**	**0.2298**
Granger causality test			F-value	P-value
F-test			4.97	0.0002

In model 1.1, Granger causality is found in the short run, from the oil price to the I44 exchange rate.

This is given by the presence of a highly significant F-test and the significance of the first lag of the explanatory variable, $\Delta logBrent_{t-1}$. However, an insignificant error correction, $\hat{u}_{t-1}$, term leads us to conclude that past values of the oil price might not influence the I44 in the long run. This is because the error correction term captures the effect of past values of Brent, in a long-term relation, through the cointegration model. Hence, we have indication of *short-term* Granger-causality from the oil price to the I44 exchange rate, by using 4 daily lags. As the coefficient on changes in Brent is negative, the implication is that a rise in the oil price leads to a fall in the I44 index, associated with a strengthening of the NOK. This evidence supports theory for oil-exporting nations, expressing that a rise in the oil price will, in isolation, lead to an appreciation of the exchange rate because of enhanced terms of trade (Bernhardsen & Røisland, 2000).

Possible explanations for the fact that Granger causality is found in the short term solely might be that oil price changes are quickly incorporated in the exchange markets. Forward looking agents seem to view exchange rates as asset prices, and changes in the oil price are incorporated as a part of public information used to determine the position in the market (Amano & Norden, 1998a; Fratzscher et al., 2014).

Following a cointegrating relationship, there exists an error correction model with a significant EC-term in the system (Engle & Granger, 1987). The EC-term in model 1.1 was insignificant, which implies that in order to verify the found cointegrating relationship, the EC-term in model 1.1R needs to be significant.

Model 1.1R – Does the I44 exchange rate Granger cause Brent?

Model 1.1R is the reverse of model 1.1, implying that the oil price represents the dependent variable and I44 the independent variable. Autocorrelation analyses suggest one lag of the respective variables to be included. The following models is tested:

$$\Delta logBrent_t = \alpha_0 + \alpha_1\, \Delta logBrent_{t-1} + \theta_1 \Delta logI44_{t-1} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.21)$$

Table 22 - Error correction model coefficient estimates and Granger causality test, model 1.1R

Dependent variable = ΔlogBrent				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	0.0003	0.0014	0.2200	0.8246
$\Delta logBrent_{t-1}$	0.0469	0.0491	0.9500	0.3404
$\Delta logI44_{t-1}$	**0.2941**	**0.2651**	**1.1100**	**0.2680**
$\hat{u}_{t-1}$	**-0.2451**	**0.0814**	**-3.0100**	**0.0028**
Granger causality test			F-value	P-value
F-test			4.70	0.0096

The results display that Granger causality is found from the I44 exchange rate to the Brent Blend oil price, solely in the long run.

The F-value is sufficiently high to reject the null hypothesis at a 1% level. The results show that $\Delta logI44_{t-1}$ is insignificant, implying that we find no short-term effect from the I44 index to the oil price. The error correction term, $\hat{u}_{t-1}$, is negative and significant at 1%, indicating that over the long run, past values of the I44 index have significant explanatory power for changes of current values of the oil price.

In summary, the findings indication that the oil price has predictive content for the I44 in the short run, while the causality is reversed in the long run. A possible explanation for the short term effect from the oil price to the I44 is that the FX market quickly reacts to changes in the oil price, which is consistent with the financial newspapers' persuasion and frequently stated headlines. Over the long run, the system seems to be more open, with a long term effect proven through the cointegrating relationship, with an indication that causality runs from the exchange rate to the oil price.

The relatively large and negative value of the EC-term indicates that if the oil price is above its equilibrium value, a great amount of the discrepancy is corrected each day. This is in line with nature of the error correction term, as it being less than zero indicates a move towards equilibrium instead of being magnified (Koop, 2007).

As stated in the Granger Representation Theorem, cointegration infers that at least one of the two variables must Granger-cause the other. The conclusion of Granger causality in specification 1.1R thus confirms the cointegrating relationship found in section 6.4.3.1 model 1, which otherwise would have been doubtful.

In summary, the result of model 1.1 and 1.1R together present the picture that past values of the oil price can explain the value of the I44 *and* vice versa, but that the effect depends on the time horizon.

Model 2.1 – Does Brent Granger cause the I44 exchange rate (with control variables)

Model 2.1 is an extended version of model 1.1 as interest rates variables are included. The autocorrelation analysis established that four lags are necessary to avoid autocorrelation, leading us to estimate the model presented in equation 6.22 below.

$$\begin{aligned}\Delta logI44_t = \alpha_0 + \alpha_1\, \Delta logI44_{t-1} + \cdots + \alpha_4 \Delta \mathrm{logI44}_{t-4} + \theta_1 \Delta logBrent_{t-1} + \cdots + \theta_4 \Delta logBrent_{t-4} \\ + \vartheta_1 \Delta INTDIFF\_I44_{t-1} + \cdots + \vartheta_4 \Delta INTDIFF\_I44_{t-4} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots \\ + \tau_4 \Delta LIBOR\_USD_{t-4} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.22)\end{aligned}$$

Table 23 - Error correction model coefficient estimates and Granger causality test, model 2.1

Dependent variable = ΔlogI44				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	-0.0001	0.0003	-0.3700	0.7108
$\Delta logI44_{t-1}$	-0.1549	0.0572	-2.7100	0.0071
$\Delta logI44_{t-2}$	-0.1198	0.0577	-2.0700	0.0386
$\Delta logI44_{t-3}$	0.1076	0.0567	1.9000	0.0584
$\Delta logI44_{t-4}$	-0.0959	0.0553	-1.7300	0.084
$\Delta logBrent_{t-1}$	**-0.0406**	**0.0092**	**-4.4300**	**<.0001**
$\Delta logBrent_{t-2}$	-0.0075	0.0094	-0.8000	0.4269
$\Delta logBrent_{t-3}$	0.0076	0.0094	0.8000	0.4216
$\Delta logBrent_{t-4}$	0.0105	0.0094	1.1200	0.2619
$\Delta INTDIFF\_I44_{t-1}$	-0.0135	0.0117	-1.1600	0.2467
$\Delta INTDIFF\_I44_{t-2}$	-0.0360	0.0117	-3.0700	0.0023
$\Delta INTDIFF\_I44_{t-3}$	0.0023	0.0118	0.1900	0.8479
$\Delta INTDIFF\_I44_{t-4}$	-0.0040	0.0118	-0.3400	0.7315
$\Delta LIBORUSD_{t-1}$	0.1125	0.0505	2.2300	0.0265
$\Delta LIBORUSD_{t-2}$	0.0412	0.0518	0.8000	0.4269
$\Delta LIBORUSD_{t-3}$	-0.0264	0.0516	-0.5100	0.6085
$\Delta LIBORUSD_{t-4}$	-0.0063	0.0509	-0.1200	0.9018
$\hat{u}_{t-1}$	**-0.0372**	**0.0198**	**-1.8800**	**0.0603**
Granger causality test			F-value	P-value
F-test			5.37	<.0001

As seen in table 23, Granger causality is found from the oil price to the exchange rate in both the short and long run, when controlling for interest rates.

The F-value implies that the null hypothesis is rejected at a 1% level. Hence, at least one of the coefficients tested have explanatory power for the dependent variable, $\Delta logI44$. The first lag of Brent, $\Delta logBrent_{t-1}$, is negative and highly significant, indicating that Brent seems to have a short term effect on the I44 exchange rate. This shows that positive changes in the oil price leads the I44 index to fall, signifying a strengthening of the NOK, in line with expectations as discussed in 6.4.3. As described above, the coefficient on lag one of the change in the oil price, θ_1, shows how quickly changes in the independent variable are reflected in the dependent variable. If $\Delta logBrent$ suddenly increases by 1%, the I44 index exchange rate would instantly decrease by 0.04%.

Further, a significant error correction term indicates that past values of Brent has statistically important information about the future values of the I44 exchange rate in the *long run*, but the result is weak, due to a significance level of 10%. Control variables included in the present specification might have resolved a potential problem of omitted variables in model 1.1.

The negative value of the EC-term of -0.04 indicates that if the I44 index is above equilibrium in one period, its value would fall in the next period[47] to restore equilibrium, and vice versa. This is in line with correcting nature of the error correction term, as described above. The absolute value of the error term coefficient, φ, describes how quickly the equilibrium is reinstated.

Model 2.1R – Does the I44 exchange rate Granger cause Brent (with control variables)?

Model 2.1R is the reverse model specification of model 2.1. The autocorrelation analysis established that one lag is necessary implying estimation of the following model.

$$\Delta logBrent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \Delta logI44_{t-1} + \vartheta_1 \Delta INTDIFF\_I44_{t-1} + \tau_1 \Delta LIBOR\_USD_{t-1} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.23)$$

Table 24 - Error correction model coefficient estimates and Granger causality test, model 2.1R

Dependent variable = ΔlogBrent				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	0.0015	0.0014	1.0400	0.2994
$\Delta logBrent_{t-1}$	0.0530	0.0495	1.0700	0.2850
$\Delta logI44_{t-1}$	**0.4656**	**0.2964**	**1.5700**	**0.1170**
$\Delta INTDIFF\_I44_{t-1}$	0.0893	0.0630	1.4200	0.1569
$\Delta LIBORUSD_{t-1}$	-0.7183	0.2665	-2.7000	0.0073
$\hat{u}_{t-1}$	**-0.1687**	**0.0988**	**-1.7100**	**0.0886**
Granger causality test			F-value	P-value
F-test			2.32	0.0999

In model 2.1R, the I44 exchange rate is found to Granger cause the oil price solely in the long run.

The result shows a significant F-value at a 10% level, indicating that at least one of the coefficients tested have predictive content for the oil price. The coefficient on $\Delta logI44_{t-1}$ is insignificant, indicating that short term causality is not present.

The EC term is negative and significant at a 5% level, which indicates long-run Granger causality. The result supports the conclusion found in model 1.1R.

The negative and significant EC-term proves that the error correction mechanism moves in the expected direction, by correcting for oil price values above or below its equilibrium value.

[47] One day in this specific case

6.5.2.2 The relation between the NOK/USD exchange rate and the oil price

Model 3.1 – Does Brent Granger cause the NOK/USD exchange rate?

Model 3 investigates the relation between the NOK/USD exchange rate and the oil price, applying four lags.

$$\Delta logUSD_t = \alpha_0 + \alpha_1 \Delta logUSD_{t-1} + \cdots + \alpha_4 \Delta logUSD_{t-4} + \theta_1 \Delta logBrent_{t-1} + \cdots + \theta_4 \Delta logBrent_{t-4} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.24)$$

Table 25 - Error correction model coefficient estimates and Granger causality test, model 3.1

Dependent variable =ΔlogUSD				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	0.000324	0.0004	0.81	0.4186
$\Delta logUSD_{t-1}$	-0.0348	0.0501	-0.69	0.4878
$\Delta logUSD_{t-2}$	0.007551	0.0501	0.15	0.8802
$\Delta logUSD_{t-3}$	0.0865	0.0501	1.73	0.0847
$\Delta logUSD_{t-4}$	-0.124	0.0498	-2.49	0.0131
$\Delta logBrent_{t-1}$	**-0.0466**	**0.0144**	**-3.24**	**0.0013**
$\Delta logBrent_{t-2}$	0.0103	0.0145	0.71	0.4789
$\Delta logBrent_{t-3}$	0.0246	0.0145	1.7	0.0908
$\Delta logBrent_{t-4}$	0.00488	0.0145	0.34	0.7372
$\hat{u}_{t-1}$	**-0.0314**	**0.0162**	**-1.94**	**0.0525**
Granger causality test			F-value	P-value
F-test			3.61	0.0033

In model 3.1, Granger causality is evident from the oil price to the USD exchange rate in the short and long run.

Testing for Granger causality in model 3.1, we are able to reject the null hypothesis at a 10% level, implying that at least one of the coefficients tested have predictive content for the USD exchange rate. Additionally, $\Delta logBrent_{t-1}$ is negative and significant at 1%, also in line with expectations. Positive changes in the oil price leads to a strengthening of the NOK.

The error correction term is negative and significant at a 1% level, leading us to conclude that there is both a long and short-term relation between the USD and the oil price. Stated differently, past values of the oil price have explanatory power for current values of the US dollar applying 4 lags. The sign of the error correction is in line with expectations.

Model 3.1R – Does the NOK/USD exchange rate Granger cause Brent?

No cointegration was found in model 3R[48]. However, as cointegration was evident for model 3, it leads us to investigate model 3.1R also in order to establish which direction the causality may run.

$$\Delta logBrent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \theta_1 \Delta logUSD_{t-1} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.25)$$

Table 26 - Error correction model coefficient estimates and Granger causality test, model 3.1R

Dependent variable =ΔlogBrent				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	0.0003	0.0014	0.2000	0.8379
$\Delta logBrent_{t-1}$	0.0399	0.0493	0.8100	0.4183
$\Delta logUSD_{t-1}$	**0.0955**	**0.1698**	**0.5600**	**0.5741**
$\hat{u}_{t-1}$	**-0.1123**	**0.0515**	**-2.1800**	**0.0296**
Granger causality test			F-value	P-value
F-test			2.40	0.0920

In model 3.1R, Granger causality is found from the USD exchange rate to the oil price in the long run.

The F-test for this specification rejects the null hypothesis at a 10% level. As seen in table 26, $\Delta logUSD_{t-1}$ is insignificant, implying no short term causality. The EC-term on the other hand is significant at a 5% level, suggesting that Granger causality is present solely in the long term horizon. As explained, the quotation of Brent in USD is an explanation for the value of the dollar.

The negative sign of the error correction term indicates that the correcting mechanism is moving in the expected direction, by lowering the value of Brent if it is higher than its equilibrium value, and vice versa.

Model 4.1 – Does Brent Granger cause the NOK/USD exchange rate (with control variables)?

Model 4.1 represents the extended version of model 3.1 as interest rates variables are added to the model to check the robustness of the above established results and prevent possible implications of omitted variables. Autocorrelation analysis indicate the necessity of six included lags, which imply that Eq.6.26 below is tested.

$$\begin{aligned}\Delta logUSD_t = \alpha_0 &+ \alpha_1 \Delta logUSD_{t-1} + \cdots + \alpha_6 \Delta logUSD_{t-6} + \theta_1 \Delta logBrent_{t-1} + \cdots + \theta_6 \Delta logBrent_{t-6} \\ &+ \vartheta_1 \Delta LIBOR\_USD_{t-1} + \cdots + \vartheta_6 \Delta LIBOR\_USD_{t-6} + \tau_1 \Delta INTDIFF\_LIBORUSD_{t-1} + \cdots \\ &+ \tau_6 \Delta INTDIFF\_LIBORUSD_{t-6} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.26)\end{aligned}$$

[48] This is not explicitly shown in the thesis, but was conducted for verification purposes.

Table 27 - Error correction model coefficient estimates and Granger causality test, model 4.1

Dependent variable = ΔlogUSD				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	0.0002	0.0005	0.4100	0.6801
$\Delta logUSD_{t-1}$	-0.0650	0.0557	-1.1700	0.2435
$\Delta logUSD_{t-2}$	-0.0185	0.0555	-0.3300	0.7383
$\Delta logUSD_{t-3}$	0.1325	0.0547	2.4200	0.0159
$\Delta logUSD_{t-4}$	-0.1043	0.0548	-1.9000	0.0578
$\Delta logUSD_{t-5}$	0.0102	0.0543	0.1900	0.8518
$\Delta logUSD_{t-6}$	0.0880	0.0542	1.6200	0.1053
$\Delta logBrent_{t-1}$	**-0.0536**	**0.0146**	**-3.6600**	**0.0003**
$\Delta logBrent_{t-2}$	-0.0049	0.0148	-0.3300	0.7399
$\Delta logBrent_{t-3}$	**0.0248**	**0.0148**	**1.6800**	**0.0940**
$\Delta logBrent_{t-4}$	0.0061	0.0148	0.4100	0.6823
$\Delta logBrent_{t-5}$	-0.0220	0.0147	-1.4900	0.1361
$\Delta logBrent_{t-6}$	-0.0106	0.0147	-0.7200	0.4711
$\Delta LIBORUSD_{t-1}$	0.1320	0.0837	1.5800	0.1156
$\Delta LIBORUSD_{t-2}$	-0.0132	0.0851	-0.1600	0.8766
$\Delta LIBORUSD_{t-3}$	-0.0842	0.0845	-1.0000	0.3198
$\Delta LIBORUSD_{t-4}$	0.1074	0.0847	1.2700	0.2057
$\Delta LIBORUSD_{t-5}$	-0.0306	0.0853	-0.3600	0.7201
$\Delta LIBORUSD_{t-6}$	0.0287	0.0846	0.3400	0.7346
$\Delta INTDIFF\_LIBORUSD_{t-1}$	-0.0081	0.0185	-0.4400	0.6611
$\Delta INTDIFF\_LIBORUSD_{t-2}$	-0.0465	0.0183	-2.5400	0.0116
$\Delta INTDIFF\_LIBORUSD_{t-3}$	0.0006	0.0185	0.0300	0.9757
$\Delta INTDIFF\_LIBORUSD_{t-4}$	0.0058	0.0185	0.3100	0.7545
$\Delta INTDIFF\_LIBORUSD_{t-5}$	0.0293	0.0184	1.5900	0.1116
$\Delta INTDIFF\_LIBORUSD_{t-6}$	0.0570	0.0185	3.0900	0.0022
$\boldsymbol{\hat{u}_{t-1}}$	**-0.0569**	**0.0197**	**-2.8900**	**0.0041**
Granger causality test			F-value	P-value
			3.98	0.0003

Model 4.1 test results show that the oil price is found to Granger cause the USD exchange rate in the short and long run.

The F-value is significant at a 1% level, leading us to reject the null hypothesis of no explanatory power of the tested coefficients.

$\Delta logBrent_{t-1}$ is negative and significant at 1%, while $\Delta logBrent_{t-3}$ is positive and significant at 10%[49]. The negative coefficient on lag one indicates that positive changes in the oil price leads to a strengthening of the NOK, through a decrease in the NOK/USD exchange rate, as expected.

The error correction term is small, negative, and significant at a 1% level, indicating that the error is corrected towards equilibrium if the value of the USD is higher or lower than its equilibrium value. By

[49] As discussed, a comprehensive analysis of the day-to-day fluctuations is not carried out, as this is not meaningful in a dynamic model.

adding the relevant control variables, the result found in model 3.1 are strengthened, indicating that these might have been missing in the previous specification. Stated otherwise, this points toward the fact that changes in LIBOR USD and the interest rate differential between NIBOR and LIBOR USD are important factors in the analysed relationship.

Model 4.1R – Does the NOK/USD exchange rate Granger cause Brent (with control variables)?

Model 4.1R represents the reverse of model 4.1. Autocorrelation analysis indicate the necessity of one lag respectively, yielding the following equation to be tested.

$$\Delta logBrent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \theta_1 \Delta logUSD_{t-1} + \vartheta_1 \Delta LIBOR\_USD_{t-1} + \tau_1 \Delta INTDIFF\_LIBORUSD_{t-1} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 6.27)$$

Table 28 - Error correction model coefficient estimates and Granger causality test, model 4.1R

Dependent variable = ΔlogBrent				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	0.0015	0.0014	1.0600	0.2886
$\Delta logBrent_{t-1}$	0.0422	0.0492	0.8600	0.3920
$\Delta logUSD_{t-1}$	**0.1927**	**0.1813**	**1.0600**	**0.2883**
$\Delta LIBORUSD_{t-1}$	-0.7105	0.2732	-2.6000	0.0096
$\Delta INTDIFF\_LIBORUSD_{t-1}$	0.0350	0.0619	0.5600	0.5725
$\hat{u}_{t-1}$	**-0.0857**	**0.0579**	**-1.4800**	**0.1398**
Granger causality test			F-value	P-value
F-test			1.46	0.2339

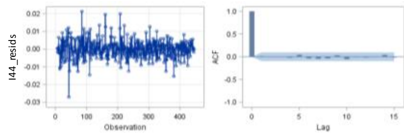
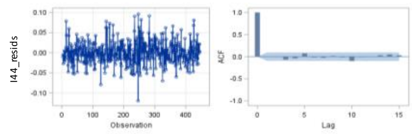
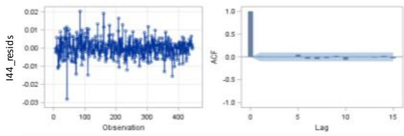
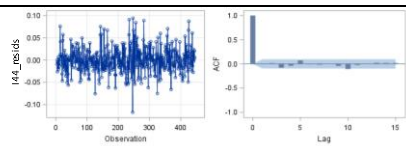
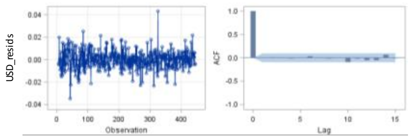
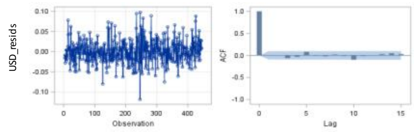
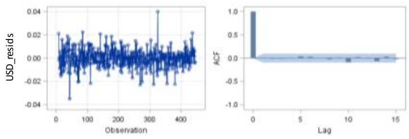
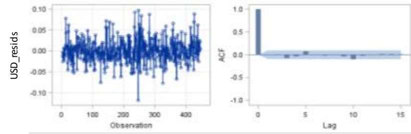
Results from testing model 4.1R provide evidence of no Granger causality from the NOK/USD exchange rate to the oil price, neither in the short nor the long term.

The F-value is insignificant, revealing that we fail to reject the null hypothesis of no Granger causality. As explained above, the test of whether the NOK/USD Granger causes Brent (without control variables)[50] showed no significant Granger causality in the short term. This is confirmed when control variables are added to the relation, as seen by the insignificant coefficient on $\Delta logUSD_{t-1}$. Further, the insignificant EC term in model 4.1R shows that Granger causality is not present through the cointegration relation either.

The below table summarizes all the models' corresponding line and ACF plots. The illustrations show that no significant autocorrelation is present.

[50] Model 3.1R

Table 29 - Summary of autocorrelation analysis, all models, sample 2.2

Check for autocorrelation Sampel 2.2			
Model	Line and ACF-plot	Model	Line and ACF-plot
Model 1.1		Model 1.1R	
Model 2.1		Model 2.1R	
Model 3.1		Model 3.1R	
Model 4.1		Model 4.1R	

6.5.4 Conclusion error correction models

The establishment of cointegration in subsample 2.2 led the authors to test for Granger causality in the short and long term through the corresponding dynamic error correction models. The findings revealed that the coefficient of the error correction term, φ, was negative in all models, indicating that the error is corrected in the expected direction when the dependent variable is beyond its equilibrium value. The absolute value of the EC-term is larger having Brent as the dependent variable, indicating that a larger part of the discrepancy is corrected each day if the oil price it beyond its equilibrium value.

Granger causality was evident in both the short and long term from the oil price to the exchange rates, while solely long run causality was evident when testing for the opposite direction. This result was slightly in contrast to the findings by Brahmasrene, Huang, & Sissoko, (2014), who found that exchange rates Granger caused crude oil in the short run, while crude oil Granger caused exchanges rates in the long run. Potentially, the short run causality effect on exchange rates can be explained by a more rapid absorption of information by market participants. Further, it is possible that oil price determination on the other hand is largely determined by fundamental changes in supply and demand.

6.6 Granger causality

For the models in which cointegration was not detected, there might still exist short term relations between the variables of interest. For this reason, short term Granger causality will be investigated for non cointegrated variables. The authors seek to understand whether the media's emphasis on the oil price as a main factor in determining the value of the NOK can be statistically proven, or if causality runs in the opposite direction.

As earlier described, past literature presents differing empirical results on the direction and causation between the oil price and various exchange rates, see for example Krugman (1980) and Golub (1983), Amano & Norden (1998), Hamilton (1983), Brahmasrene et al. (2014) and Ellen & Martinsen, (2016). As discussed, Krugman (1980) and Golub (1983) found that oil exporting nations experience an appreciation of their currency through the wealth-transfer effect, tested empirically by Amano & Norden (1998). The latter, consistent with Hamilton (1983) proved that Granger causality ran from oil prices to exchange rates and not the other way. A comparable result was also found by (Benassy-Quere et al., 2007) and (Chaudhuri & Daniel B.C., 1997).

6.6.1 Estimation method

The estimation method for non-cointegrated variables generally follow the same methods explained for the Granger causality tests within the error correction models.

Firstly, we also here seek only to estimate the effect of the past values of X, and not the contemporaneous, as explained in 6.5.2. To conform with the stationarity assumption behind Granger causality testing, the first differenced variables are used. The lag length is applied in the same manner as in section 6.5.2.1, with a maximum lag length of 15. The assumptions regarding autocorrelations applies also in this section, in which a model is only accepted if it yields no significant autocorrelation.

We are also interested in investigating differences between the subsets chosen, which is why each subsample will be presented separately. The full sample period as well as all subsamples, with the exception of sample 2.2, will be reviewed[51]. The inclusion of specific control variables in the relations is done following the same argumentation as in the test for cointegration presented in section 6.4.2.

An overview of the models that have been estimated is as follows:

[51] Cointegration was established in subsample 2.2. Granger causality was therefore tested within the error correction models.

Figure 33 – Overview of model specifications to be tested for Granger causality

Overview of models tested for Granger causality		
Model	Granger causality from X → Y	Model specification
Does the oil price Granger cause the exchange rates?		
Model 1.1	ΔlogBrent → ΔlogI44	$\Delta\log I44_t = \alpha_0 + \alpha_1 \Delta logI44_{t-1} + \cdots + \alpha_m \Delta logI44_{t-m} + \theta_1 \Delta \log Brent_{t-1} + \cdots + \theta_j \Delta logBrent_{t-j} + \varepsilon_t$
Model 2.1	ΔlogBrent → ΔlogI44	$\Delta\log I44_t = \alpha_0 + \alpha_1 \Delta logI44_{t-1} + \cdots + \alpha_m \Delta log44_{t-m} + \theta_1 \Delta \log Brent_{t-1} + \cdots + \theta_j \Delta logBrent_{t-j} + \vartheta_1 \Delta INTDIFF\_I44_{t-1} + \ldots + \vartheta_p \Delta INTDIFF\_I44_{t-p} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots + \tau_n \Delta LIBOR\_USD_{t-n} + \varepsilon_t$
Model 3.1	ΔlogBrent → ΔlogUSD	$\Delta \log USD_t = \alpha_0 + \alpha_1 \Delta logUSD_{t-1} + \cdots + \alpha_m \Delta logUSD_{t-m} + \theta_1 \Delta \log Brent_{t-1} + \cdots + \theta_j \Delta logBrent_{t-j} + \varepsilon_t$
Model 4.1	ΔlogBrent → ΔlogUSD	$\Delta \log USD_t = \alpha_0 + \alpha_1 \Delta logUSD_{t-1} + \cdots + \alpha_m \Delta logUSD_{t-m} + \theta_1 \Delta \log Brent_{t-1} + \cdots + \theta_j \Delta logBrent_{t-j} + \vartheta_1 \Delta INTDIFF\_LIBORUSD_{t-1} + \ldots + \vartheta_p \Delta INTDIFF\_LIBORUSD_{t-p} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots + \tau_n \Delta LIBOR\_USD_{t-n} + \varepsilon_t$
Does the exchange rate Granger cause the oil price?		
Model 1.1R	ΔlogI44 → ΔlogBrent	$\Delta\log Brent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \cdots + \alpha_m \Delta logBrent_{t-m} + \theta_1 \Delta \log I44_{t-1} + \cdots + \theta_j \Delta logI44_{t-j} + \varepsilon_t$
Model 2.1R	ΔlogI44 → ΔlogBrent	$\Delta\log Brent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \cdots + \alpha_m \Delta logBrent_{t-m} + \theta_1 \Delta \log I44_{t-1} + \cdots + \theta_j \Delta logI44_{t-j} + \vartheta_1 \Delta INTDIFF\_I44_{t-1} + \ldots + \vartheta_p \Delta INTDIFF\_I44_{t-p} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots + \tau_n \Delta LIBOR\_USD_{t-n} + \varepsilon_t$
Model 3.1R	ΔlogUSD → ΔlogBrent	$\Delta \log Brent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \cdots + \alpha_m \Delta logBrent_{t-m} + \theta_1 \Delta \log USD_{t-1} + \cdots + \theta_j \Delta logUSD_{t-j} + \varepsilon_t$
Model 4.1R	ΔlogUSD → ΔlogBrent	$\Delta \log Brent_t = \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \cdots + \alpha_m \Delta logBrent_{t-m} + \theta_1 \Delta \log USD_{t-1} + \cdots + \theta_j \Delta logUSD_{t-j} + \vartheta_1 \Delta INTDIFF\_LIBORUSD_{t-1} + \ldots + \vartheta_p \Delta INTDIFF\_LIBORUSD_{t-p} + \tau_1 \Delta LIBOR\_USD_{t-1} + \cdots + \tau_n \Delta LIBOR\_USD_{t-n} + \varepsilon_t$

6.6.2 Empirical findings

An overview of the results from the Granger causality tests can be found in table 30 below.

Table 30 – Overview of Granger causality test results for non-cointegrated variables across all samples

Granger causality test results[1]						
Model	Granger causality from X → Y	Control variables	Full sample	Sample 2.1	Sample 3.1	Sample 3.2
Does the oil price Granger cause the exchange rate?						
Model 1.1	ΔlogBrent → ΔlogI44	-	Yes, 1%	Yes, 1%	Yes, 1%	Yes, 1%
Model 2.1	ΔlogBrent → ΔlogI44	ΔINTDIFF_I44, ΔLIBORUSD	Yes, 1%	Yes, 1%	Yes, 1%	Yes, 1%
Model 3.1	ΔlogBrent → ΔlogUSD	-	Yes, 1%	Yes, 1%	Yes, 1%	Yes, 1%
Model 4.1	ΔlogBrent → ΔlogUSD	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	Yes, 1%	Yes, 1%	Yes, 1%	Yes, 1%
Does the exchange rate Granger cause the oil price?						
Model 1.1R	ΔlogI44 → ΔlogBrent	-	Yes, 10%	Yes, 10%	No	Yes, 1%
Model 2.1R	ΔlogI44 → ΔlogBrent	ΔINTDIFF_I44, ΔLIBORUSD	Yes, 10%	Yes, 5%	No	Yes, 1%
Model 3.1R	ΔlogUSD → ΔlogBrent	-	Yes, 5%	Yes, 1%	No	Yes, 5%
Model 4.1R	ΔlogUSD → ΔlogBrent	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	Yes, 5%	Yes, 5%	No	Yes, 1%

[1] % indicates the significance level of the F-value

6.4.2.1 Full sample period

The results from the Granger causality tests in the full sample are summarized in table 31 below.

Table 31 - Overview of Granger causality test results for non-cointegrated variables, full sample

Granger causality test results Full sample				
Model	Granger causality from X → Y	Control variables	# of lags to ensure no sign. autocorr.	F-value
Does the oil price Granger cause the exchange rates?				
Model 1.1	ΔlogBrent → ΔlogI44	-	4	***17.05
Model 2.1	ΔlogBrent → ΔlogI44	ΔINTDIFF_I44, ΔLIBORUSD	15	***5.60
Model 3.1	ΔlogBrent → ΔlogUSD	-	1	***54.49
Model 4.1	ΔlogBrent → ΔlogUSD	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	1	***51.27
Does the exchange rate Granger cause the oil price?				
Model 1.1R	ΔlogI44 → ΔlogBrent	-	15	*1.64
Model 2.1R	ΔlogI44 → ΔlogBrent	ΔINTDIFF_I44, ΔLIBORUSD	11	*1.67
Model 3.1R	ΔlogUSD → ΔlogBrent	-	13	**2.11
Model 4.1R	ΔlogUSD → ΔlogBrent	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	11	**2.23

6.4.2.1.1 The relationship between the I44 exchange rate and the oil price – model 1.1, 2.1, 1.1R and 2.1R

Firstly, the results of the models testing for Granger causality from the oil price to the I44 exchange rate will be discussed. By investigating model 1.1, the results reveal that $\Delta logBrent$ Granger cause $\Delta logI44$ applying 4 daily lags. Analysing model 2.1, we see that the results are robust when adding control variables, although more lags are necessary to eliminate autocorrelation. The implication of these results are that past information on changes in the crude oil price may improve forecasts of the exchange rate. The findings are consistent with Amano & Norden (1998) and Hamilton (1983), who found Granger causality from the oil price to the exchange rates, when investigating the US real exchange rate and the oil price. As discussed in the introduction of the thesis, the popular perception in financial media is that the oil price has a large impact on the value of the Norwegian krone, which relates to the above findings.

Further, we examine Granger causality from the I44 exchange rate to the oil price, through the reverse specifications, model 1.1R and 2.1 R. The result from model 1.1R shows that the null hypothesis, that lagged values of $\Delta logI44$ do not have predictive content for $\Delta logBrent$, is rejected at a 10% level. This result is consistent when adding control variables to the relation, through specification 2.1R. Thus, it seems that changes in the I44 exchange rate can be used to predict changes in the oil price in the short run. For example, a weakening of the NOK can be related to pessimistic economic outlook for Norway, which often is thought to occur in association with a downwards trending oil price. The significance level although indicates a somewhat weak result.

6.4.2.1.2 The relationship between the USD and the oil price – model 3.1, 4.1, 3.1R and 4.1R

In the full sample period, causality is analysed also between the NOK/USD exchange rate and the oil price. Results from model specification 3.1, testing whether $\Delta logBrent$ Granger cause $\Delta logUSD$, shows a highly significant F-value at a 1% level. This result holds when control variables are added to the model, through specification 4.1, by applying one lag. The results are in line with expectations, as the oil price is expected to affect the exchange rate for an oil exporting nation such as Norway, c.f. previous discussions in 6.4.3.2.

When investigating whether the NOK/USD exchange rate Granger causes Brent, through model 3.1R and 4.1R, the null hypothesis can again be rejected, although at a 5% level. Results are robust when control variables are added to the model, yielding a slightly higher F-value, indicating that $\Delta LIBORUSD\ and\ \Delta INTDIFF\_LIBORUSD$ are important variables to account for in the relationship. Results therefore indicate that $\Delta logUSD$ Granger cause $\Delta logBrent$. This result is possibly an implication of the previously discussed characteristic that the oil price is quoted in US dollar. Therefore, changes in the value of the US dollar against the Norwegian krone are found to have "forecast-ability" for changes in the oil price.

The findings yield bilateral Granger causality between both the I44 exchange rate and the oil price, as well as between the NOK/USD and the oil price.

6.4.2.2 Sample 2.1

Sample 2.1 ranges from the initiation of the full sample period (01-01-2001) until post oil price collapse in 2014 (13-01-2015). The variables of interest occasionally experienced strong volatility during both the financial crisis and the 2014 oil price drop. The results from sample 2.1 are summarized in table 32.

Table 32 - Overview of Granger causality test results for non-cointegrated variables, sample 2.1

Granger causality test results Sample 2.1				
Model	Granger causality from X → Y	Control variables	# of lags to ensure no sign. autocorr.	F-value
Does the oil price Granger cause the exchange rates?				
Model 1.1	ΔlogBrent → ΔlogI44	-	2	***22.38
Model 2.1	ΔlogBrent → ΔlogI44	ΔINTDIFF_I44, ΔLIBORUSD	15	***4.14
Model 3.1	ΔlogBrent → ΔlogUSD	-	1	***43.01
Model 4.1	ΔlogBrent → ΔlogUSD	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	1	***41.52
Does the exchange rate Granger cause the oil price?				
Model 1.1R	ΔlogI44 → ΔlogBrent	-	13	*1.66
Model 2.1R	ΔlogI44 → ΔlogBrent	ΔINTDIFF_I44, ΔLIBORUSD	11	**1.91
Model 3.1R	ΔlogUSD → ΔlogBrent	-	15	***2.21
Model 4.1R	ΔlogUSD → ΔlogBrent	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	7	**2.30

6.4.2.2.1 The relationship between the I44 exchange rate and the oil price – model 1.1, 2.1, 1.1R and 2.1R

Results from model 1.1 reveal that $\Delta logBrent$ Granger cause $\Delta logI44$ using 2 daily lags, as the F-value is significant at a 1% level. When adding control variables, and thereby testing model specification 2.1, we see that the results are robust, although more lags are necessary to eliminate autocorrelation, similar to the findings in the full sample. Information on changes in crude oil prices may support forecasts of the I44 effective exchange rate. The findings are in line with previous literature and the authors expectations.

Further, the reverse specifications, model 1.1R and 2.1R, are examined to test for Granger causality from the I44 exchange rate to the oil price. For model 1.1R, the null hypothesis, that lagged values of $\Delta logI44$ do not have predictive content for $\Delta logBrent$, is rejected at a 10% level also in this sample. This result is strengthened when adding control variables to the relation, through specification 2.1R.

The results are overall consistent with the findings in the full sample.

6.4.2.2.2 The relationship between the USD and the oil price – model 3.1, 4.1, 3.1R and 4.1R

For the relation between the oil price and the US dollar, the results are similar to the ones presented in the full sample. The resulting F-value from model specification 3.1, testing whether $\Delta logBrent$ Granger cause $\Delta logUSD$, is highly significant. The result is robust in model 4.1, where $\Delta LIBOUSD$ and $\Delta INTDIFF\_LIBORUSD$ are added to the model. As the oil price is expected to affect the exchange rate for oil exporting nations, the result is in line with expectations.

When investigating model 3.1R, whether the NOK/USD exchange rate Granger causes Brent, the null hypothesis can again be rejected at a 1% level. Results are robust in model 4.2R, where control variables are added to the model, however yielding a slightly lower F-value. Results therefore indicate that changes in the NOK/USD exchange rate contain predictive content for changes in the oil price, in the short run, in line with the expectations.

Also in subsample 2.1, we find bilateral Granger causality between the I44 exchange rate and the oil price, as well as between the NOK/USD and the oil price.

6.4.2.4 Sample 3.1

Sample 3.1 runs from the beginning of the full sample period (01-01-2001) until the beginning of the financial crisis (03-07-2008), where the oil price peaked at $144/bbl. The period is characterized by stable increases in the Brent oil price. Results from Granger causality in sample 3.1 differ from other subsamples. Granger causality is *not* found from the exchange rates to the oil price, both with respect to the I44 and the NOK/USD. A summary of the samples' results is found in table 33.

Table 33 - Overview of Granger causality test results for non-cointegrated variables, sample 3.1

Granger causality test results Sample 3.1				
Model	Granger causality from X → Y	Control variables	# of lags to ensure no sign. autocorr.	F-value
Does the oil price Granger cause the exchange rates?				
Model 1.1	ΔlogBrent → ΔlogI44	-	5	***4.09
Model 2.1	ΔlogBrent → ΔlogI44	ΔINTDIFF_I44, ΔLIBORUSD	5	***4.24
Model 3.1	ΔlogBrent → ΔlogUSD	-	4	***6.48
Model 4.1	ΔlogBrent → ΔlogUSD	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	4	***6.67
Does the exchange rate Granger cause the oil price?				
Model 1.1R	ΔlogI44 → ΔlogBrent	-	5	0.40
Model 2.1R	ΔlogI44 → ΔlogBrent	ΔINTDIFF_I44, ΔLIBORUSD	5	0.39
Model 3.1R	ΔlogUSD → ΔlogBrent	-	6	1.59
Model 4.1R	ΔlogUSD → ΔlogBrent	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	6	1.59

6.4.2.4.1 The relationship between the I44 exchange rate and the oil price – model 1.1, 2.1, 1.1R and 2.1R

As seen above, the Granger causality tests in model 1.1 and 2.1 imply that we reject the null hypothesis of no explanatory power at a 1% level. As found in the full sample, as well as the samples preceding 3.2, oil price changes have predictive content for changes in the I44 exchange rate.

However, when testing the reverse specifications in model 1.1R and 2.1R, we are not able to reject the null hypothesis. Tests therefore indicate that information on changes in the I44 exchange rate cannot improve forecasts on changes in the oil price.

6.4.2.4.2 The relationship between the USD and the oil price – model 3.1, 4.1, 3.1R and 4.1R

When testing the relationship between the NOK/USD exchange rate and the oil price, the results reveal that Granger causality runs from the oil price to the exchange rate. The null hypothesis is rejected at a 1% level, both in model specification 3.1 and 4.1.

In model 3.1R and 4.1R, we do not find evidence causation due to the resulting insignificant F-value, hence we cannot reject the null hypothesis that the tested coefficients have no predictive content for the oil price. Results reveal that information on US dollar exchange rate movements cannot significantly be used to predict changes in the oil price in this subsample.

To summarize the findings in subsample 3.1, we found that causality runs from the oil price to the respective exchange rates, but not the converse. This was consistent when control variables are added to the models. As described, this period is recognised by less volatility, and the findings of no Granger causality might be that low expectations of radical changes in the markets cushioned the effect of occurring events. A further explanation might be that the financialisation of oil as a commodity was not as strong at this time (Morgan Stanley, n.d.). Stated differently, as oil behaves more like a financial asset, the less the price formation is affected by the forces of supply and demand. Sample 3.1 is characterised by a lower average open interest in crude oil than the following samples. Thus, market information on the development of other financial assets, as the exchange rates, might not have been as strongly absorbed in the oil price determination in the early 2000s.

6.4.2.5 Sample 3.2

Sample 3.2 covers the period from pre-financial crisis (04-07-2008) until the initiation of the oil price drop in 2014 (13-01-2015). It might be described as the most volatile period of the sample, as there are large variations in the financial variables under consideration. Results from the Granger causality tests can be found in table 34.

Table 34 - Overview of Granger causality test results for non-cointegrated variables, sample 3.2

Granger causality test results Sample 3.2				
Model	Granger causality from X → Y	Control variables	# of lags to ensure no sign. autocorr.	F-value
Does the oil price Granger cause the exchange rates?				
Model 1.1	ΔlogBrent → ΔlogI44	-	1	***33.29
Model 2.1	ΔlogBrent → ΔlogI44	ΔINTDIFF_I44, ΔLIBORUSD	1	***32.73
Model 3.1	ΔlogBrent → ΔlogUSD	-	2	***14.51
Model 4.1	ΔlogBrent → ΔlogUSD	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	13	***3.15
Does the exchange rate Granger cause the oil price?				
Model 1.1R	ΔlogI44 → ΔlogBrent	-	13	***2.19
Model 2.1R	ΔlogI44 → ΔlogBrent	ΔINTDIFF_I44, ΔLIBORUSD	10	**2.09
Model 3.1R	ΔlogUSD → ΔlogBrent	-	13	***2.24
Model 4.1R	ΔlogUSD → ΔlogBrent	ΔLIBORUSD, ΔINTDIFF_LIBORUSD	15	***1.77

6.4.2.5.1 The relationship between the I44 exchange rate and the oil price

By investigating model 1.1 and model 2.1, we find that the F-value is sufficient to reject the null hypothesis at a 1% level. With strong statistical significance, we verify that $\Delta logBrent$ Granger cause $\Delta logI44$, also when controlling for $\Delta INTDIFF\_I44$ and $\Delta LIBORUSD$.

Reversing the relation, investigating model 1.1R and 2.1R, we find similar results. Information on changes in the I44 exchange rate is useful when predicting changes in the oil price.

6.4.2.5.2 The relationship between the NOK/USD exchange rate and the oil price

Investigating model 3.1 and 4.1, we see that the F-value is large, and suffices to reject the null hypothesis at a 1% level for both specifications. Changes in Brent has predictive content for changes in the NOK/USD exchange rate.

Model 3.1R and 4.1R reveal that the null hypothesis can be rejected at a 5% and 1% level, respectively. The bilateral relation between the oil price and the NOK/USD is evident, and supports findings in the full sample as well as sample 2.1

Summarizing sample 3.2, we see that bilateral Granger causality is found both between the oil price and the I44 exchange rate, as well as the NOK/USD, almost exclusively at a 1% significance level. Sample 3.2 therefore stands out as the sample with the strongest causality results. This gives the authors reason to believe that more variation in the data yields stronger Granger causality results.

6.6.3 Conclusion Granger causality

The overall findings reveal bilateral causality across all subsamples with the exception of sample 3.1. Subsample 3.1, characterised by less volatility, showed no Granger causality from exchange rates to the oil price, even when controlling for relevant variables. One potential reason might be that low expectations of radical changes in the markets cushioned the effect of occurring events. Further, as it is believed that the financialisation of the oil price was limited, the oil price might not have reacted to the same extent to changes in other financial assets, such as the exchange rates. On the other hand, the most volatile period, sample 3.2, indicated the strongest causality results.

6.7 Conclusion empirical analysis

The findings cannot be said to provide a clear picture of the relation between the oil price and the exchange rate, as the results differ depending on the sample investigated, the time horizon, and the model specifications.

Overall, the stationarity analysis concluded that all variables were integrated of order 1. These results led to investigation of a cointegrating relation between the oil price and the respective exchange rates, where a long term relation was confirmed both between the I44 and the oil price, as well as the NOK/USD and the oil price. Where cointegration was established, in subsample 2.2, the relation was further examined through error correction models, and subsequent Granger causality analyses investigated both potential short and long term causality relations. Findings enabled the authors to conclude that causation was evident from the oil price to exchange rates was evident both in the short and long term. Investigation of causation from the oil price to the exchange rates was, on the contrary, only evident in the long run.

Further analysis of Granger causality in specifications where no cointegration was established, indicated that bilateral causality existed for both relations across all subsamples, with the exception of subsample 3.1. Most significant results where prominent in subsample 3.2, where the variables could be said to have exhibited the most volatility.

7. Robustness check

In empirical studies, it is often desired to examine the robustness of the empirical results. The relations may be augmented by adding or removing regressors or examining other data frequencies. As discussed in section 5.1.3, certain control variables where omitted from the previous analyses, as these were not obtainable on the desired frequency. In order to include some of these potentially important variables, further empirical analyses have been conducted on a monthly basis. It is worth mentioning that on one hand, this might increase the robustness. On the other hand, the frequency change yields fewer observations, which might reduce the strength of the results.

7.1 Variable choices

The robustness data set analysed represents monthly data covering the full sample period from January 2001 to December 2016. The robustness analyses will not be carried out on subsamples, due to the limited number of observations.

As described in the theory section, multiple variables are relevant to consider when modelling relations between the oil price and the exchange rates.

Firstly, additional variables can be included to control for the changes in the exchange rates. As described by Madura & Fox (2011) and discussed in 3.1.1, the variations in the supply and demand levels of currencies can be explained by changes in inflation, interest rates, government income, government control and expectations. Inflation is also emphasized in fundamental theories such as PPP. With regards to the oil price, theory and historical examination of the price development suggest that geopolitical tensions, the development of the world economy, natural disasters and financial markets development among others are influential variables, cf. section 3.2.1. Good proxies for government control, expectations, natural disasters, geopolitical tensions and the movements in the financial markets as a whole are not readily available. Control variables are added in correspondence with previous literature by Akram (2002) and Habib & Kalamova (2007). These are *industrial production* and *inflation* (measured by the Consumer Price Index, CPI) for the relevant geographical areas.

Common for previous literature is the established negative relationship between changes in the oil price and productivity variables such as GDP, economic growth and industrial production[52], see for example (Cobo-Reyes & Quirós, 2005; Hamilton, 1983; Kim & Willet, 2000). As argued in section 3.2.1, the state of the global economy may have an influence on the oil price, through its effect on energy demand. Industrial production is argued to be one of the leading indicators of gross domestic product[53] which reflects the overall economic performance of a country. Stated differently, increases or decreases in industrial production indicate whether an economy is expanding or contracting (Bayar & Kilic, 2014). A

[52] Industrial production is according to OECD "the output of industrial establishments", and includes sectors as manufacturing, public utilities (electricity, gas and water) and mining. It is measured in an index with base year 2010, and expresses change in the volume of production output (OECD, 2017).

[53] GDP is reported solely on a quarterly basis, which is why the chosen proxy is industrial production

relatively higher growth in productivity is believed to raise the value of a country's currency (Balassa, n.d.). Prior research emphasizes oil and gas as crucial inputs to the industrial production, as about one-half of the world's total delivered energy is consumed by the industrial sector.

The inclusion of consumer price indices[54] stems from their ability to capture the respective countries' price levels. As previously explained, high domestic inflation would generally result in increased demand for lower priced foreign goods, which consequently results in rising demand for foreign currency. As theoretically explained, this is expected to impact the exchange rates.

Weighted indices for both industrial production and CPI are constructed to represent the respective variables in accordance with the trade-weighted exchange rate I44. Identical weights as applied to the I44 interest rate[55] are used to construct these. Data on both variables are retrieved from OECD.

7.2 Stationarity

The stationarity analysis conducted in the following section is conducted in a similar manner as the analysis carried out in section 6.4.2-6.4.3. Graphical analysis, correlogram analysis and stationarity tests will be performed to establish the nature of the variables under investigation.

7.2.1 Empirical estimation and findings

Table 35 summarises the findings from stationarity analyses conducted on variables in level form, in the robustness sample. With the exception of the three CPI variables, all other variables clearly exhibit a unit root. The price index variables show mixed conclusions, both with respect to the ADF test and the ACF plot. The authors have chosen to require that the null hypothesis of a unit root is rejected at a 1 or 5% level, to ensure that no non-stationary variables are included in the subsequent analyses. On the basis of this, the final conclusion is that the CPI variables exhibit a unit root, and that proper transformation is required.

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[54] CPI is a measure for inflation, defined by OECD as the "change in the prices of a basket of goods or services [...]". It is measured in terms of the annual growth rate of prices, and in an index with base year 2010 (OECD, n.d.-b).

[55] See appendix 1

Table 35 - Stationarity analysis for all samples, variables in level form, monthly data

Variables in level form Robustness sample					
Name	Model specification	BG-test conclusion	Lag(s) in ADF-test	Test statistic (tau-value)	Conclusion (significance)
logBrent	RW with drift	>10	10/20	0.80/0.84	Unit root
logI44	RW with drift	9	9	-2.71	Unit root
logUSD	RW with drift	1	1	-1.71	Unit root
I44_INTRATE	RW with drift	8	8	-1.4	Unit root
LIBORUSD	RW with drift	>10	10/20	-1.65/-1.69	Unit root
NIBOR	RW with drift	5	5	-1.81	Unit root
logINDPRO_I44	RW with drift	3	3	-2.87	Unit root
logINDPRO_USD	RW with drift	4	4	-2.71	Unit root
logINDPRO_NOK	RW with drift & trend	>10	10/20	-2.37/-2.38	Unit root
CPI_I44	RW with drift	>10	10/20	-2.79/-2.54	*Stationarity /Unit root
CPI_USD	RW with drift	>10	10/20	-2.81/-2.76	*Stationarity/*Stationarity
CPI_NOK	RW with drift	>10	10/20	-2.88/-2.43	**Stationarity/Unit root

Critical values applicable for RW with drift: 10% = -2.57, 5% = -2.86, 1% = -3.43 / Critical values applicable for RW with drift & trend: 10% = -3.12, 5% = -3.41, 1% = -3.96

7.2.2 Correcting for non-stationarity

As previously discussed, time series that exhibit a unit root becomes stationary by taking the first difference of the variable. Thus, the first difference of the variables has been analysed.

The results show that all variables become stationary after the transformation, and the null hypothesis of a unit root in rejected at a 1% significance level, with the exception of $\Delta LIBORUSD$ which is rejected at a 10% level, see table 36. However, the respective ACF plot is in line with expectations, leading the authors to believe that the somewhat lower test-statistic is due to extreme values in the time series. The results can be seen in summary table 37.

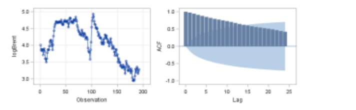
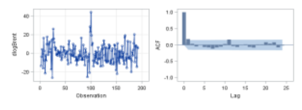
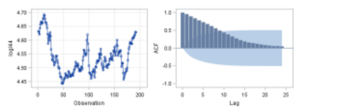
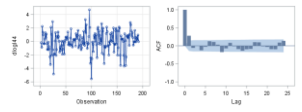
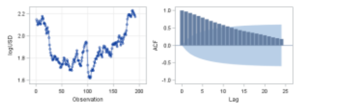
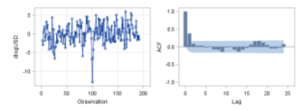
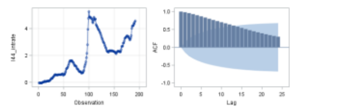
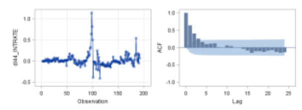
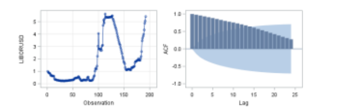
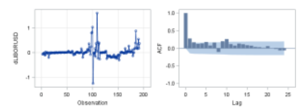
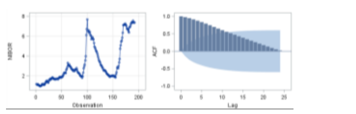
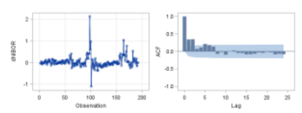
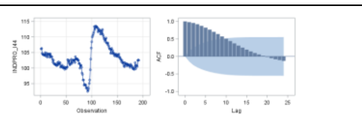
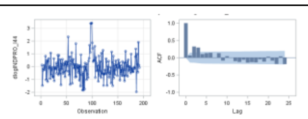
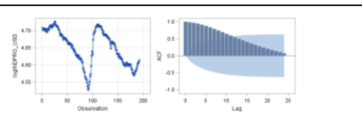
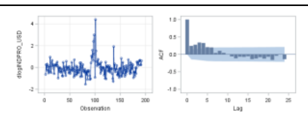
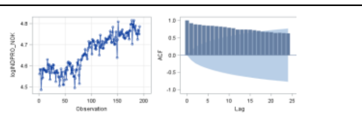
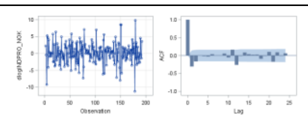
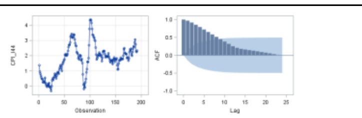
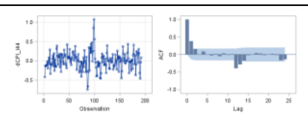
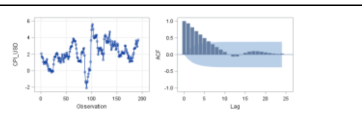
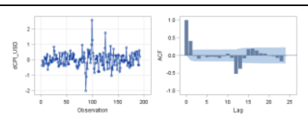
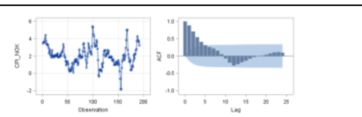
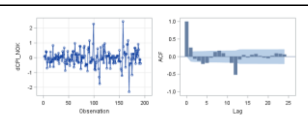
Table 36 - Stationarity analysis for all samples, variables in differenced form, monthly data

Variables in first differences, Δ Robustness sample					
Name	Model specification	BG-test conclusion	Lag(s) in ADF-test	Test statistic (tau-value)	Conclusion (significance)
ΔlogBrent	Pure RW	0	0	-11.50	***Stationary
ΔlogI44	Pure RW	8	8	-4.98	***Stationary
ΔlogNOK/USD	Pure RW	0	0	-9.22	***Stationary
ΔI44_INTRATE	Pure RW	0	0	-6.34	*Stationary
ΔLIBORUSD	Pure RW	9	9	-1.63	***Stationary
ΔNIBOR	Pure RW	7	7	-4.09	***Stationary
ΔlogINDPRO_I44	Pure RW	>10	10/20	-3.39/-2.76	***Stationary
ΔlogINDPRO_USD	Pure RW	6	6	-3.62	***Stationary
ΔlogINDPRO_NOK	RW with drift	>10	10/20	-3.97/-3.66	***Stationary
ΔCPI_I44	Pure RW	>10	10/20	-3.73/-3.04	***Stationary
ΔCPI_USD	Pure RW	>10	10/20	-4.62/-3.58	***Stationary
ΔCPI_NOK	Pure RW	>10	10/20	-4.52/-3.75	***Stationary

Critical values applicable for Pure RW: 10% = -1.61, 5% = -1.95, 1% = -2.58/ Critical values applicable for RW with drift: 10% = -2.57, 5% = -2.86, 1% = -3.43

The following table summarises the time-series properties and autocorrelation functions for the variables in level and first differenced form. We clearly see that autocorrelation is reduced when variables in first differences are analysed.

Table 37 - Summary of stationarity analysis*:* Line and ACF plots, monthly data

Overview of line and ACF plots Robustness sample		
Variable	Undifferenced varibale	First difference of variable
logBrent		
log I44		
log USD		
I44_INTRATE		
LIBORUSD		
NIBOR		
log (INDPRO_I44)		
log (INDPRO_USD)		
log (INDPRO_NOK)		
CPI_I44		
CPI_USD		
CPI_NOK		

7.3 Cointegration

As discussed, we run the risk of not finding a significant cointegrating relationship if relevant factors associated with the dependent variable are omitted. To investigate whether prior analyses have been subject to misspecification, we further analyse whether the inclusion of industrial production and consumer price indices alter the until now established conclusions.

The following table summarises the cointegration models tested and the corresponding findings.

Table 38 - Overview of cointegration model specifications, monthly data

Overview of cointegration models tested Robustness				
Model	Model specification	# of lags to ensure no sign. autocorr[1]	Test statistic (tau-value)	Stationarity conclusion on regression residuals
	I44 and Brent			
Model 1	$\log I44_t = \beta_0 + \beta_1 \log Brent_t + u_t$	14	-2.81	Unit root
Model 2	$\log I44_t = \beta_0 + \beta_1 \log Brent_t + \beta_2 INTDIFF\_I44_t + \beta_3 LIBOR\_USD_t + u_t$	11	-2.77	Unit root
Model 5	$\log I44_t = \beta_0 + \beta_1 \log Brent_t + \beta_2 INTDIFF\_I44_T + \beta_3 LIBOR\_USD_t + \beta_4 logINDPRO\_USD_t + \beta_5 logINDPRO\_NOK_t + \beta_6 logINDPRO\_I44_t + \beta_7 CPIDIFF\_I44_t + u_t$	11	-2.83	Unit root
	NOK/USD and Brent			
Model 3	$\log USD_t = \beta_0 + \beta_1 logBrent_t + u_t$	2	-2.31	Unit root
Model 4	$\log USD_t = \beta_0 + \beta_1 \log Brent_t + \beta_2 INTDIFF\_LIBORUSD_t + \beta_3 LIBOR\_USD_t + u_t$	2	-1.78	Unit root
Model 6	$\log USD_t = \beta_0 + \beta_1 \log Brent_t + \beta_2 INTDIFF\_LIBORUSD_t + \beta_3 LIBOR\_USD_t + \beta_4 logINDPRO\_USD_t + \beta_5 logINDPRO\_NOK_t + \beta_6 CPIDIFF\_USD_t + u_t$	**0**	***-4.80	Stationarity

[1] Significance level depends on the number of lags i model.

Engle-Granger critical values (applicable to the ADF test): 10% = -2.84, 5% = -3.17, 1% = -3.77

Overall, the results from the robustness analyses both support and contradict the conclusions reached in the analyses conducted on daily data in the full sample in section 6.4.3. With respect to the I44 exchange rate and the oil price, the results support the findings of no cointegration, also when controlling for industrial production and inflation. However, the conclusion changes when analysing the relationship between the NOK/USD exchange rate and the oil price, when the two formerly omitted control variables are added to the relation (model 6). The latter is further analysed in what follows.

Model 6

Model 6 tests whether the inclusion of Norwegian and US industrial production as well as the price level differential between Norway and the US changes the results previously established.

Formally we test the following model

$$logUSD_t = \beta_0 + \beta_1 logBrent_t + \beta_2 INTDIFF\_LIBORUSD_t + \beta_3 LIBORUSD_t + \beta_4 logINDPRO\_USD_t + \beta_5 logINDPRO\_NOK_t + \beta_6 CPIDIFF\_USD_t + u_t \qquad (Eq. 7.1)$$

Table 39 – Cointegration coefficient estimates, model 6

Dependent variable = logUSD		
Variable	**Estimate**	**Std. Error**
Intercept	4.4161	0.9328
logBrent	-0.3309	0.0125
INTDIFF_LIBORUSD	0.0038	0.0029
LIBORUSD	0.0103	0.0041
logINDPRO_USD	0.5357	0.1165
logINDPRO_NOK	-0.7913	0.1144
CPIDIFF_USD	0.0145	0.0030

$$\widehat{logUSD}_t = 4.42 - 0.33logBrent_t + 0.004INTDIFF\_LIBORUSD_t + 0.01LIBORUSD_t + 0.54logINDPRO\_USD_t - 0.79logINDPRO\_NOK_t + 0.01CPIDIFF\_USD_t + u_t$$

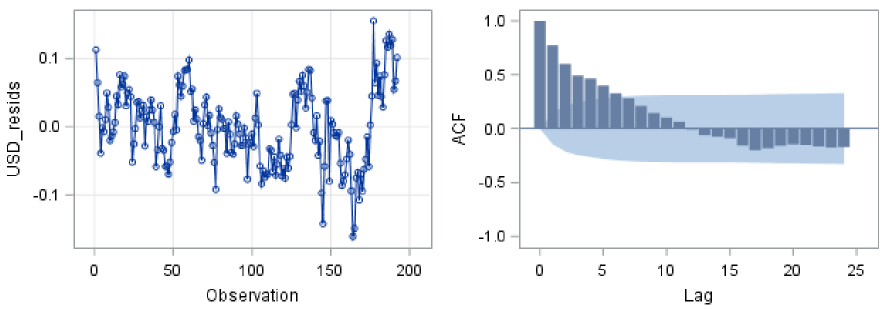
The Breusch-Godfrey test indicates that no lags are necessary to ensure no significant autocorrelation. The results from the ADF[56] test shows that the null hypothesis of a unit root is rejected at a 1% level, see table 40. The ACF plot below shows that autocorrelation coefficients decline fast towards zero, supporting the ADF test conclusion. The KPSS-test however rejects the null hypothesis of stationarity at a 1% significance level, contradicting the ADF test. The authors have chosen to emphasize the ADF test in conjunction with the ACF plot, and thus conclude that cointegration is present.

Table 40 - Stationarity analysis on regression residuals, model 6

Stationarity analysis on regression residuals		
	ADF test	KPSS test
# of lags to ensure no sign. autocorr	0	14
Test statistic	***-4.80	***0.14
Conclusion	Stationarity	Unit root

Engle-Granger critical values (applicable to the DF test): 10% = -2.84, 5% = -3.17, 1% = -3.77

Figure 34 - Line and ACF plot on regression residuals, model 6



[56] In this case the Dickey-Fuller are zero lags are included in the model

7.4 Error correction models

Following the previously conducted analyses, error correction models will be estimated where a cointegrating relationship was found.

7.4.1 Empirical estimation and findings

The results from the Granger causality tests for cointegrated variables are found in table 41 below.

Table 41 - Overview of Granger causality test results for cointegrated variables, monthly data

Granger causality for cointegrated variables Robustness							
Model	Granger causality from X → Y	Control variables	# of lags to ensure no sign. autocorr.	F-value	Error correction term	Coefficient on lag of ΔX	Conclusion
Does the oil price Granger cause the exchange rates?							
Model 6.1	ΔlogBrent → ΔlogUSD	ΔINTDIFF_LIBORUSD, ΔLIBORUSD, ΔlogINDPRO_NOK, ΔlogINDPRO_USD, ΔCPIDIFF_USD	1	*2.54	**-0.0758	0.0055	GC in LR
Does the exchange rate Granger cause the oil price?							
Model 6.1R	ΔlogUSD → ΔlogBrent	ΔINTDIFF_LIBORUSD, ΔLIBORUSD, ΔlogINDPRO_NOK, ΔlogINDPRO_USD, ΔCPIDIFF_USD	1	***6.60	-0.2098	***-0.9227	GC in SR

7.4.1.1 The relation between the NOK/USD exchange rate and the oil price

Model 6.1

Grange causality is tested from the oil price to the NOK/USD exchange rate, and the converse. Model 6.1 is an extension of error correction model 3.1 which was estimated on daily data, with the inclusion of the control variables industrial production and CPI.

$$\Delta logUSD_t = \alpha_0 + \alpha_1 \Delta logUSD_{t-1} + \theta_1 \Delta logBrent_{t-1} + \vartheta_1 \Delta LIBOR_{USD_{t-1}} + \tau_1 \Delta INTDIFF\_LIBORUSD_{t-1} + \omega_1 \Delta logINDPRO\_NOK_{t-1} + \lambda_1 logINDPRO\_USD_{t-1} + \eta_1 CPIDIFF\_USD_{t-1} + \varphi \hat{u}_{t-1} + \varepsilon_t \qquad (Eq. 7.2)$$

Figure 35 - Error correction model coefficient estimates and Granger causality test, model 6.1

Dependent variable = ΔlogUSD				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	0.0005	0.0018	0.3000	0.7663
$\Delta logUSD_{t-1}$	0.3513	0.0799	4.4000	<.0001
$\Delta logBrent_{t-1}$	**0.0055**	**0.0215**	**0.2500**	**0.8003**
$\Delta LIBORUSD_{t-1}$	-0.0209	0.0086	-2.4300	0.0162
$\Delta INTDIFF\_LIBORUSD_{t-1}$	-0.0110	0.0080	-1.3700	0.1724
$\Delta logINDPRO\_NOK_{t-1}$	-0.0046	0.0585	-0.0800	0.9370
$\Delta logINDPRO\_USD_{t-1}$	-0.2829	0.2640	-1.0700	0.2854
$\Delta CPIDIFF\_USD_{t-1}$	0.0033	0.0030	1.1100	0.2705
$\hat{u}_{t-1}$	**-0.0758**	**0.0342**	**-2.2100**	**0.0281**
Granger causality test			F-value	P-value
F-test			2.54	0.0819

The results from model 6.1 show that the oil price Granger causes the NOK/USD in the long run.

The F-value is significant at a 10% level, leading us to reject the null hypothesis of no Granger causality. The coefficient on $\Delta logBrent_{t-1}$ is insignificant, rejecting any short-term causality. The error correction term is significant at a 5% level, leading the causality results to prevail from the long-run relation. The EC term is small and negative, in line with expectations.

When controlling for industrial production and CPI, we now find a cointegrating relationship with a corresponding error correction model. The cointegration findings may indicate that specification 4.1[57] tested in the full sample suffered from omitted variable bias. This indicates that these variables contain important information about the relationship between the NOK/USD exchange rate and the oil price.

Model 6.1R

Model 6.1R represents the reverse specification of model 6.1

$$\begin{aligned} \Delta logBrent_t = {} & \alpha_0 + \alpha_1 \Delta logBrent_{t-1} + \theta_1 \Delta logUSD_{t-1} + \vartheta_1 \Delta LIBOR\_USD_{t-1} + \tau_1 \Delta INTDIFF\_LIBORUSD_{t-1} \\ & + \omega_1 \Delta logINDPRO\_NOK_{t-1} + \lambda_1 logINDPRO\_USD_{t-1} + \eta_1 CPIDIFF\_USD_{t-1} + \varphi \hat{u}_{t-1} \\ & + \varepsilon_t \qquad (Eq. 7.3) \end{aligned}$$

[57] Model 4.1: $\Delta logUSD_t = \alpha_0 + \alpha_1 \Delta logUSD_{t-1} + \cdots + \alpha_6 \Delta logUSD_{t-6} + \theta_1 \Delta logBrent_{t-1} + \cdots + \theta_6 \Delta logBrent_{t-6} + \vartheta_1 \Delta LIBOR\_USD_{t-1} + \cdots + \vartheta_6 \Delta LIBOR\_USD_{t-6} + \tau_1 \Delta INTDIFF\_LIBORUSD_{t-1} + \cdots + \tau_6 \Delta INTDIFF\_LIBORUSD_{t-6} + \varphi \hat{u}_{t-1} + \varepsilon_t$

Figure 36 - Error correction model coefficient estimates and Granger causality test, model 6.1R

Dependent variable = ΔlogBrent				
Variable	Estimate	Std. Error	t-value	P-value
Intercept	-0.0042	0.0069	-0.6000	0.5505
$\Delta logBrent_{t-1}$	0.0656	0.0831	0.7900	0.4312
$\Delta logUSD_{t-1}$	**-0.9227**	**0.3086**	**-2.9900**	**0.0032**
$\Delta LIBORUSD_{t-1}$	0.0653	0.0332	1.9700	0.0505
$\Delta INTDIFF\_LIBORUSD_{t-1}$	0.0066	0.0311	0.2100	0.8317
$\Delta logINDPRO\_NOK_{t-1}$	0.4502	0.2261	1.9900	0.0480
$\Delta logINDPRO\_USD_{t-1}$	1.4126	1.0198	1.3900	0.1677
$\Delta CPIDIFF\_USD_{t-1}$	-0.0158	0.0116	-1.3600	0.1767
$\boldsymbol{\hat{u}_{t-1}}$	**-0.2098**	**0.1322**	**-1.5900**	**0.1143**
Granger causality test			F-value	P-value
F-test			6.60	0.0017

The result from model 6.1R displays that the NOK/USD exchange rate Granger causes the oil price in the short run.

Model 6.1R has a significant F-value at a 1% level, and the null hypothesis of no Granger causality is rejected here as well. The coefficient on $\Delta logUSD_{t-1}$ is highly significant and negative, indicating that an increase in the exchange rate may lead to a decrease in Brent. This is in line with economic theory, explaining that the phenomenon results from US dollar denomination of the oil price. The error correction term is insignificant, leading us to reject that long-run Granger causality is present. This result thus contrasts the conclusion of model 4.1R.

7.5 Granger causality

Table 44 below presents the results of the Granger causality test conducted on monthly data, followed by a discussion of the findings. The test is conducted on the model specification where no cointegration was found.

Table 42 - Overview of Granger causality test results for non-cointegrated variables, monthly data

Granger causality test results Full sample, robustness				
Model	Granger causality from X → Y	Control variables	# of lags to ensure no sign. autocorr.	F-value
Does the oil price Granger cause the exchange rates?				
Model 1.1	ΔlogBrent → ΔlogI44	-	13	1.14
Model 2.1	ΔlogBrent → ΔlogI44	ΔINTDIFF_I44, ΔLIBORUSD	4	**3.33
Model 5.1	ΔlogBrent → ΔlogI44	ΔINTDIFF_I44, ΔLIBORUSD, ΔlogINDPRO_NOK, ΔlogINDPRO_I44, ΔlogINDPRO_USD, ΔCPIDIFF_I44	4	**2.78
Model 3.1	ΔlogBrent → ΔlogUSD	-	1	0.54
Model 4.1	ΔlogBrent → ΔlogUSD	ΔINTDIFF_LIBORUSD, ΔLIBORUSD	1	0.14
Does the exchange rate Granger cause the oil price?				
Model 1.1R	ΔlogI44 → ΔlogBrent	-	11	***2.41
Model 2.1R	ΔlogI44 → ΔlogBrent	ΔINTDIFF_I44, ΔLIBORUSD	10	**1.94
Model 5.1R	ΔlogI44 → ΔlogBrent	ΔINTDIFF_I44, ΔLIBORUSD, ΔlogINDPRO_NOK, ΔlogINDPRO_I44, ΔlogINDPRO_USD, ΔCPIDIFF_I44	14	1.42
Model 3.1R	ΔlogUSD → ΔlogBrent	-	11	***4.04
Model 4.1R	ΔlogUSD → ΔlogBrent	ΔINTDIFF_LIBORUSD, ΔLIBORUSD	11	***3.09

7.5.1 The relationship between the I44 exchange rate and the oil price

As presented above, the results show that the null hypothesis of Granger non-causality cannot be rejected for model 1.1, in contrast to the findings on daily data. When adding the interest rate differential and LIBOR USD as control variables, in model 2.1, causality is established, and the results correspond to those from daily data. Conclusions from model 2.1 are unchanged when controlling for industrial production and inflation (CPI), in model 5.1[58].

For the reverse specifications, model 1.1R, 2.1R and 5.1R, we find that $\Delta logI44$ Granger cause $\Delta logBrent$. The results are surprisingly strongest when no control variables are included. In the daily dataset, the results were significant at a 10% level, whereas we find significance at a 5% and 1% level for models in the monthly dataset. The stronger results analysing monthly data might indicate that the oil price requires more time than a few days to adjust to changes in the I44 exchange rate.

[58] Although with a somewhat lower F-value

7.5.2 The relationship between the NOK/USD exchange rate and the oil price

By testing for Granger causality from the oil price to the NOK/USD exchange rate, we find no significant causal relationships using monthly data. This opposes to the strong results found in the daily data, where causality was established at a 1% significance level. A possible reason for this might be that the effect of changes in the oil price are internalized more rapidly in the exchange rates, implying that monthly data is not able to capture the changes. This might follow from the fact that monthly data represents the average of daily data. The result indicates solid efficiency of the exchange rate markets, and corresponds to financial media's presentation of the relationship.

When investigating causality from NOK/USD to the oil price, the results are similar to the daily data, although the significance level is strengthened. Changes in the NOK/USD exchange rate thus seem to affect the oil price both through day-to-day and monthly variations.

7.6 Conclusion robustness check

The conclusions from the cointegration analysis carried out on daily data in the full sample were confirmed by the findings using monthly data, before controlling for industrial production and inflation, that were thought to be missing in the daily specifications. When these are included, we find a cointegrating relationship between the NOK/USD exchange rate and Brent.

The major differences when analysing monthly data is that we find no Granger causality from the oil price to the NOK/USD exchange rate. The differences in the findings may, as discussed, be due to the rapidness of the information flow from one variable to another. Daily and monthly changes are not directly comparable when investigating financial markets. If the results where more clear cut, it might yield additional reliability to the initial findings. However, in this specific case, it is difficult to determine whether one result is more correct than another.

8. Conclusion

The objective of the thesis was to analyse the relationship between the oil price and the value of the Norwegian krone. The Norwegian economy's dependence on oil has significantly risen since the discovery in the 1960s, and one gets the impression that their development is closely intertwined. The large oil price drop in 2014 further sparked the authors interest in investigating whether this caused a change to the relationship, as experts have recently questioned whether the relation still is as clear cut as earlier expressed.

In summary, statistical evidence did not support that the historical interlinkage is broken. However, we concluded that the relationship has changed following the 2014 oil price collapse. Our findings concluded that a long run, cointegrating relation exists between the oil price and the respective exchange rate, solely after the collapse.

Analyses were conducted on daily data from 2001 to 2016, investigating the relation between the Brent Blend and the nominal effective exchange rate I44, as well as between Brent and the NOK/USD exchange rate. The results of the unit root and stationarity tests concluded that all variables were integrated of order 1, across all samples. To investigate whether a long run cointegrating relationship existed between the variables, the two-step Engle-Granger methodology was applied. This led us to conclude that a long run relationship was found both between the oil price and the I44 exchange rate, as well as between Brent and the NOK/USD exchange rate, after the oil price collapse in 2014. Results were robust when interest rates variables were added to the model. The empirical results imply that the price of Brent Blend, the interest rate differential between the relevant countries, as well as the interest rate level in the US are important determinants of the exchange rates.

The establishment of cointegration led us to estimate the corresponding error correction models, and test for Granger causality in the short and long term through these dynamic models. The coefficient on the error correction term, i. e. the speed of the correcting parameter φ, was negative in all models. This indicates that the error is corrected in the expected direction when the dependent variable is beyond its equilibrium value. Granger causality was evident in both the short and long term from the oil price to the exchange rates, and when testing for the opposite direction, causality was found solely in the long run. A potential explanation is that the FX market is the worlds most traded and liquid market, implying that relevant information, such as oil price changes, is rapidly absorbed by market participants. Potential reasons for the long run causality from the exchange rates to the oil price are that the price development of Brent Blend is more affected by fundamental changes in supply and demand, and that changes in other assets, such as exchange rates, are not absorbed as rapidly in this relation.

Where cointegration was not found, tests for short run Granger causality were carried out through the use of ADL models. The period from January 2001 to July 2008 yielded proof of unidirectional causality from the oil price to the exchange rates, whereas bidirectional causality was found for all other samples.

Lastly, a robustness check on monthly data was conducted to review the strength of the aforementioned findings, as well as to incorporate the possibility of modelling variables that are solely available on a monthly basis. Conclusion with the respect to the relationship between the I44 exchange rate and the oil price were unchanged, while the inclusion of industrial production and consumer prices indices resulted in the establishment of a cointegrating relationship between the NOK/USD exchange rate and the oil price. This altered result can be an indicator that initial tests were subject to omitted variable bias.

We believe that our findings can help investors obtain a clearer understanding of the complexity that underlies the relation between the oil price and the value of the krone, and subsequently include a wider range of elements in their investment decisions.

9. Criticism

Econometric analyses will never yield a perfect presentation of the real world as methods are largely based on assumptions that might affect the result. A short critique of the methodology is provided, in order to elaborate on possible pitfalls in the conducted analyses. Firstly, specifically for analyses covering data from various countries, there is a risk of measurement error, as data may be defined differently across geographic areas. Attempting to account for the potential problem, the authors collected all similar variables from the same source. Secondly, the elimination of possibly important variables due to the use of daily data may have led to omitted variable bias. The same might be true for the control variables that were eliminated due to the lack of good proxies. Thirdly, another possible effect on the results is that borderline cases are difficult to judge, and the final results are to some extent based on subjective decision made by the authors. Further, the results might be affected by the specific subsamples chosen. Also here, the results may be affected by subjectivity, as the cut-off dates in the samples were chosen at what was viewed as the extreme points, namely the oil price peak July 3rd 2008 and the oil price bottom January 13th 2015.

10. Additional perspectives

There exist numerous possibilities of extending the work of this thesis, and some aspects will be considered in what follows. Firstly, the authors have not investigated whether the relation between the oil price and the exchange rate was subject to nonlinearity. There exists a possibility for that the results of the specifications were affected by the level of the observations. With regards to the oil price, this could be a logical hypothesis, as the effect of oil price changes most probably depends on its price range. Specifically, for lower values of the oil price, oil producers may run the risk of producing oil at lower than break-even levels. As stated by an analyst from Danske Bank Markets: "*[…] an oil price fall of 10 percentage near an historical bottom should have a larger effect on the krone than the oil price rise of 50 percent that we have seen the recent months*"[59] (Sundberg, 2016). As found by Akram (2000, 2002a), the strength of the relationship between the oil price and the Norwegian exchange rate was relatively stronger when then oil price was below $14 and falling. A nonlinear relation of the data might also be a reason for the difference between subsamples.

An additional aspect to consider is the fact that global oil reserves eventually will come to an end. One might speculate whether this over time will alter the structure of the price formation, as oil becomes a scarce resource. On the other hand, the increasing availability of alternative energy sources, such as

[59] Authors' own translation

renewables, may lead to decreased demand for oil, potentially having the ability to limit or outweigh this effect.

Arbitrary movements in financial variables may to an unknown extent be affected by market movements caused by speculators. Investors striving for short term profits may shake up the markets by selling or buying large holdings. The effect may result in drastic changes of asset prices, without necessarily having a well-reasoned explanation. This further leads to the discussion about the importance of expectations. Even though certain actions, such as interest rate cuts or production limits set by OPEC, are expected to have a specific impact, it all depends on whether or not the actions are factored in by market participants. For example, experts explain that even though interest rate cuts by the Norwegian central bank are generally followed by a depreciation of the krone, the policy may not function as intended (Aarø, 2017). Due to the close to zero interest rate level, the extent to which the interest rate can continue to fall is limited. Additionally, if the cuts were expected, the interaction of these factors may cause an appreciation of the krone, contrary to the intention.

Figure list

Table list

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An econometric analysis of the relationship between the oil price and the value of the Norwegian krone

APPENDIX

Master Thesis

MSc in Applied Economics and Finance

Copenhagen Business School

May 15th 2017

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Appendix

Contents

1. Calculation of I44 weighted variables

Norways 6 largest trading partners, 2001-2016															
2001		2002		2003		2004		2005		2006		2007		2008	
Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight
EUR	43.9%	EUR	46.4%	EUR	47.6%	EUR	47.3%	EUR	49.1%	EUR	48.9%	EUR	49.3%	EUR	48.4%
SEK	19.4%	SEK	19.9%	SEK	20.2%	SEK	21.3%	SEK	21.1%	SEK	19.8%	SEK	21.0%	SEK	20.5%
USD	10.8%	GBP	10.3%	DKK	10.4%	DKK	10.4%	DKK	9.9%	DKK	10.1%	DKK	9.6%	GBP	9.6%
GBP	10.7%	USD	9.3%	GBP	9.6%	GBP	9.5%	GBP	8.8%	GBP	9.9%	GBP	8.9%	DKK	8.9%
DKK	8.4%	DKK	9.2%	USD	8.1%	USD	6.8%	USD	6.5%	USD	6.9%	USD	7.4%	USD	6.6%
JPY	6.8%	JPY	4.9%	JPY	4.0%	JPY	4.8%	JPY	4.6%	JPY	4.4%	JPY	3.8%	CAD	6.0%
Sum	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**
2009		2010		2011		2012		2013		2014		2015		2016	
Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight	Currency	Weight
EUR	49.4%	EUR	48.6%	EUR	47.3%	EUR	47.4%	EUR	47.9%	EUR	48.3%	EUR	48.9%	EUR	47.8%
SEK	20.4%	SEK	20.0%	SEK	21.3%	SEK	20.3%	SEK	20.6%	SEK	20.0%	SEK	18.3%	SEK	17.5%
DKK	9.8%	DKK	9.8%	DKK	9.4%	DKK	9.6%	DKK	9.4%	GBP	9.6%	GBP	9.6%	USD	9.9%
GBP	8.6%	USD	8.9%	GBP	8.9%	GBP	8.5%	GBP	9.3%	DKK	9.1%	USD	9.2%	GBP	9.8%
USD	7.7%	GBP	8.7%	USD	8.2%	USD	8.1%	USD	8.2%	USD	8.1%	DKK	9.1%	DKK	8.7%
CAD	4.0%	PLN	4.0%	CAD	4.9%	CAD	6.1%	PLN	4.6%	PLN	4.9%	PLN	4.8%	KRW	6.3%
	100.0%		**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**

Source: Compiled by authors/Norges Bank (2017)

2. Correlation

The measure of the degree of linear association is given by the following (Gujarati & Porter, 2009):

$$r = \pm\sqrt{R^2} \quad Eq. 2.1$$

or

$$r = \frac{\sum x_i y_i}{\sqrt{(\sum x_i^2)(\sum y_i^2)}} = \frac{n\sum X_i Y_i - (\sum X_i)(\sum Y_i)}{\sqrt{\left[n\sum X_i^2 - (\sum X_i)^2\right]\left[n\sum Y_i^2 - (\sum Y_i)^2\right]}} \quad Eq. 2.2$$

Where

R^2 is the coefficient of determination, most commonly used to measure the goodness of fit of a regression line

n is the number of observations

x_i *and* y_i are given values of x *and* y from the sample

X_i *and* Y_i are given values of X *and* Y from the population

3. Correlation

Correlation coefficients, sample 2.1 Number of observations = 3150								
	I44	USD	Brent	I44_INTRATE	LIBOR_USD	NIBOR	INTDIFF_I44	INTDIFF_LIBORUSD
I44	1.0000	0.7364	-0.6470	0.2346	0.2285	0.1901	0.0349	-0.0258
P-value		*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*0.05*	*0.1476*
USD		1.0000	-0.8082	0.3084	0.1960	0.5147	0.5041	0.3247
P-value			*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*
Brent			1.0000	-0.4051	-0.3277	-0.4149	-0.2103	-0.1032
P-value				*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*
I44_INTRATE				1.0000	0.8061	0.8218	0.1690	0.0580
P-value					*<.0001*	*<.0001*	*<.0001*	*0.0011*
LIBOR_USD					1.0000	0.4585	-0.2167	-0.4814
P-value						*<.0001*	*<.0001*	*<.0001*
NIBOR						1.0000	0.7005	0.5583
P-value							*<.0001*	*<.0001*
INTDIFF_I44							1.0000	0.8931
P-value								*<.0001*
INTDIFF_LIBORUSD								1.0000
P-value								

Correlation coefficients, sample 2.2 Number of observations = 445								
	I44	USD	Brent	I44_INTRATE	LIBOR_USD	NIBOR	INTDIFF_I44	INTDIFF_LIBORUSD
I44	1.0000	0.8498	-0.8223	-0.2694	0.2167	-0.6896	-0.7541	-0.4344
P-value		*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*
USD		1.0000	-0.7698	-0.4927	0.5077	-0.6517	-0.5500	-0.6146
P-value			*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*
Brent			1.0000	0.2681	-0.4095	0.6544	0.7072	0.5496
P-value				*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*
I44_INTRATE				1.0000	-0.8751	0.7090	0.2812	0.8860
P-value					*<.0001*	*<.0001*	*<.0001*	*<.0001*
LIBOR_USD					1.0000	-0.6588	-0.2982	-0.9492
P-value						*<.0001*	*<.0001*	*<.0001*
NIBOR						1.0000	0.8761	0.8621
P-value							*<.0001*	*<.0001*
INTDIFF_I44							1.0000	0.5674
P-value								*<.0001*
INTDIFF_LIBORUSD								1.0000
P-value								

Correlation coefficients, sample 3.1 Number of observations = 1676								
	I44	USD	Brent	I44_INTRATE	LIBOR_USD	NIBOR	INTDIFF_I44	INTDIFF_LIBORUSD
I44	1.0000	0.7209	-0.5784	-0.1048	-0.0697	0.0184	0.0845	0.0581
P-value		*<.0001*	*<.0001*	*<.0001*	*0.0043*	*0.451*	*0.0005*	*0.0174*
USD		1.0000	-0.8183	-0.0631	-0.2853	0.4628	0.6518	0.5409
P-value			*<.0001*	*0.0097*	*<.0001*	*<.0001*	*<.0001*	*<.0001*
Brent			1.0000	0.4598	0.5316	-0.1279	-0.4332	-0.4332
P-value				*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*
I44_INTRATE				1.0000	0.5420	0.7206	0.3863	0.2241
P-value					*<.0001*	*<.0001*	*<.0001*	*<.0001*
LIBOR_USD					1.0000	0.0051	-0.3034	-0.6228
P-value						*0.8344*	*<.0001*	*<.0001*
NIBOR						1.0000	0.9179	0.7792
P-value							*<.0001*	*<.0001*
INTDIFF_I44							1.0000	0.9083
P-value								*<.0001*
INTDIFF_LIBORUSD								1.0000
P-value								

Correlation coefficients, sample 3.2 Number of observations = 1474								
	I44	USD	Brent	I44_INTRATE	LIBOR_USD	NIBOR	INTDIFF_I44	INTDIFF_LIBORUSD
I44	1.0000	0.8646	-0.7111	0.1586	0.2632	0.1277	-0.0727	-0.0602
P-value		*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*0.0052*	*0.0208*
USD		1.0000	-0.7461	-0.0240	0.1352	-0.0174	0.0216	-0.1981
P-value			*<.0001*	*0.358*	*<.0001*	*0.5056*	*0.4066*	*<.0001*
Brent			1.0000	-0.1257	-0.2274	-0.1474	-0.1943	-0.0227
P-value				*<.0001*	*<.0001*	*<.0001*	*<.0001*	*0.3835*
I44_INTRATE				1.0000	0.9393	0.9880	0.5368	0.8577
P-value					*<.0001*	*<.0001*	*<.0001*	*<.0001*
LIBOR_USD					1.0000	0.9289	0.5089	0.6653
P-value						*<.0001*	*<.0001*	*<.0001*
NIBOR						1.0000	0.6608	0.8945
P-value							*<.0001*	*<.0001*
INTDIFF_I44							1.0000	0.7176
P-value								*<.0001*
INTDIFF_LIBORUSD								1.0000
P-value								

4. ADF critical values

Agumented Dickey-Fulles critical values, large samples			
Deterministic regressors	10%	5%	1%
No intercept	-1.61	-1.95	-2.58
Intercept only	-2.57	-2.86	-3.43
Intercept and time trend	-3.12	-3.41	-3.96

Source: Gujarati & Porter (2009)

5. Engle-Granger critical values

ROBERT F. ENGLE AND C. W. J. GRANGER

TABLE III

CRITICAL VALUES AND POWER WITH LAGS

MODEL I: $\Delta y_t = .8\Delta y_{t-4} + \varepsilon_t$, $\Delta x_t = .8\Delta x_{t-4} + \eta_t$; 100 observations, 10,000 replications, $p = 4$, ε_t, η_t independent standard normal.

Critical Values				
Statistic	Name	1%	5%	10%
1	CRDW	.455	.282	.209
2	DF	3.90	3.05	2.71
3	ADF	3.73	3.17	2.91
4	RVAR	37.2	22.4	17.2
5	ARVAR	16.2	12.3	10.5
6	UVAR	59.0	40.3	31.4
7	AUVAR	28.0	22.0	19.2

MODEL II: $y_t + 2x_t = u_t$, $\Delta u_t = (\rho - 1)u_{t-1} + .8\Delta u_{t-4} + \varepsilon_t$, $y_t + x_t = v_t$, $\Delta v_t = .8\Delta v_{t-4} + \eta_t$; $\rho = .9, .8$. 100 observations, 1000 replications, $p = 4$.

Rejections per 100: $\rho = .9$				
Statistic	Name	1%	5%	10%
1	CRDW	15.6	39.9	65.6
2	DF	9.4	25.5	37.8
3	ADF	36.0	61.2	72.2
4	RVAR	.3	4.4	10.9
5	ARVAR	26.4	48.5	62.8
6	UVAR	.0	.5	3.5
7	AUVAR	9.4	26.8	40.3

Rejections per 100: $\rho = .8$				
Statistic	Name	1%	5%	10%
1	CRDW	77.5	96.4	98.6
2	DF	66.8	89.7	96.0
3	ADF	68.9	90.3	94.4
4	RVAR	7.0	42.4	62.5
5	ARVAR	57.2	80.5	89.3
6	UVAR	2.5	10.8	25.9
7	AUVAR	32.2	53.0	67.7

(Engle & Granger, 1987)

6. Stationarity analysis

6.1 Full Sample

6.1.1 Autocorrelation analysis

Columns market by stars in correspondence with lag 1-10 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market **dark** green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Cells market with **light** green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis - Breusch Godfrey-test Sample 3.2											
Variable	0 lag	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag
logI44	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
logUSD	insig	*	insig	insig	insig	insig	insig	insig	insig	insig	insig
logBrent	insig	insig	insig	*	**	insig	**	insig	insig	insig	insig
I44_intrate		***	***	***	***	***	***	***	***	***	***
LIBORUSD		***	***	***	***	***	***	***	***	***	***
NIBOR		***	***	***	***	***	***	***	***	***	***
ΔlogI44	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
ΔlogUSD	insig	insig	insig	insig	insig	insig	insig	insig	*	**	*
ΔlogBrent		insig	*	***	insig	**	insig	insig	insig	insig	insig
ΔI44_INTRATE		***	***	***	***	***	***	***	***	***	***
ΔLIBORUSD		***	***	***	***	***	***	***	***	***	***
ΔNIBOR		***	***	***	***	***	***	***	***	***	***

6.1.2 Variable: Brent

Stationarity analysis on logBrent

PROC ARIMA: Variable = logBRENT

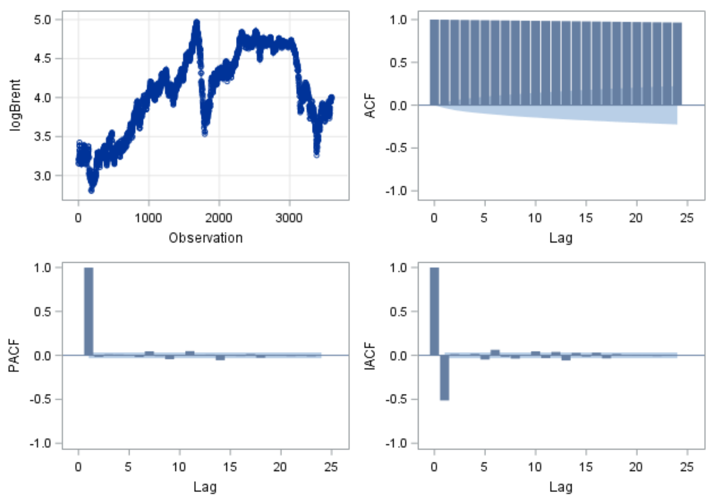
The ARIMA Procedure

Name of Variable = logBrent	
Mean of Working Series	4.078951
Standard Deviation	0.52917
Number of Observations	3595

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.997	0.996	0.994	0.993	0.991
12	9999.99	12	<.0001	0.990	0.989	0.987	0.986	0.984	0.983
18	9999.99	18	<.0001	0.982	0.980	0.979	0.977	0.976	0.974
24	9999.99	24	<.0001	0.973	0.972	0.970	0.968	0.967	0.965

Trend and Correlation Analysis for logBrent



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.1199	0.7113	0.34	0.7848		
	1	0.1170	0.7106	0.33	0.7805		
	2	0.1077	0.7084	0.30	0.7733		
	3	0.1079	0.7084	0.31	0.7745		
	4	0.1087	0.7086	0.31	0.7755		
	5	0.1117	0.7093	0.31	0.7765		
Single Mean	0	-5.1713	0.4196	-1.91	0.3258	2.01	0.5556
	1	-5.3474	0.4034	-1.93	0.3171	2.04	0.5485
	2	-5.2138	0.4156	-1.88	0.3423	1.91	0.5798
	3	-5.1070	0.4256	-1.86	0.3508	1.88	0.5880
	4	-5.0825	0.4279	-1.86	0.3517	1.88	0.5884
	5	-5.2780	0.4097	-1.90	0.3318	1.96	0.5669
Trend	0	-5.0894	0.8145	-1.48	0.8349	1.83	0.8106
	1	-5.3699	0.7937	-1.53	0.8196	1.87	0.8035
	2	-5.3080	0.7984	-1.51	0.8273	1.77	0.8241
	3	-5.1528	0.8099	-1.48	0.8366	1.73	0.8309
	4	-5.1046	0.8134	-1.47	0.8393	1.73	0.8316
	5	-5.3371	0.7962	-1.51	0.8250	1.81	0.8157

Stationarity analysis on first difference of logBrent, $\Delta logBrent$

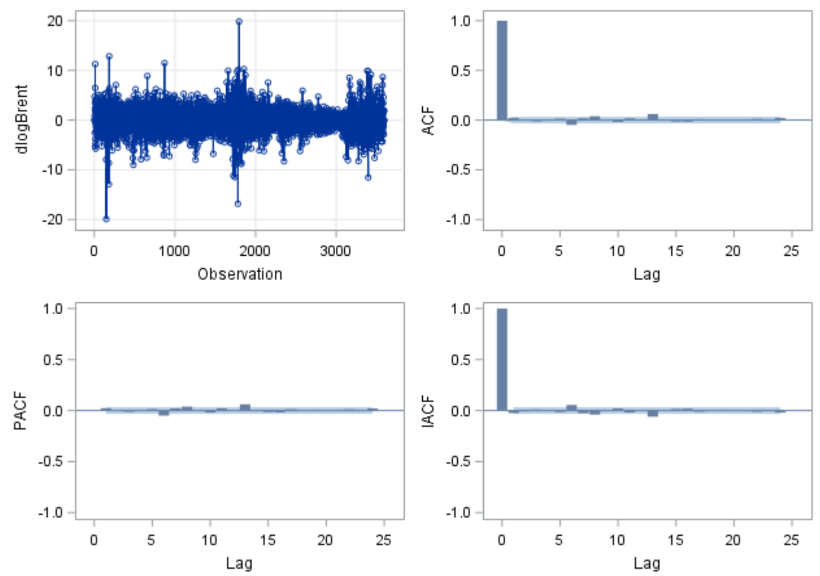
PROC ARIMA: Variable = dlogBRENT

The ARIMA Procedure

Name of Variable = dlogBrent	
Mean of Working Series	0.023723
Standard Deviation	2.386232
Number of Observations	3594

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	11.78	6	0.0671	0.023	0.003	-0.012	-0.005	0.014	-0.049
12	21.12	12	0.0487	0.019	0.039	0.003	-0.019	0.018	0.008
18	36.57	18	0.0060	0.061	-0.002	-0.014	-0.015	0.009	-0.001
24	39.10	24	0.0266	0.000	0.000	0.003	0.012	-0.006	0.022



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3491.83	0.0001	-41.79	<.0001		
	2	-3618.42	0.0001	-34.69	<.0001		
	3	-3686.02	0.0001	-30.15	<.0001		
	4	-3428.67	0.0001	-26.53	<.0001		
	5	-4745.30	0.0001	-25.50	<.0001		
	10	-2949.53	0.0001	-17.81	<.0001		
	20	-1884.94	0.0001	-12.49	<.0001		
Single Mean	1	-3492.76	0.0001	-41.79	<.0001	873.33	0.0010
	2	-3620.32	0.0001	-34.69	<.0001	601.59	0.0010
	3	-3689.27	0.0001	-30.15	<.0001	454.50	0.0010
	4	-3433.07	0.0001	-26.53	<.0001	351.94	0.0010
	5	-4755.70	0.0001	-25.50	<.0001	325.21	0.0010
	10	-2960.34	0.0001	-17.82	<.0001	158.72	0.0010
	20	-1901.70	0.0001	-12.50	<.0001	78.10	0.0010
Trend	1	-3496.74	0.0001	-41.81	<.0001	874.02	0.0010
	2	-3628.53	0.0001	-34.71	<.0001	602.27	0.0010
	3	-3703.37	0.0001	-30.17	<.0001	455.18	0.0010
	4	-3452.49	0.0001	-26.56	<.0001	352.63	0.0010
	5	-4801.65	0.0001	-25.53	<.0001	325.92	0.0010
	10	-3012.12	0.0001	-17.84	<.0001	159.13	0.0010
	20	-1990.56	0.0001	-12.54	<.0001	78.61	0.0010

6.1.3 Variable: I44

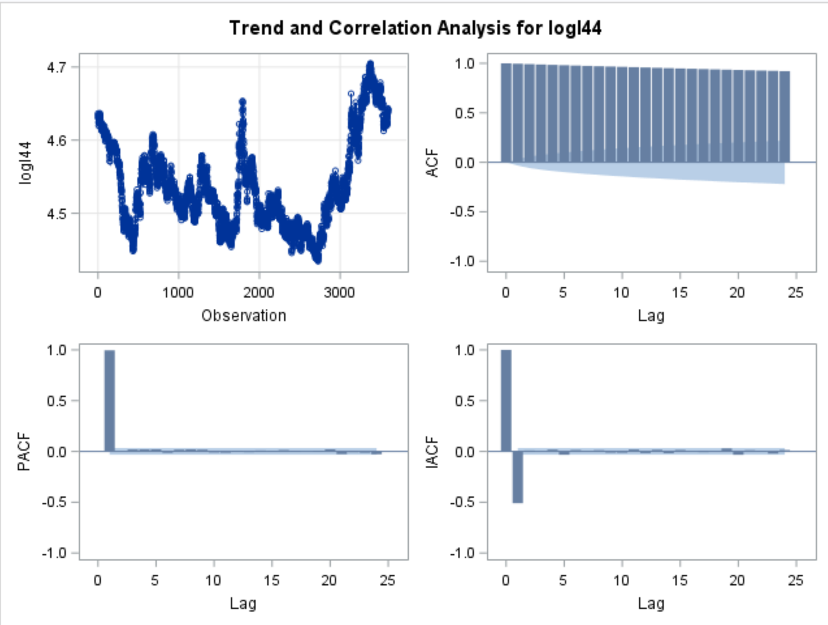
Stationarity analysis on logI44

PROC ARIMA: Variable = logI44

The ARIMA Procedure

Name of Variable = logI44	
Mean of Working Series	4.536522
Standard Deviation	0.059568
Number of Observations	3595

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.996	0.992	0.988	0.985	0.981	0.977
12	9999.99	12	<.0001	0.974	0.971	0.968	0.964	0.961	0.958
18	9999.99	18	<.0001	0.955	0.951	0.948	0.945	0.942	0.939
24	9999.99	24	<.0001	0.936	0.933	0.930	0.927	0.924	0.921



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.0009	0.6830	-0.01	0.6784		
	2	-0.0001	0.6831	-0.00	0.6825		
	3	0.0001	0.6832	0.00	0.6838		
	4	-0.0003	0.6831	-0.01	0.6816		
	5	0.0005	0.6833	0.01	0.6862		
	6	0.0018	0.6836	0.03	0.6930		
Single Mean	1	-11.3938	0.0968	-2.37	0.1499	2.81	0.3486
	2	-10.8009	0.1117	-2.30	0.1727	2.64	0.3932
	3	-10.2550	0.1273	-2.23	0.1941	2.50	0.4303
	4	-9.6784	0.1462	-2.17	0.2157	2.36	0.4645
	5	-10.1616	0.1302	-2.21	0.2011	2.45	0.4417
	6	-9.6482	0.1472	-2.14	0.2286	2.29	0.4829
Trend	1	-12.5664	0.2868	-2.59	0.2861	4.09	0.3526
	2	-11.9471	0.3188	-2.51	0.3208	3.92	0.3872
	3	-11.3866	0.3501	-2.46	0.3508	3.81	0.4096
	4	-10.8081	0.3848	-2.40	0.3774	3.76	0.4194
	5	-11.2834	0.3561	-2.44	0.3610	3.76	0.4200
	6	-10.7356	0.3893	-2.36	0.4011	3.57	0.4590

Stationarity analysis on first difference of logI44, $\Delta logI44$

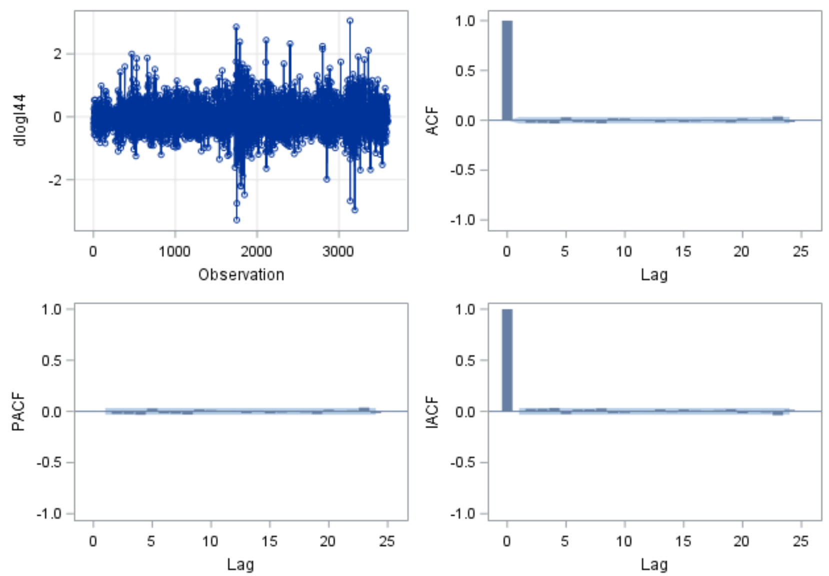
PROC ARIMA: Variable = dlogI44

The ARIMA Procedure

Name of Variable = dlogI44	
Mean of Working Series	0.000073
Standard Deviation	0.476642
Number of Observations	3594

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	12.44	6	0.0528	-0.001	-0.024	-0.026	-0.032	0.029	-0.017
12	20.04	12	0.0664	-0.022	-0.030	0.019	0.017	-0.000	0.006
18	23.76	18	0.1631	-0.019	0.010	-0.017	-0.012	-0.002	-0.011
24	33.76	24	0.0891	-0.022	0.017	-0.001	0.012	0.039	-0.018

Trend and Correlation Analysis for dlogI44



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3775.14	0.0001	-43.44	<.0001		
	2	-4092.62	0.0001	-36.09	<.0001		
	3	-4737.76	0.0001	-31.94	<.0001		
	4	-4047.46	0.0001	-27.40	<.0001		
	5	-4622.23	0.0001	-25.41	<.0001		
Single Mean	1	-3775.14	0.0001	-43.43	<.0001	943.14	0.0010
	2	-4092.63	0.0001	-36.09	<.0001	651.11	0.0010
	3	-4737.77	0.0001	-31.93	<.0001	509.87	0.0010
	4	-4047.47	0.0001	-27.40	<.0001	375.38	0.0010
	5	-4622.27	0.0001	-25.41	<.0001	322.80	0.0010
Trend	1	-3779.94	0.0001	-43.45	<.0001	944.03	0.0010
	2	-4103.71	0.0001	-36.11	<.0001	652.01	0.0010
	3	-4762.50	0.0001	-31.96	<.0001	510.85	0.0010
	4	-4076.29	0.0001	-27.43	<.0001	376.23	0.0010
	5	-4672.49	0.0001	-25.44	<.0001	323.64	0.0010

6.1.4 Variable: USD

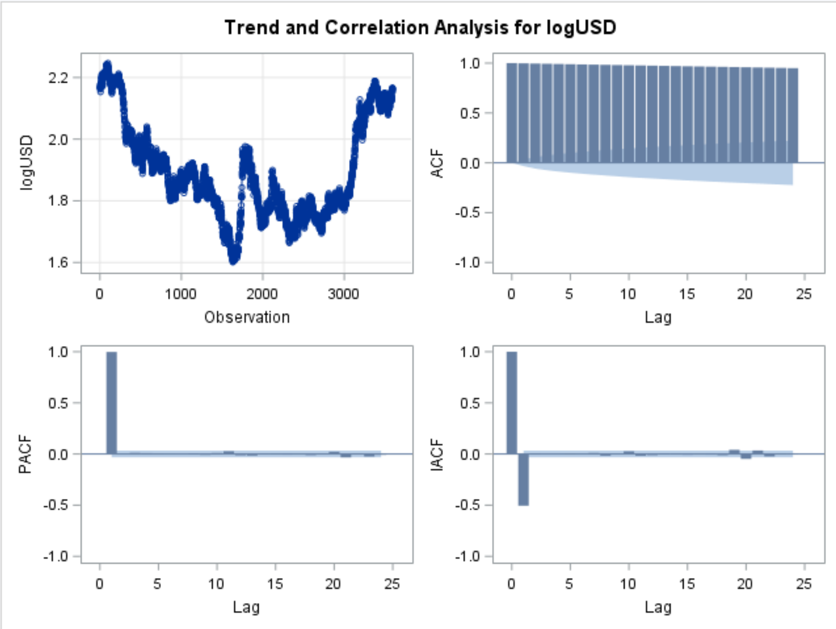
Stationarity analysis on logUSD

PROC ARIMA: Variable = logUSD

The ARIMA Procedure

Name of Variable = logUSD	
Mean of Working Series	1.891766
Standard Deviation	0.155115
Number of Observations	3595

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.998	0.996	0.993	0.991	0.989	0.987
12	9999.99	12	<.0001	0.985	0.983	0.981	0.979	0.977	0.975
18	9999.99	18	<.0001	0.973	0.971	0.969	0.967	0.964	0.962
24	9999.99	24	<.0001	0.960	0.958	0.956	0.954	0.952	0.950



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-0.0466	0.6725	-0.18	0.6216		
	1	-0.0403	0.6739	-0.16	0.6302		
	2	-0.0399	0.6740	-0.16	0.6293		
	3	-0.0355	0.6750	-0.14	0.6353		
	4	-0.0378	0.6745	-0.15	0.6310		
	5	-0.0404	0.6739	-0.16	0.6276		
Single Mean	0	-5.2243	0.4147	-1.66	0.4531	1.37	0.7188
	1	-5.1013	0.4262	-1.62	0.4734	1.31	0.7356
	2	-4.8662	0.4488	-1.58	0.4905	1.26	0.7492
	3	-4.7522	0.4601	-1.55	0.5070	1.21	0.7621
	4	-4.6677	0.4686	-1.55	0.5086	1.20	0.7633
	5	-4.7652	0.4588	-1.57	0.4971	1.24	0.7543
Trend	0	-4.2511	0.8715	-1.33	0.8809	2.76	0.6226
	1	-4.1376	0.8785	-1.29	0.8893	2.65	0.6444
	2	-3.8805	0.8937	-1.25	0.8999	2.72	0.6305
	3	-3.7692	0.8999	-1.22	0.9064	2.66	0.6435
	4	-3.6610	0.9058	-1.20	0.9094	2.75	0.6238
	5	-3.7451	0.9012	-1.22	0.9050	2.79	0.6164

Stationarity analysis on first difference of logUSD, ΔlogUSD

PROC ARIMA: Variable = dlogUSD

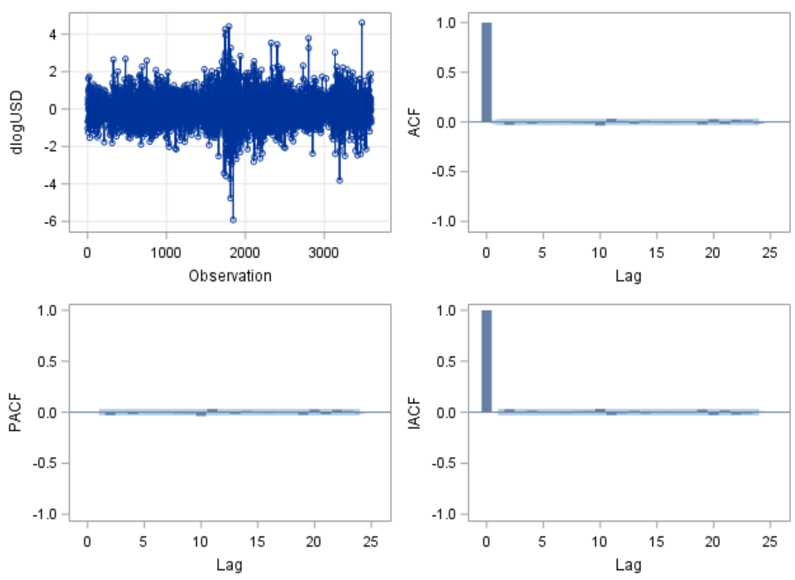
The ARIMA Procedure

Name of Variable = dlogUSD	
Mean of Working Series	-0.00062
Standard Deviation	0.815508
Number of Observations	3594

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	3.99	6	0.6774	-0.001	-0.028	-0.004	-0.017	0.005	0.000
12	13.55	12	0.3304	0.006	-0.009	-0.011	-0.036	0.031	0.011
18	15.32	18	0.6396	-0.016	0.012	0.002	-0.007	0.001	0.003
24	24.73	24	0.4206	-0.025	0.027	-0.019	0.022	0.016	-0.013

Trend and Correlation Analysis for dlogUSD



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3803.03	0.0001	-43.59	<.0001		
	2	-3856.64	0.0001	-35.41	<.0001		
	3	-4148.43	0.0001	-31.00	<.0001		
	4	-4037.77	0.0001	-27.39	<.0001		
	5	-4062.26	0.0001	-24.92	<.0001		
Single Mean	1	-3803.03	0.0001	-43.58	<.0001	949.70	0.0010
	2	-3856.64	0.0001	-35.40	<.0001	626.60	0.0010
	3	-4148.44	0.0001	-30.99	<.0001	480.32	0.0010
	4	-4037.78	0.0001	-27.38	<.0001	374.90	0.0010
	5	-4062.27	0.0001	-24.92	<.0001	310.43	0.0010
Trend	1	-3815.27	0.0001	-43.64	<.0001	952.41	0.0010
	2	-3882.09	0.0001	-35.47	<.0001	629.01	0.0010
	3	-4197.85	0.0001	-31.07	<.0001	482.77	0.0010
	4	-4110.95	0.0001	-27.47	<.0001	377.26	0.0010
	5	-4167.02	0.0001	-25.01	<.0001	312.69	0.0010

6.1.5 Variable: I44 interest rate

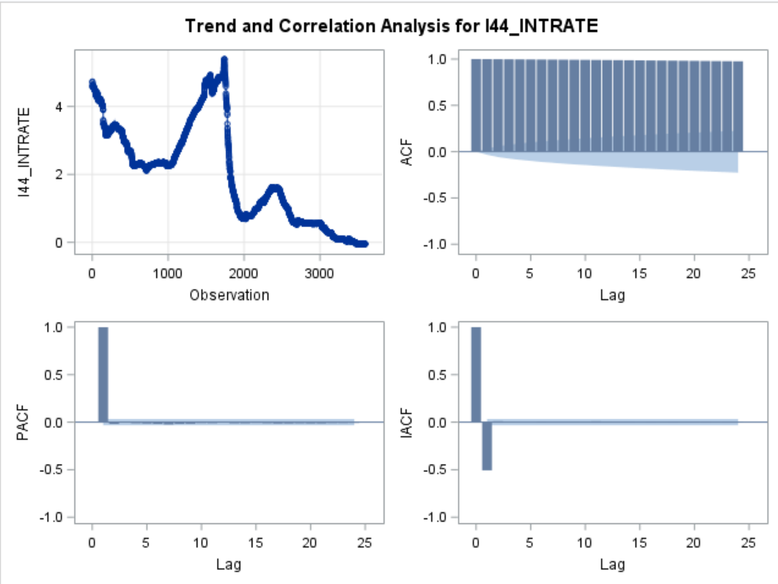
Stationarity analysis on I44_INTRATE

PROC ARIMA: Variable = I44_INTRATE

The ARIMA Procedure

Name of Variable = I44_INTRATE	
Mean of Working Series	2.007072
Standard Deviation	1.501477
Number of Observations	3595

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.998	0.998	0.997	0.996	0.995
12	9999.99	12	<.0001	0.994	0.993	0.992	0.991	0.990	0.989
18	9999.99	18	<.0001	0.988	0.987	0.986	0.985	0.984	0.983
24	9999.99	24	<.0001	0.982	0.981	0.979	0.978	0.977	0.976



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1.8923	0.3438	-3.58	0.0004		
	2	-1.8515	0.3488	-2.74	0.0062		
	3	-1.8702	0.3465	-2.43	0.0147		
	4	-1.9339	0.3388	-2.26	0.0234		
	5	-2.0375	0.3266	-2.24	0.0240		
	10	-2.3702	0.2906	-1.97	0.0466		
	20	-3.0954	0.2271	-1.82	0.0654		
Single Mean	1	-1.0540	0.8814	-1.20	0.6781	7.10	0.0010
	2	-1.0977	0.8772	-0.98	0.7635	4.09	0.0808
	3	-1.2093	0.8663	-0.95	0.7734	3.16	0.2584
	4	-1.3969	0.8470	-0.98	0.7617	2.65	0.3900
	5	-1.6113	0.8238	-1.07	0.7291	2.58	0.4084
	10	-2.5142	0.7167	-1.26	0.6507	1.95	0.5711
	20	-4.5944	0.4761	-1.61	0.4766	1.87	0.5923
Trend	1	-1.1990	0.9858	-0.87	0.9575	0.73	0.9900
	2	-1.6793	0.9776	-0.96	0.9480	0.57	0.9900
	3	-2.0891	0.9681	-1.05	0.9357	0.61	0.9900
	4	-2.5641	0.9538	-1.15	0.9182	0.72	0.9900
	5	-2.9022	0.9412	-1.23	0.9023	0.83	0.9848
	10	-5.0112	0.8202	-1.60	0.7917	1.33	0.9111
	20	-10.1219	0.4290	-2.24	0.4682	2.53	0.6693

Stationarity analysis on first difference of I44_INTRATE , ΔI44_INTRATE

PROC ARIMA: Variable = dI44_INTRATE

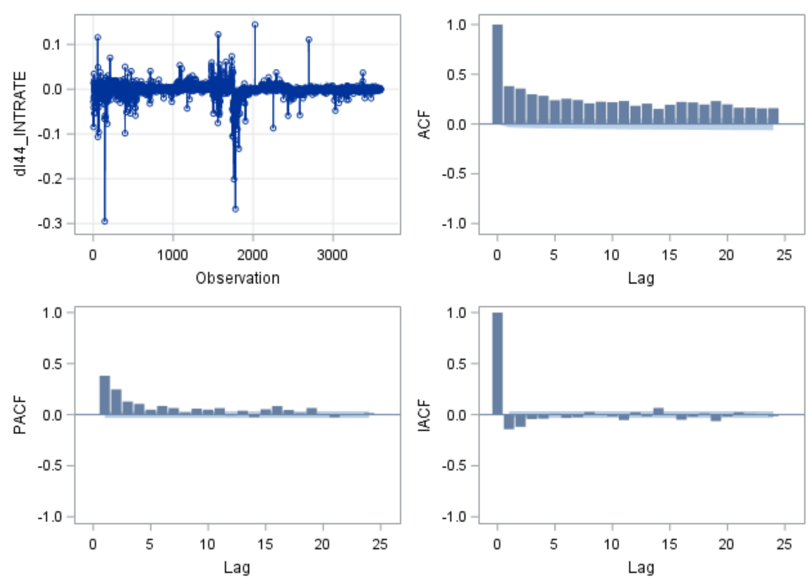
The ARIMA Procedure

Name of Variable = dI44_INTRATE	
Mean of Working Series	-0.00133
Standard Deviation	0.014754
Number of Observations	3594

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	2032.77	6	<.0001	0.381	0.357	0.300	0.284	0.239	0.255
12	3067.33	12	<.0001	0.241	0.208	0.224	0.219	0.232	0.183
18	3926.60	18	<.0001	0.205	0.152	0.194	0.222	0.217	0.196
24	4639.10	24	<.0001	0.231	0.198	0.164	0.165	0.158	0.160

Trend and Correlation Analysis for dI44_INTRATE



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1327.93	0.0001	-25.96	<.0001		
	2	-980.680	0.0001	-20.95	<.0001		
	3	-749.154	0.0001	-17.72	<.0001		
	4	-650.976	0.0001	-16.03	<.0001		
	5	-510.982	0.0001	-14.11	<.0001		
	10	-260.447	0.0001	-9.95	<.0001		
	20	-125.951	0.0001	-6.85	<.0001		
Single Mean	1	-1345.61	0.0001	-26.12	<.0001	341.15	0.0010
	2	-997.077	0.0001	-21.09	<.0001	222.38	0.0010
	3	-763.588	0.0001	-17.85	<.0001	159.28	0.0010
	4	-665.396	0.0001	-16.16	<.0001	130.65	0.0010
	5	-523.352	0.0001	-14.23	<.0001	101.32	0.0010
	10	-267.743	0.0001	-10.04	<.0001	50.41	0.0010
	20	-130.496	0.0001	-6.94	<.0001	24.09	0.0010
Trend	1	-1346.37	0.0001	-26.12	<.0001	341.18	0.0010
	2	-997.681	0.0001	-21.09	<.0001	222.39	0.0010
	3	-764.099	0.0001	-17.85	<.0001	159.28	0.0010
	4	-665.999	0.0001	-16.17	<.0001	130.68	0.0010
	5	-523.974	0.0001	-14.24	<.0001	101.38	0.0010
	10	-267.941	0.0001	-10.04	<.0001	50.41	0.0010
	20	-130.720	0.0001	-6.94	<.0001	24.12	0.0010

6.1.6 Variable: LIBOR_USD

Stationarity analysis on LIBOR_USD

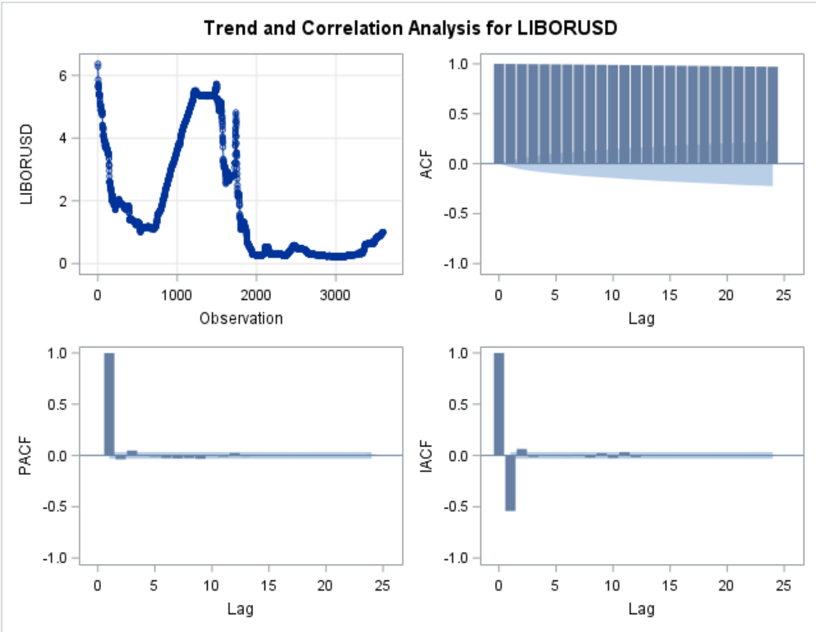
PROC ARIMA: Variable = LIBORUSD

The ARIMA Procedure

Name of Variable = LIBORUSD	
Mean of Working Series	1.793539
Standard Deviation	1.776005
Number of Observations	3595

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.998	0.997	0.996	0.995	0.994
12	9999.99	12	<.0001	0.992	0.991	0.990	0.989	0.987	0.986
18	9999.99	18	<.0001	0.985	0.983	0.982	0.981	0.979	0.978
24	9999.99	24	<.0001	0.977	0.976	0.974	0.973	0.972	0.970



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3.5441	0.1961	-3.26	0.0011		
	2	-2.8652	0.2452	-2.57	0.0099		
	3	-2.9074	0.2418	-2.47	0.0131		
	4	-3.0223	0.2326	-2.22	0.0254		
	5	-3.2038	0.2191	-2.21	0.0262		
	10	-3.8128	0.1800	-2.05	0.0384		
	20	-3.2942	0.2127	-2.34	0.0188		
Single Mean	1	-4.1920	0.5186	-2.72	0.0713	5.50	0.0222
	2	-3.2615	0.6255	-2.06	0.2594	3.37	0.2057
	3	-3.3662	0.6130	-2.02	0.2789	3.13	0.2673
	4	-3.6793	0.5762	-1.91	0.3290	2.58	0.4081
	5	-4.0084	0.5388	-1.95	0.3093	2.59	0.4053
	10	-5.2933	0.4083	-2.01	0.2830	2.42	0.4498
	20	-4.0895	0.5298	-2.05	0.2671	2.89	0.3296
Trend	1	-3.2168	0.9277	-1.72	0.7434	4.12	0.3479
	2	-2.4750	0.9567	-1.29	0.8897	2.39	0.6982
	3	-2.6547	0.9506	-1.31	0.8845	2.22	0.7311
	4	-3.2302	0.9271	-1.38	0.8666	1.87	0.8021
	5	-3.6586	0.9059	-1.47	0.8406	1.93	0.7908
	10	-5.6054	0.7758	-1.75	0.7291	2.03	0.7704
	20	-3.6093	0.9085	-1.50	0.8311	2.15	0.7462

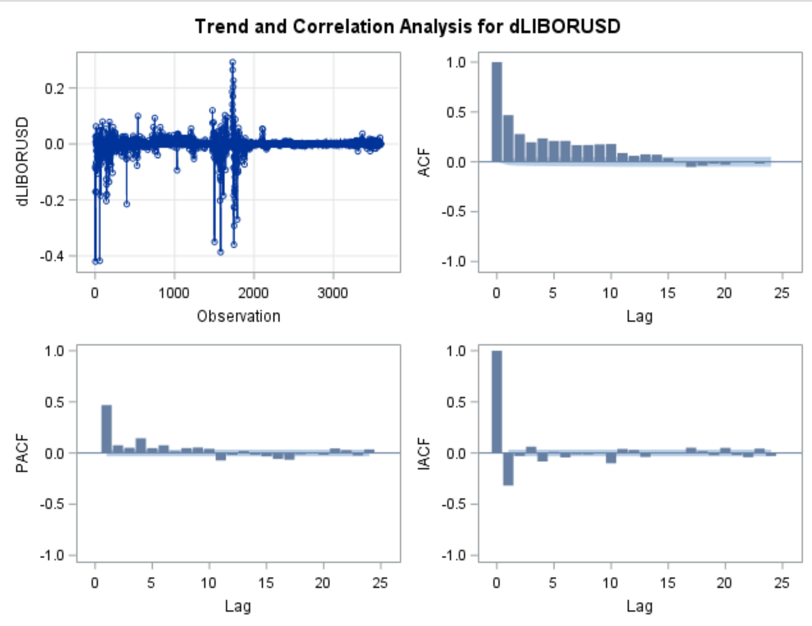
Stationarity analysis on first difference of LIBOR_USD, ΔLIBOR_USD

PROC ARIMA: Variable = dLIBORUSD

The ARIMA Procedure

Name of Variable = dLIBORUSD	
Mean of Working Series	-0.0015
Standard Deviation	0.027578
Number of Observations	3594

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1721.14	6	<.0001	0.468	0.279	0.196	0.235	0.209	0.210
12	2190.78	12	<.0001	0.167	0.168	0.175	0.179	0.088	0.060
18	2250.57	18	<.0001	0.075	0.072	0.038	-0.009	-0.052	-0.039
24	2256.26	24	<.0001	-0.019	-0.028	-0.006	0.007	-0.018	-0.004



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1649.75	0.0001	-30.15	<.0001		
	2	-1448.74	0.0001	-25.50	<.0001		
	3	-981.515	0.0001	-20.27	<.0001		
	4	-837.389	0.0001	-18.01	<.0001		
	5	-653.043	0.0001	-15.68	<.0001		
	10	-562.848	0.0001	-13.14	<.0001		
	20	-1110.01	0.0001	-11.93	<.0001		
Single Mean	1	-1656.43	0.0001	-30.20	<.0001	455.95	0.0010
	2	-1456.86	0.0001	-25.54	<.0001	326.28	0.0010
	3	-987.704	0.0001	-20.31	<.0001	206.32	0.0010
	4	-843.534	0.0001	-18.05	<.0001	162.85	0.0010
	5	-658.305	0.0001	-15.72	<.0001	123.53	0.0010
	10	-569.276	0.0001	-13.18	<.0001	86.82	0.0010
	20	-1160.74	0.0001	-11.99	<.0001	71.92	0.0010
Trend	1	-1665.59	0.0001	-30.25	<.0001	457.72	0.0010
	2	-1467.94	0.0001	-25.60	<.0001	327.77	0.0010
	3	-995.944	0.0001	-20.36	<.0001	207.26	0.0010
	4	-851.777	0.0001	-18.09	<.0001	163.72	0.0010
	5	-665.444	0.0001	-15.77	<.0001	124.31	0.0010
	10	-577.452	0.0001	-13.21	<.0001	87.30	0.0010
	20	-1232.34	0.0001	-12.07	<.0001	72.81	0.0010

6.1.7 Variable: NIBOR

Stationarity analysis on NIBOR

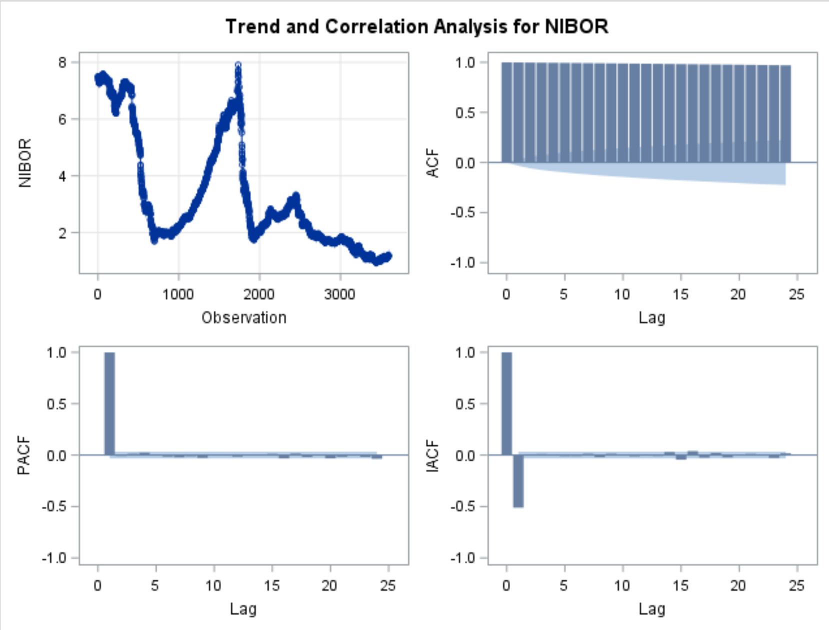
PROC ARIMA: Variable = NIBOR

The ARIMA Procedure

Name of Variable = NIBOR	
Mean of Working Series	3.269024
Standard Deviation	1.971162
Number of Observations	3595

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.998	0.997	0.996	0.995	0.993
12	9999.99	12	<.0001	0.992	0.991	0.990	0.989	0.988	0.986
18	9999.99	18	<.0001	0.985	0.984	0.983	0.981	0.980	0.979
24	9999.99	24	<.0001	0.978	0.976	0.975	0.973	0.972	0.970



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-2.2168	0.3066	-2.72	0.0065		
	2	-2.1838	0.3102	-2.73	0.0062		
	3	-2.1378	0.3152	-2.93	0.0034		
	4	-2.1056	0.3188	-2.86	0.0042		
	5	-2.1272	0.3164	-2.75	0.0059		
	10	-2.2798	0.2999	-2.45	0.0141		
	20	-2.5518	0.2729	-2.00	0.0434		
Single Mean	1	-2.9879	0.6586	-1.89	0.3359	3.86	0.0953
	2	-2.8972	0.6697	-1.87	0.3449	3.88	0.0938
	3	-2.7127	0.6923	-1.92	0.3208	4.42	0.0606
	4	-2.6538	0.6995	-1.86	0.3489	4.20	0.0743
	5	-2.7467	0.6881	-1.84	0.3633	3.89	0.0931
	10	-3.2945	0.6215	-1.83	0.3663	3.21	0.2474
	20	-4.5363	0.4821	-1.84	0.3630	2.44	0.4446
Trend	1	-3.2555	0.9260	-1.48	0.8356	1.80	0.8160
	2	-3.1213	0.9320	-1.45	0.8455	1.77	0.8240
	3	-2.7428	0.9474	-1.40	0.8609	1.85	0.8066
	4	-2.7129	0.9485	-1.37	0.8688	1.74	0.8293
	5	-2.9073	0.9410	-1.40	0.8614	1.69	0.8393
	10	-3.9054	0.8923	-1.56	0.8080	1.73	0.8305
	20	-6.4939	0.7054	-1.88	0.6638	2.01	0.7746

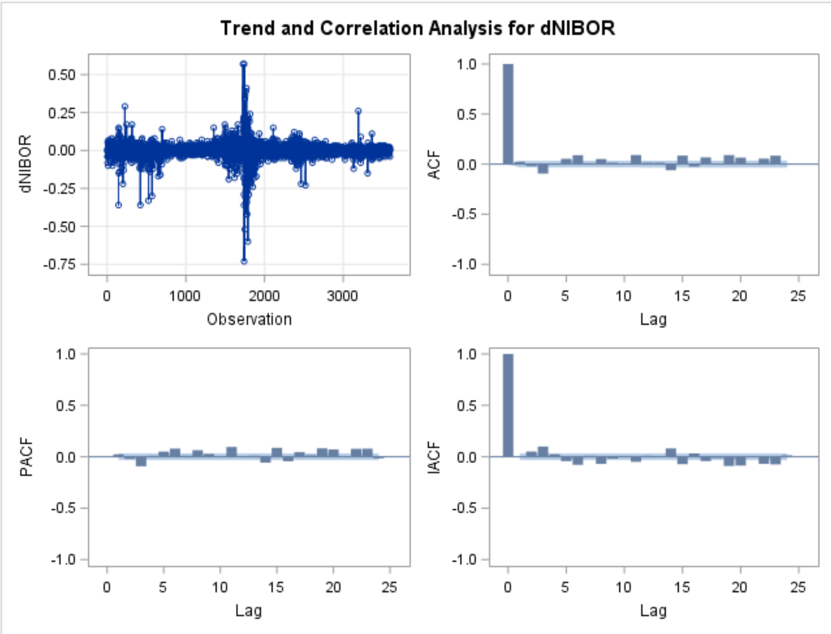
Stationarity analysis on first difference of NIBOR, ΔNIBOR

PROC ARIMA: Variable = dNIBOR

The ARIMA Procedure

Name of Variable = dNIBOR	
Mean of Working Series	-0.00176
Standard Deviation	0.050673
Number of Observations	3594

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	74.67	6	<.0001	0.024	-0.021	-0.094	0.005	0.054	0.089
12	115.86	12	<.0001	0.010	0.051	0.014	0.002	0.091	0.014
18	174.98	18	<.0001	0.014	-0.061	0.085	-0.025	0.067	0.007
24	256.93	24	<.0001	0.090	0.065	0.005	0.055	0.085	-0.005



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3644.49	0.0001	-42.68	<.0001		
	2	-4878.02	0.0001	-38.10	<.0001		
	3	-4637.72	0.0001	-31.81	<.0001		
	4	-3517.13	0.0001	-26.68	<.0001		
	5	-2316.04	0.0001	-22.48	<.0001		
	10	-861.041	0.0001	-14.37	<.0001		
	20	-326.898	0.0001	-9.33	<.0001		
Single Mean	1	-3657.34	0.0001	-42.75	<.0001	913.64	0.0010
	2	-4918.84	0.0001	-38.18	<.0001	729.03	0.0010
	3	-4705.24	0.0001	-31.90	<.0001	508.79	0.0010
	4	-3583.28	0.0001	-26.77	<.0001	358.36	0.0010
	5	-2361.74	0.0001	-22.57	<.0001	254.76	0.0010
	10	-884.287	0.0001	-14.46	<.0001	104.53	0.0010
	20	-338.594	0.0001	-9.41	<.0001	44.29	0.0010
Trend	1	-3661.76	0.0001	-42.77	<.0001	914.46	0.0010
	2	-4933.01	0.0001	-38.21	<.0001	730.05	0.0010
	3	-4728.21	0.0001	-31.93	<.0001	509.67	0.0010
	4	-3605.76	0.0001	-26.80	<.0001	359.11	0.0010
	5	-2376.98	0.0001	-22.60	<.0001	255.35	0.0010
	10	-891.886	0.0001	-14.48	<.0001	104.90	0.0010
	20	-342.442	0.0001	-9.44	<.0001	44.54	0.0010

6.2 Sample 2.1

6.2.1 Autocorrelation analysis

Columns market by stars in correspondence with lag 1-10 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market **dark** green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Cells market with **light** green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis - Breusch-Godfrey test Sample 2.1											
Variable	0 lag	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag
logI44		*	**	insig	insig	insig	insig	insig	insig	*	insig
logUSD	insig	insig	*	**	insig	insig	insig	insig	insig	insig	insig
logBrent	insig	insig	insig	*	**	insig	insig	insig	insig	insig	insig
I44_intrate		***	***	***	***	***	**	***	***	***	***
LIBORUSD		***	***	***	***	***	***	***	***	***	***
NIBOR		***	***	***	***	***	***	***	***	***	***
ΔlogI44		**	insig	insig	insig	insig	insig	insig	insig	insig	insig
ΔlogUSD	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
ΔlogBrent		insig	insig	***	***	***	***	**	**	**	**
ΔI44_INTRATE		***	***	***	***	***	***	***	***	***	***
ΔLIBORUSD		***	***	***	***	***	***	***	**	**	**
ΔNIBOR		***	***	***	***	***	***	***	***	***	***

6.2.2 Variable: Brent

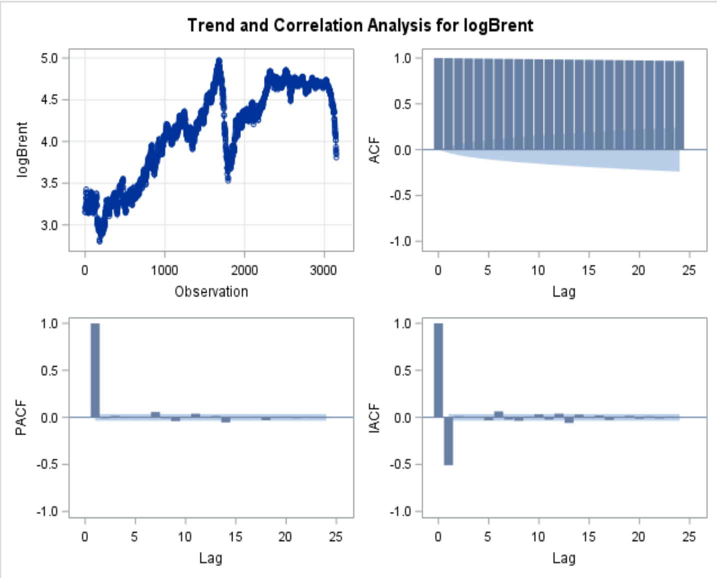
Stationarity analysis on log(Brent)

PROC ARIMA: Variable = logBRENT

The ARIMA Procedure

Name of Variable = logBrent	
Mean of Working Series	4.111095
Standard Deviation	0.553523
Number of Observations	3150

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.997	0.996	0.994	0.993	0.992
12	9999.99	12	<.0001	0.991	0.989	0.988	0.987	0.985	0.984
18	9999.99	18	<.0001	0.983	0.982	0.981	0.979	0.978	0.977
24	9999.99	24	<.0001	0.975	0.974	0.973	0.971	0.970	0.969



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.0839	0.7027	0.27	0.7642		
	1	0.0816	0.7022	0.26	0.7607		
	2	0.0723	0.7000	0.23	0.7522		
	3	0.0711	0.6997	0.22	0.7512		
	4	0.0713	0.6997	0.22	0.7514		
	5	0.0764	0.7009	0.24	0.7560		
Single Mean	0	-4.0820	0.5306	-1.75	0.4080	1.65	0.6475
	1	-4.1986	0.5179	-1.76	0.4018	1.67	0.6435
	2	-4.0752	0.5314	-1.70	0.4317	1.55	0.6743
	3	-4.0513	0.5340	-1.69	0.4364	1.53	0.6789
	4	-4.0579	0.5333	-1.69	0.4355	1.53	0.6780
	5	-4.1315	0.5252	-1.72	0.4191	1.60	0.6615
Trend	0	-2.7432	0.9474	-0.55	0.9813	1.57	0.8638
	1	-3.2499	0.9262	-0.64	0.9765	1.57	0.8643
	2	-3.2746	0.9251	-0.64	0.9765	1.46	0.8862
	3	-3.2394	0.9267	-0.63	0.9770	1.44	0.8893
	4	-3.2356	0.9269	-0.63	0.9771	1.45	0.8887
	5	-3.2231	0.9275	-0.62	0.9773	1.50	0.8769

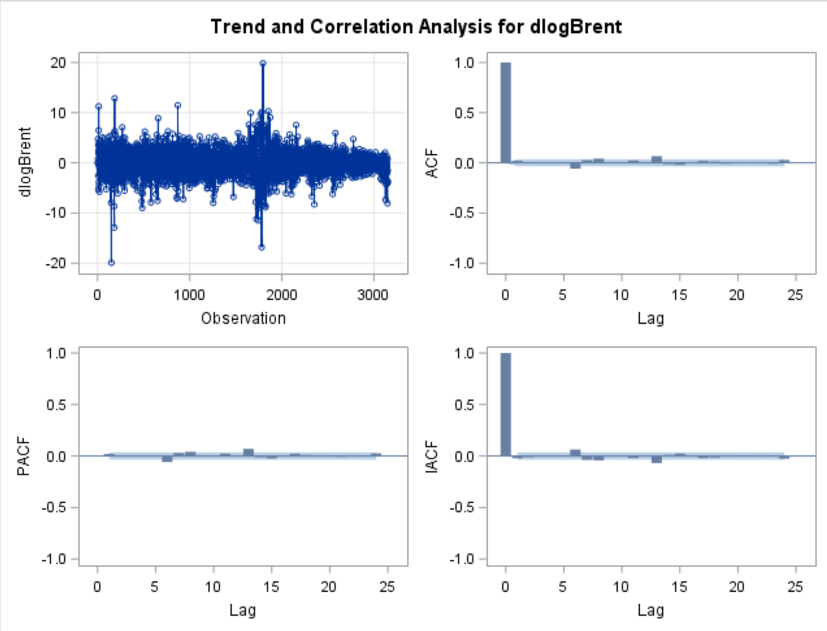
Stationarity analysis on first difference of logBrent, $\Delta logBrent$

PROC ARIMA: Variable = dlogBRENT

The ARIMA Procedure

Name of Variable = dlogBrent	
Mean of Working Series	0.020817
Standard Deviation	2.307406
Number of Observations	3149

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	12.10	6	0.0599	0.020	0.004	-0.001	-0.000	-0.002	-0.058
12	21.67	12	0.0414	0.027	0.042	0.005	-0.003	0.023	0.004
18	39.07	18	0.0028	0.066	-0.013	-0.021	0.001	0.019	0.012
24	42.14	24	0.0124	-0.009	0.000	0.000	0.002	-0.009	0.028



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3057.88	0.0001	-39.09	<.0001		
	2	-3066.41	0.0001	-32.07	<.0001		
	3	-3068.48	0.0001	-27.82	<.0001		
	4	-3093.93	0.0001	-24.93	<.0001		
	5	-4633.85	0.0001	-24.13	<.0001		
	10	-2203.34	0.0001	-16.23	<.0001		
	20	-1297.40	0.0001	-11.19	<.0001		
Single Mean	1	-3058.60	0.0001	-39.09	<.0001	763.92	0.0010
	2	-3067.85	0.0001	-32.07	<.0001	514.23	0.0010
	3	-3070.87	0.0001	-27.82	<.0001	387.01	0.0010
	4	-3097.78	0.0001	-24.93	<.0001	310.77	0.0010
	5	-4644.94	0.0001	-24.13	<.0001	291.08	0.0010
	10	-2210.30	0.0001	-16.23	<.0001	131.72	0.0010
	20	-1308.94	0.0001	-11.19	<.0001	62.66	0.0010
Trend	1	-3066.06	0.0001	-39.13	<.0001	765.54	0.0010
	2	-3082.27	0.0001	-32.12	<.0001	515.72	0.0010
	3	-3094.65	0.0001	-27.87	<.0001	388.45	0.0010
	4	-3134.16	0.0001	-24.99	<.0001	312.24	0.0010
	5	-4742.80	0.0001	-24.19	<.0001	292.62	0.0010
	10	-2278.10	0.0001	-16.29	<.0001	132.61	0.0010
	20	-1395.14	0.0001	-11.28	<.0001	63.70	0.0010

6.2.3 Variable: I44

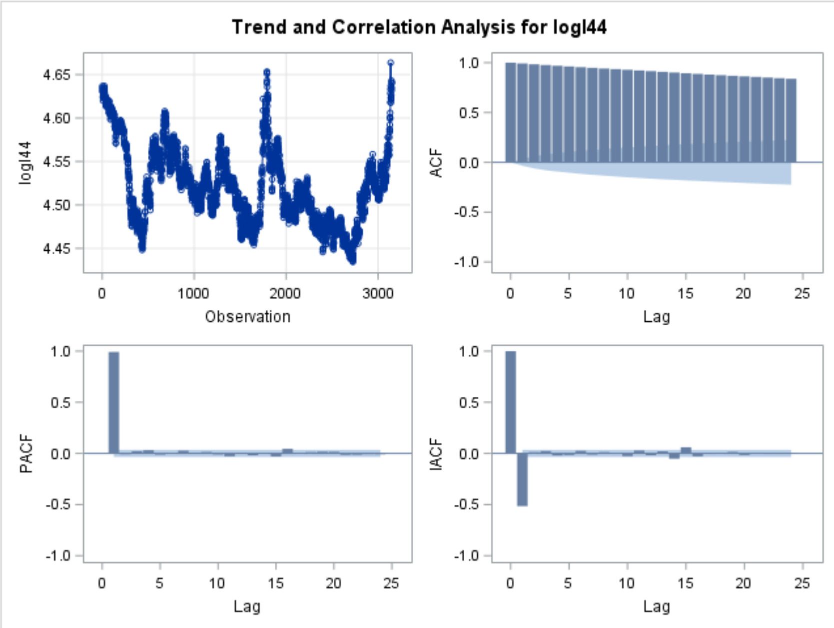
Stationarity analysis on logI44

PROC ARIMA: Variable = logI44

The ARIMA Procedure

Name of Variable = logI44	
Mean of Working Series	4.520744
Standard Deviation	0.043858
Number of Observations	3150

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.992	0.984	0.976	0.969	0.962	0.955
12	9999.99	12	<.0001	0.948	0.942	0.935	0.929	0.922	0.915
18	9999.99	18	<.0001	0.908	0.901	0.894	0.887	0.881	0.875
24	9999.99	24	<.0001	0.869	0.863	0.857	0.851	0.845	0.838



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.0003	0.6831	-0.01	0.6814		
	2	0.0004	0.6832	0.01	0.6854		
	3	0.0005	0.6833	0.01	0.6864		
	4	0.0001	0.6832	0.00	0.6836		
	5	0.0010	0.6834	0.02	0.6889		
Single Mean	1	-17.9468	0.0194	-2.96	0.0392	4.39	0.0622
	2	-17.1891	0.0234	-2.88	0.0485	4.15	0.0772
	3	-15.8209	0.0327	-2.76	0.0657	3.80	0.0989
	4	-15.6725	0.0339	-2.75	0.0666	3.78	0.1000
	5	-16.2858	0.0292	-2.78	0.0622	3.86	0.0951
Trend	1	-17.2538	0.1208	-2.54	0.3064	4.42	0.2872
	2	-16.3503	0.1438	-2.45	0.3557	4.18	0.3340
	3	-14.6228	0.1987	-2.27	0.4485	3.88	0.3963
	4	-14.3526	0.2087	-2.25	0.4633	3.88	0.3962
	5	-15.1951	0.1787	-2.31	0.4278	3.92	0.3876

Stationarity analysis on first difference of logI44, ΔlogI44

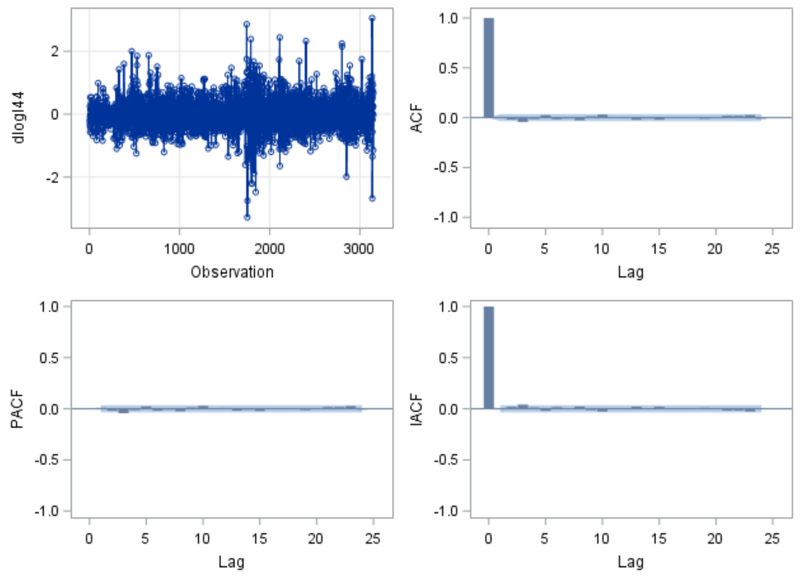
PROC ARIMA: Variable = dlogI44

The ARIMA Procedure

Name of Variable = dlogI44	
Mean of Working Series	0.000126
Standard Deviation	0.466354
Number of Observations	3149

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	10.60	6	0.1017	0.009	-0.020	-0.043	-0.013	0.024	-0.016
12	16.58	12	0.1659	-0.008	-0.026	0.014	0.030	-0.002	0.007
18	19.60	18	0.3558	-0.021	-0.008	-0.020	-0.004	-0.004	-0.001
24	24.67	24	0.4240	-0.010	0.003	0.019	0.018	0.026	-0.011

Trend and Correlation Analysis for dlogI44



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3243.00	0.0001	-40.25	<.0001		
	2	-3706.95	0.0001	-34.13	<.0001		
	3	-3911.31	0.0001	-29.50	<.0001		
	4	-3447.55	0.0001	-25.51	<.0001		
	5	-3907.25	0.0001	-23.65	<.0001		
Single Mean	1	-3243.00	0.0001	-40.25	<.0001	809.94	0.0010
	2	-3706.94	0.0001	-34.12	<.0001	582.22	0.0010
	3	-3911.32	0.0001	-29.49	<.0001	434.96	0.0010
	4	-3447.56	0.0001	-25.50	<.0001	325.22	0.0010
	5	-3907.25	0.0001	-23.65	<.0001	279.69	0.0010
Trend	1	-3250.25	0.0001	-40.29	<.0001	811.49	0.0010
	2	-3724.75	0.0001	-34.17	<.0001	583.80	0.0010
	3	-3946.17	0.0001	-29.55	<.0001	436.55	0.0010
	4	-3490.48	0.0001	-25.56	<.0001	326.63	0.0010
	5	-3980.48	0.0001	-23.71	<.0001	281.06	0.0010

6.2.4 Variable: USD

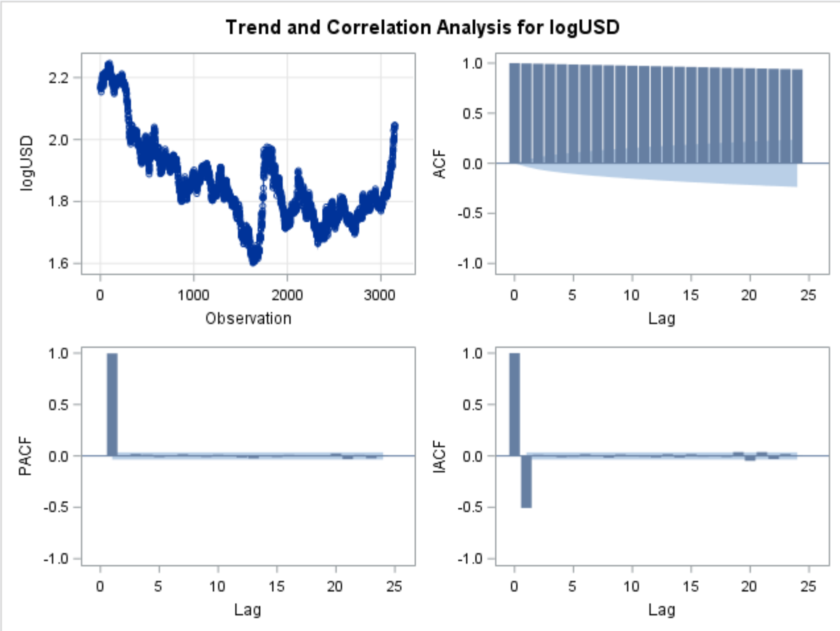
Stationarity analysis on logUSD

PROC ARIMA: Variable = logUSD

The ARIMA Procedure

Name of Variable = logUSD	
Mean of Working Series	1.860992
Standard Deviation	0.139883
Number of Observations	3150

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.997	0.995	0.992	0.989	0.987	0.984
12	9999.99	12	<.0001	0.982	0.979	0.977	0.974	0.972	0.969
18	9999.99	18	<.0001	0.967	0.964	0.962	0.959	0.956	0.954
24	9999.99	24	<.0001	0.951	0.949	0.946	0.944	0.941	0.938



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-0.1088	0.6583	-0.45	0.5209		
	1	-0.1024	0.6598	-0.42	0.5315		
	2	-0.1025	0.6597	-0.43	0.5266		
	3	-0.0978	0.6608	-0.42	0.5327		
	4	-0.1014	0.6600	-0.43	0.5268		
	5	-0.1041	0.6594	-0.44	0.5232		
Single Mean	0	-6.9569	0.2786	-2.14	0.2285	2.33	0.4725
	1	-6.8148	0.2880	-2.09	0.2477	2.22	0.5005
	2	-6.5820	0.3041	-2.07	0.2547	2.19	0.5087
	3	-6.3768	0.3189	-2.03	0.2733	2.10	0.5329
	4	-6.4910	0.3106	-2.06	0.2603	2.16	0.5159
	5	-6.6285	0.3008	-2.09	0.2489	2.22	0.5006
Trend	0	-5.1357	0.8111	-1.13	0.9233	2.45	0.6849
	1	-5.0091	0.8203	-1.10	0.9284	2.34	0.7066
	2	-4.4857	0.8565	-1.01	0.9416	2.37	0.7008
	3	-4.1733	0.8763	-0.95	0.9494	2.31	0.7138
	4	-4.2763	0.8699	-0.97	0.9469	2.37	0.7013
	5	-4.4535	0.8586	-1.00	0.9428	2.41	0.6926

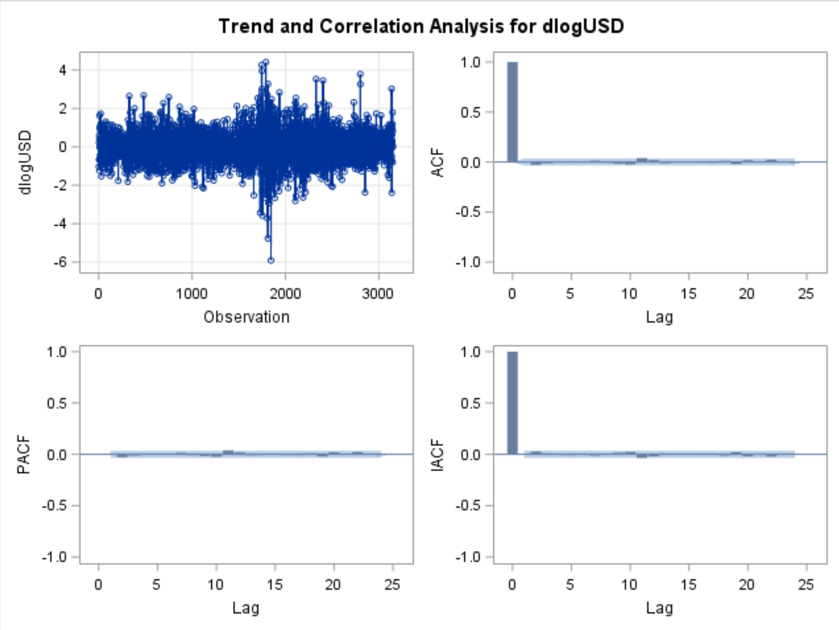
Stationarity analysis on first difference of logUSD, $\Delta logUSD$

PROC ARIMA: Variable = dlogUSD

The ARIMA Procedure

Name of Variable = dlogUSD	
Mean of Working Series	-0.00415
Standard Deviation	0.81048
Number of Observations	3149

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	3.10	6	0.7963	0.001	-0.028	-0.011	0.002	0.006	-0.003
12	12.36	12	0.4173	0.013	-0.007	-0.016	-0.024	0.039	0.019
18	13.48	18	0.7621	-0.011	-0.002	0.003	-0.006	-0.008	0.011
24	17.69	24	0.8177	-0.020	0.017	-0.004	0.023	-0.002	-0.010



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-3145.77	0.0001	-56.07	<.0001		
	1	-3327.54	0.0001	-40.78	<.0001		
	2	-3446.21	0.0001	-33.35	<.0001		
	3	-3430.53	0.0001	-28.62	<.0001		
	4	-3323.72	0.0001	-25.33	<.0001		
	5	-3389.24	0.0001	-23.14	<.0001		
Single Mean	0	-3145.85	0.0001	-56.07	<.0001	1571.65	0.0010
	1	-3327.79	0.0001	-40.77	<.0001	831.14	0.0010
	2	-3446.73	0.0001	-33.35	<.0001	556.13	0.0010
	3	-3431.44	0.0001	-28.62	<.0001	409.58	0.0010
	4	-3325.09	0.0001	-25.33	<.0001	320.75	0.0010
	5	-3391.23	0.0001	-23.14	<.0001	267.65	0.0010
Trend	0	-3149.41	0.0001	-56.12	<.0001	1574.64	0.0010
	1	-3339.19	0.0001	-40.83	<.0001	833.73	0.0010
	2	-3471.12	0.0001	-33.42	<.0001	558.48	0.0010
	3	-3473.64	0.0001	-28.70	<.0001	411.85	0.0010
	4	-3386.54	0.0001	-25.41	<.0001	322.96	0.0010
	5	-3479.29	0.0001	-23.23	<.0001	269.77	0.0010

6.2.5 Variable: I44 interest rate

Stationarity analysis on I44_INTRATE

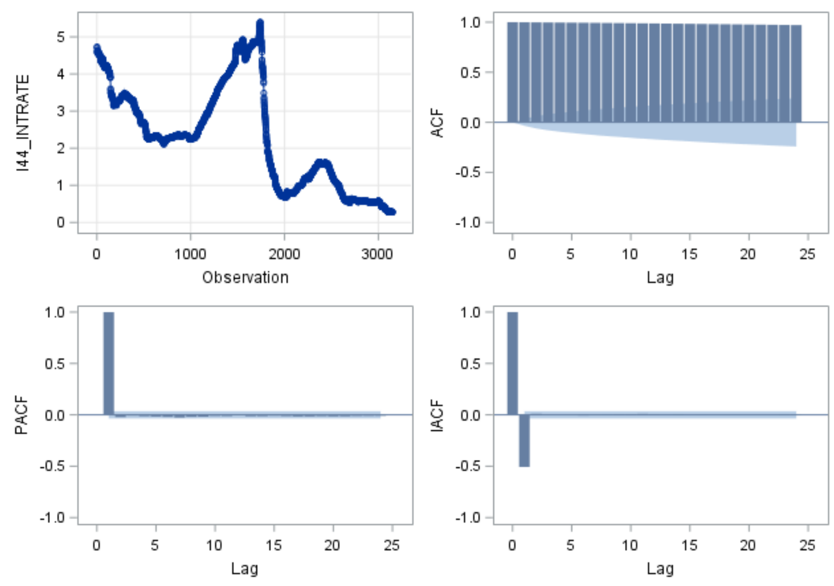
PROC ARIMA: Variable = I44_INTRATE

The ARIMA Procedure

Name of Variable = I44_INTRATE	
Mean of Working Series	2.284036
Standard Deviation	1.39729
Number of Observations	3150

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.998	0.997	0.996	0.995	0.994
12	9999.99	12	<.0001	0.993	0.992	0.991	0.990	0.989	0.987
18	9999.99	18	<.0001	0.986	0.985	0.984	0.983	0.981	0.980
24	9999.99	24	<.0001	0.978	0.977	0.976	0.974	0.973	0.971

Trend and Correlation Analysis for I44_INTRATE



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1.6523	0.3744	-3.34	0.0009		
	2	-1.6160	0.3793	-2.56	0.0104		
	3	-1.6323	0.3771	-2.27	0.0225		
	4	-1.6879	0.3697	-2.11	0.0339		
	5	-1.7786	0.3580	-2.10	0.0346		
	10	-2.0685	0.3230	-1.84	0.0625		
	20	-2.7082	0.2586	-1.70	0.0846		
Single Mean	1	-0.9005	0.8954	-0.95	0.7712	6.02	0.0103
	2	-0.9730	0.8889	-0.81	0.8166	3.46	0.1825
	3	-1.1105	0.8760	-0.81	0.8157	2.67	0.3844
	4	-1.3265	0.8544	-0.87	0.7986	2.25	0.4924
	5	-1.5602	0.8294	-0.97	0.7673	2.21	0.5033
	10	-2.5918	0.7071	-1.21	0.6735	1.74	0.6254
	20	-5.0265	0.4332	-1.63	0.4681	1.82	0.6041
Trend	1	-1.0471	0.9878	-0.81	0.9634	0.47	0.9900
	2	-1.4594	0.9817	-0.89	0.9562	0.42	0.9900
	3	-1.8195	0.9746	-0.97	0.9463	0.48	0.9900
	4	-2.2376	0.9640	-1.07	0.9322	0.58	0.9900
	5	-2.5392	0.9546	-1.15	0.9191	0.68	0.9900
	10	-4.4042	0.8618	-1.50	0.8297	1.14	0.9485
	20	-8.9794	0.5100	-2.10	0.5437	2.22	0.7319

Stationarity analysis on first difference of I44_INTRATE, ΔI44_INTRATE

PROC ARIMA: Variable = dl44_INTRATE

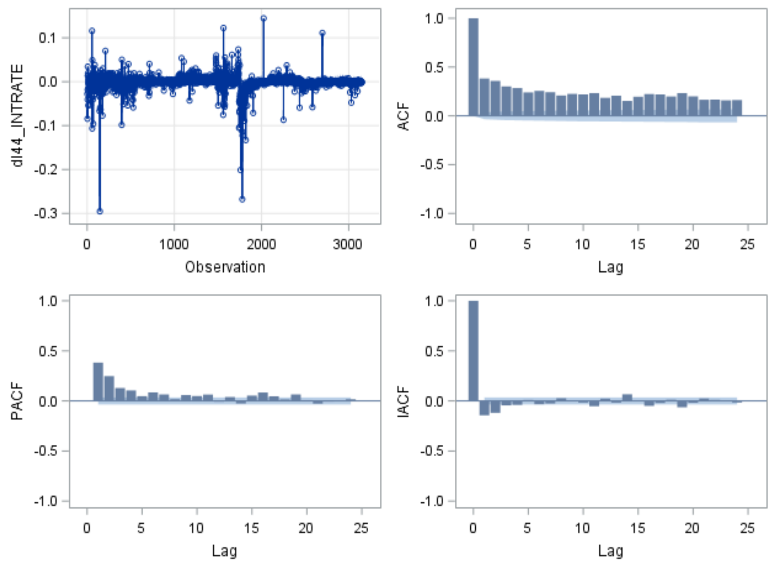
The ARIMA Procedure

Name of Variable = dl44_INTRATE	
Mean of Working Series	-0.00142
Standard Deviation	0.015692
Number of Observations	3149

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1797.84	6	<.0001	0.383	0.358	0.302	0.285	0.240	0.256
12	2712.33	12	<.0001	0.242	0.209	0.225	0.220	0.232	0.184
18	3478.22	18	<.0001	0.207	0.153	0.196	0.223	0.219	0.198
24	4113.29	24	<.0001	0.233	0.200	0.165	0.166	0.159	0.162

Trend and Correlation Analysis for dl44_INTRATE



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1158.96	0.0001	-24.25	<.0001		
	2	-854.438	0.0001	-19.56	<.0001		
	3	-653.416	0.0001	-16.55	<.0001		
	4	-568.912	0.0001	-14.99	<.0001		
	5	-446.198	0.0001	-13.18	<.0001		
	10	-227.698	0.0001	-9.30	<.0001		
	20	-109.532	0.0001	-6.39	<.0001		
Single Mean	1	-1174.32	0.0001	-24.40	<.0001	297.72	0.0010
	2	-868.624	0.0001	-19.69	<.0001	193.86	0.0010
	3	-665.910	0.0001	-16.67	<.0001	139.00	0.0010
	4	-581.437	0.0001	-15.11	<.0001	114.20	0.0010
	5	-456.953	0.0001	-13.30	<.0001	88.51	0.0010
	10	-234.019	0.0001	-9.39	<.0001	44.07	0.0010
	20	-113.465	0.0001	-6.48	<.0001	20.97	0.0010
Trend	1	-1174.56	0.0001	-24.40	<.0001	297.65	0.0010
	2	-868.783	0.0001	-19.69	<.0001	193.81	0.0010
	3	-666.038	0.0001	-16.67	<.0001	138.96	0.0010
	4	-581.630	0.0001	-15.11	<.0001	114.18	0.0010
	5	-457.188	0.0001	-13.30	<.0001	88.51	0.0010
	10	-234.044	0.0001	-9.39	<.0001	44.05	0.0010
	20	-113.545	0.0001	-6.48	<.0001	20.97	0.0010

6.2.6 Variable: LIBOR_USD

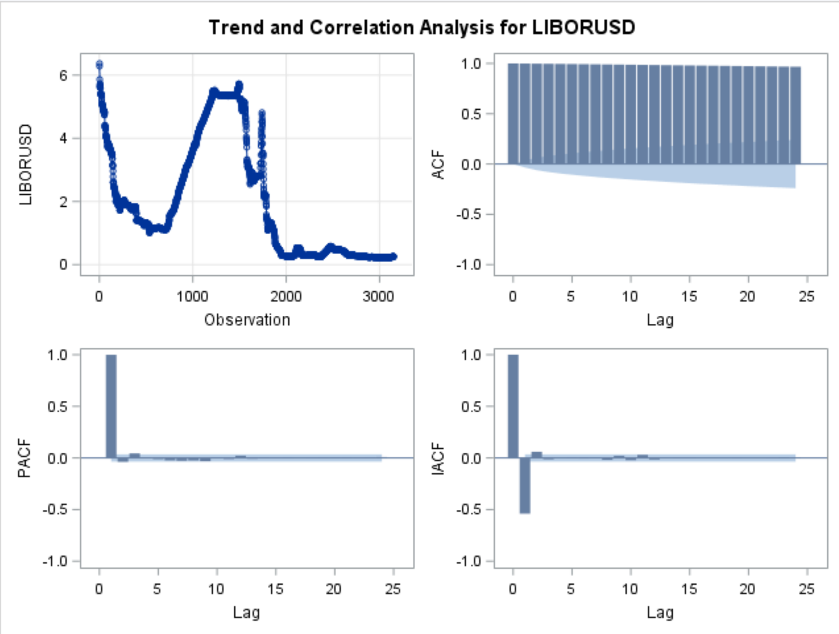
Stationarity analysis on LIBOR_USD

PROC ARIMA: Variable = LIBORUSD

The ARIMA Procedure

Name of Variable = LIBORUSD	
Mean of Working Series	1.971341
Standard Deviation	1.826545
Number of Observations	3150

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.998	0.996	0.995	0.994	0.993
12	9999.99	12	<.0001	0.991	0.990	0.989	0.987	0.986	0.984
18	9999.99	18	<.0001	0.983	0.981	0.980	0.979	0.977	0.976
24	9999.99	24	<.0001	0.974	0.973	0.971	0.970	0.968	0.967



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3.1885	0.2202	-3.13	0.0018		
	2	-2.5887	0.2694	-2.48	0.0128		
	3	-2.6261	0.2660	-2.38	0.0166		
	4	-2.7262	0.2570	-2.14	0.0312		
	5	-2.8850	0.2436	-2.13	0.0323		
	10	-3.4165	0.2043	-1.97	0.0471		
	20	-2.9588	0.2376	-2.25	0.0238		
Single Mean	1	-3.3808	0.6112	-2.26	0.1847	4.92	0.0395
	2	-2.5394	0.7136	-1.66	0.4527	3.08	0.2807
	3	-2.6394	0.7013	-1.63	0.4654	2.84	0.3413
	4	-2.9405	0.6644	-1.57	0.4965	2.30	0.4804
	5	-3.2453	0.6274	-1.63	0.4674	2.29	0.4836
	10	-4.4495	0.4911	-1.74	0.4089	2.09	0.5356
	20	-3.2972	0.6212	-1.71	0.4272	2.55	0.4153
Trend	1	-2.9329	0.9400	-1.66	0.7678	2.67	0.6408
	2	-2.3032	0.9621	-1.28	0.8932	1.40	0.8971
	3	-2.4634	0.9571	-1.29	0.8890	1.35	0.9080
	4	-2.9784	0.9381	-1.35	0.8743	1.24	0.9293
	5	-3.3533	0.9213	-1.43	0.8526	1.33	0.9113
	10	-5.0706	0.8158	-1.68	0.7590	1.59	0.8588
	20	-3.2861	0.9245	-1.45	0.8462	1.46	0.8863

Stationarity analysis on first difference of LIBOR_USD, ΔLIBOR_USD

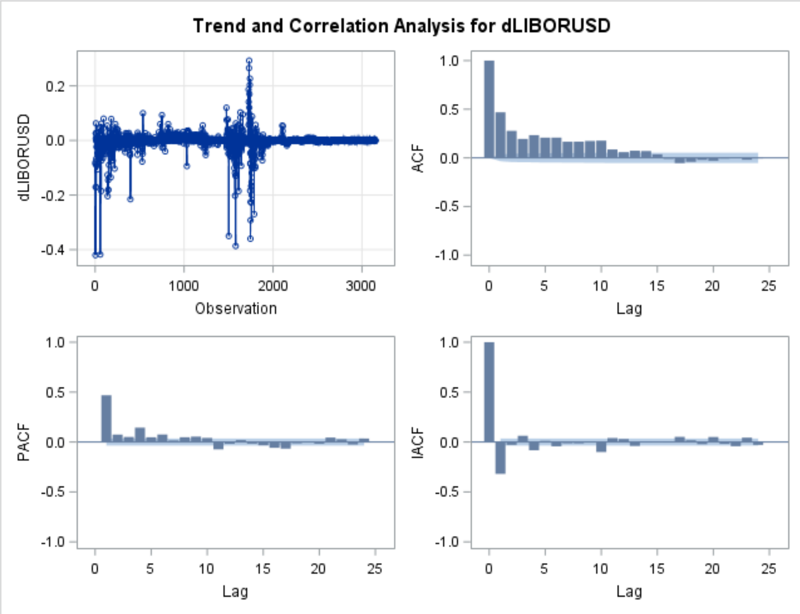
PROC ARIMA: Variable = dLIBORUSD

The ARIMA Procedure

Name of Variable = dLIBORUSD	
Mean of Working Series	-0.00194
Standard Deviation	0.02937
Number of Observations	3149

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1500.72	6	<.0001	0.468	0.278	0.195	0.234	0.208	0.208
12	1904.89	12	<.0001	0.166	0.167	0.174	0.177	0.086	0.059
18	1956.84	18	<.0001	0.074	0.070	0.036	-0.011	-0.054	-0.041
24	1962.76	24	<.0001	-0.021	-0.030	-0.008	0.005	-0.020	-0.006



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1445.34	0.0001	-28.23	<.0001		
	2	-1270.26	0.0001	-23.88	<.0001		
	3	-860.175	0.0001	-18.98	<.0001		
	4	-734.237	0.0001	-16.86	<.0001		
	5	-572.519	0.0001	-14.68	<.0001		
	10	-495.542	0.0001	-12.32	<.0001		
	20	-983.171	0.0001	-11.18	<.0001		
Single Mean	1	-1454.29	0.0001	-28.30	<.0001	400.40	0.0010
	2	-1281.19	0.0001	-23.95	<.0001	286.72	0.0010
	3	-868.569	0.0001	-19.04	<.0001	181.24	0.0010
	4	-742.574	0.0001	-16.92	<.0001	143.13	0.0010
	5	-579.645	0.0001	-14.74	<.0001	108.58	0.0010
	10	-504.470	0.0001	-12.37	<.0001	76.50	0.0010
	20	-1054.73	0.0001	-11.27	<.0001	63.47	0.0010
Trend	1	-1458.30	0.0001	-28.31	<.0001	400.96	0.0010
	2	-1285.97	0.0001	-23.96	<.0001	287.21	0.0010
	3	-871.968	0.0001	-19.05	<.0001	181.52	0.0010
	4	-746.013	0.0001	-16.93	<.0001	143.41	0.0010
	5	-582.678	0.0001	-14.75	<.0001	108.85	0.0010
	10	-507.567	0.0001	-12.37	<.0001	76.62	0.0010
	20	-1085.38	0.0001	-11.30	<.0001	63.80	0.0010

6.2.7 Variable: NIBOR

Stationarity analysis on NIBOR

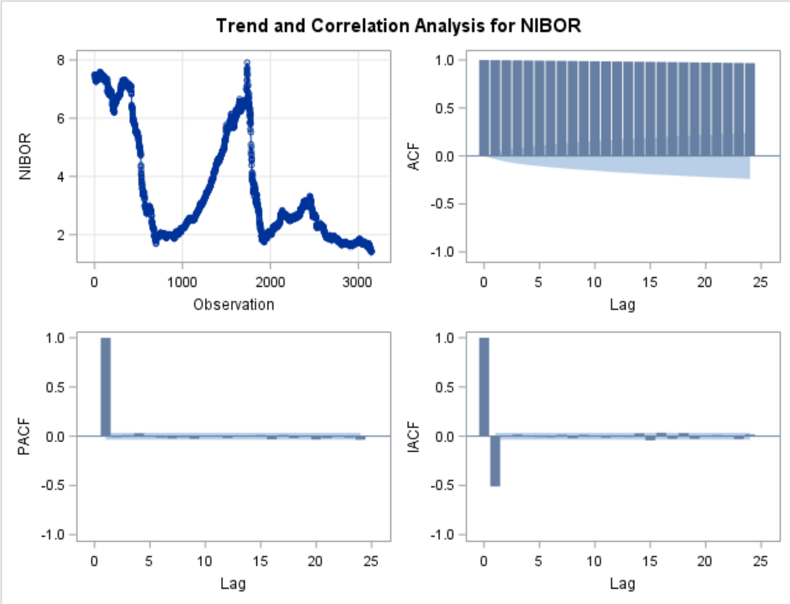
PROC ARIMA: Variable = NIBOR

The ARIMA Procedure

Name of Variable = NIBOR	
Mean of Working Series	3.565006
Standard Deviation	1.92964
Number of Observations	3150

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.997	0.996	0.995	0.994	0.993
12	9999.99	12	<.0001	0.992	0.990	0.989	0.988	0.986	0.985
18	9999.99	18	<.0001	0.984	0.982	0.981	0.980	0.978	0.977
24	9999.99	24	<.0001	0.975	0.974	0.972	0.971	0.969	0.967



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1.9395	0.3381	-2.55	0.0105		
	2	-1.9110	0.3415	-2.57	0.0101		
	3	-1.8698	0.3466	-2.76	0.0057		
	4	-1.8418	0.3500	-2.69	0.0071		
	5	-1.8617	0.3476	-2.58	0.0098		
	10	-2.0029	0.3306	-2.28	0.0219		
	20	-2.2502	0.3030	-1.87	0.0583		
Single Mean	1	-2.7384	0.6891	-1.72	0.4228	3.42	0.1921
	2	-2.6498	0.7000	-1.69	0.4343	3.43	0.1889
	3	-2.4535	0.7241	-1.73	0.4178	3.92	0.0913
	4	-2.4007	0.7306	-1.67	0.4464	3.71	0.1175
	5	-2.5020	0.7182	-1.65	0.4566	3.43	0.1894
	10	-3.0859	0.6467	-1.68	0.4439	2.82	0.3464
	20	-4.3534	0.5012	-1.72	0.4209	2.20	0.5076
Trend	1	-2.8265	0.9442	-1.39	0.8639	1.47	0.8828
	2	-2.7148	0.9484	-1.36	0.8716	1.44	0.8908
	3	-2.3797	0.9598	-1.31	0.8839	1.49	0.8795
	4	-2.3580	0.9604	-1.29	0.8901	1.40	0.8990
	5	-2.5343	0.9548	-1.31	0.8841	1.36	0.9054
	10	-3.4453	0.9169	-1.47	0.8396	1.43	0.8913
	20	-5.7162	0.7671	-1.77	0.7206	1.70	0.8365

Stationarity analysis on first difference of NIBOR, ΔNIBOR

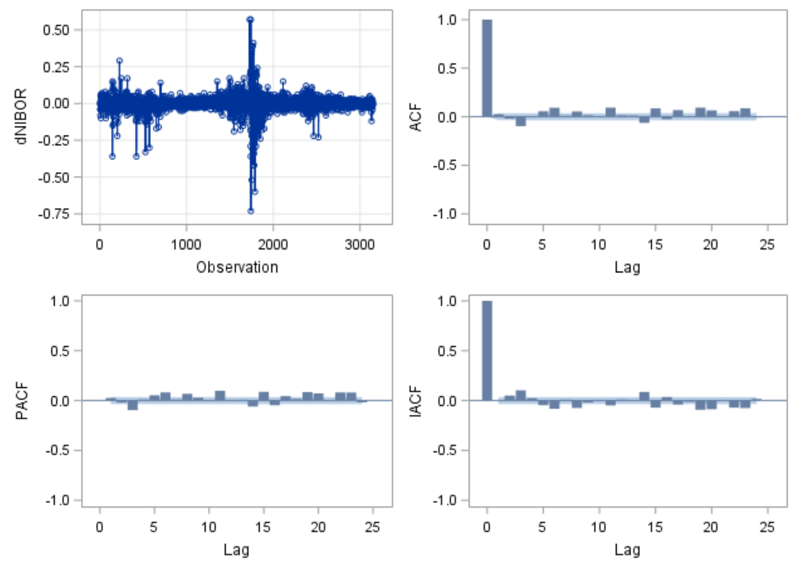
PROC ARIMA: Variable = dNIBOR

The ARIMA Procedure

Name of Variable = dNIBOR	
Mean of Working Series	-0.00193
Standard Deviation	0.05342
Number of Observations	3149

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	70.28	6	<.0001	0.026	-0.020	-0.097	0.006	0.056	0.092
12	109.14	12	<.0001	0.011	0.054	0.014	0.004	0.094	0.015
18	162.92	18	<.0001	0.013	-0.063	0.086	-0.026	0.069	0.008
24	238.92	24	<.0001	0.094	0.065	0.005	0.057	0.087	-0.007

Trend and Correlation Analysis for dNIBOR



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-3178.90	0.0001	-39.86	<.0001		
	2	-4297.48	0.0001	-35.72	<.0001		
	3	-4052.98	0.0001	-29.75	<.0001		
	4	-3032.45	0.0001	-24.89	<.0001		
	5	-1983.84	0.0001	-20.94	<.0001		
	10	-718.001	0.0001	-13.29	<.0001		
	20	-279.600	0.0001	-8.67	<.0001		
Single Mean	1	-3191.02	0.0001	-39.93	<.0001	797.12	0.0010
	2	-4336.48	0.0001	-35.81	<.0001	641.01	0.0010
	3	-4116.74	0.0001	-29.85	<.0001	445.41	0.0010
	4	-3093.43	0.0001	-24.98	<.0001	312.02	0.0010
	5	-2025.44	0.0001	-21.03	<.0001	221.06	0.0010
	10	-738.098	0.0001	-13.37	<.0001	89.40	0.0010
	20	-290.122	0.0001	-8.75	<.0001	38.29	0.0010
Trend	1	-3194.15	0.0001	-39.94	<.0001	797.63	0.0010
	2	-4346.69	0.0001	-35.82	<.0001	641.69	0.0010
	3	-4132.96	0.0001	-29.87	<.0001	445.99	0.0010
	4	-3108.99	0.0001	-25.00	<.0001	312.52	0.0010
	5	-2035.84	0.0001	-21.04	<.0001	221.44	0.0010
	10	-743.094	0.0001	-13.39	<.0001	89.63	0.0010
	20	-292.712	0.0001	-8.77	<.0001	38.43	0.0010

6.3 Sample 2.2

6.3.1 Autocorrelation analysis

Columns market by stars in correspondence with lag 1-10 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market **dark** green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Cells market with **light** green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis - Breusch-Godfrey test Sample 2.2											
Variable	0 lag	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag
logI44		**	*	***	insig	insig	*	insig	insig	insig	insig
logUSD		*	*	***	insig	insig	insig	insig	insig		insig
logBrent	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
I44_intrate		***	**	*	**	**	**	insig	insig	insig	*
LIBORUSD		***	***	**	insig	insig	*	*	**	**	*
NIBOR	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
ΔlogI44		**	***	insig	insig	*	*	insig	insig	insig	insig
ΔlogUSD		*	***	insig	insig	**	insig	insig	insig	insig	insig
ΔlogBrent	insig	insig	insig	insig	insig	insig					insig
ΔI44_INTRATE		**	***	***	**	***	**	insig	insig	*	**
ΔLIBORUSD		**	***			*	*	**	*	insig	insig
ΔNIBOR	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig

6.3.2 Variable: Brent

Stationarity analysis on logBrent

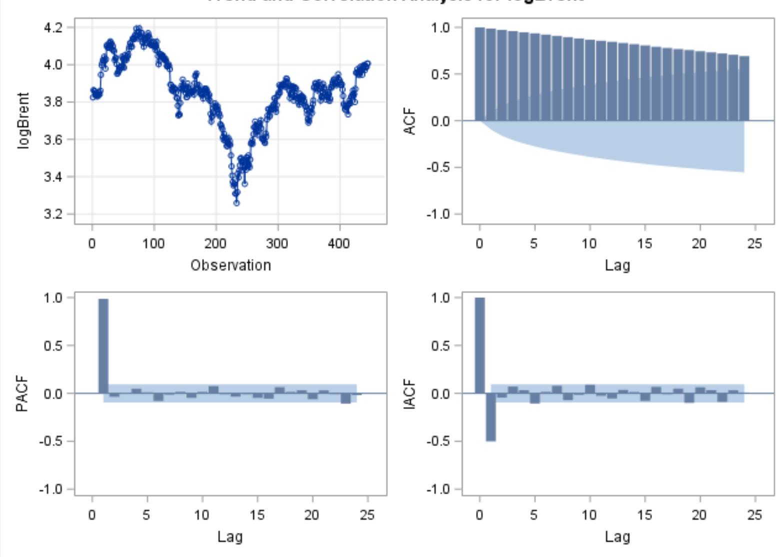
PROC ARIMA: Variable = logBRENT

The ARIMA Procedure

Name of Variable = logBrent	
Mean of Working Series	3.851414
Standard Deviation	0.185183
Number of Observations	445

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	2463.60	6	<.0001	0.987	0.973	0.960	0.948	0.936	0.923
12	4567.21	12	<.0001	0.909	0.896	0.881	0.868	0.857	0.845
18	6347.31	18	<.0001	0.833	0.821	0.807	0.793	0.780	0.768
24	7832.28	24	<.0001	0.757	0.745	0.733	0.721	0.707	0.692

Trend and Correlation Analysis for logBrent



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.0355	0.6909	0.22	0.7514		
	1	0.0241	0.6883	0.15	0.7289		
	2	0.0260	0.6887	0.16	0.7323		
	3	0.0277	0.6891	0.18	0.7383		
	4	0.0323	0.6902	0.21	0.7481		
	5	0.0303	0.6897	0.18	0.7393		
Single Mean	0	-5.0448	0.4297	-1.54	0.5141	1.23	0.7572
	1	-5.4526	0.3921	-1.59	0.4850	1.30	0.7395
	2	-5.5290	0.3854	-1.60	0.4830	1.30	0.7373
	3	-4.9176	0.4420	-1.50	0.5354	1.15	0.7768
	4	-4.7723	0.4563	-1.47	0.5503	1.12	0.7857
	5	-5.8294	0.3598	-1.62	0.4727	1.34	0.7275
Trend	0	-5.3450	0.7941	-1.51	0.8254	1.21	0.9355
	1	-5.6639	0.7696	-1.53	0.8181	1.28	0.9213
	2	-5.7952	0.7592	-1.54	0.8131	1.29	0.9192
	3	-5.0962	0.8127	-1.43	0.8521	1.12	0.9507
	4	-5.0103	0.8189	-1.41	0.8562	1.09	0.9557
	5	-6.2570	0.7223	-1.59	0.7971	1.34	0.9097

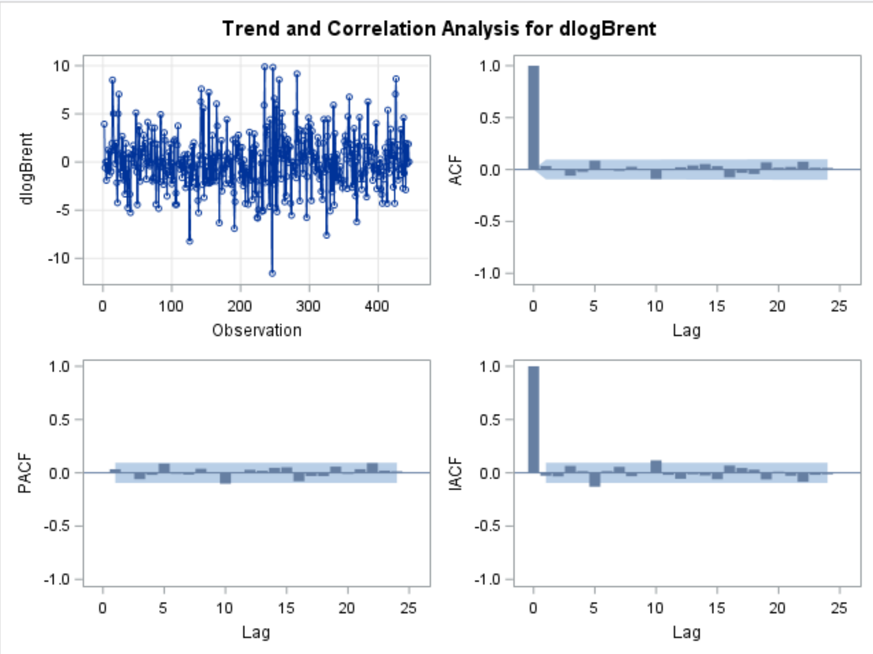
Stationarity analysis on first difference of logBrent, ΔlogBrent

PROC ARIMA: Variable = dlogBRENT

The ARIMA Procedure

Name of Variable = dlogBrent	
Mean of Working Series	0.040965
Standard Deviation	2.885409
Number of Observations	444

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	5.58	6	0.4715	0.034	0.002	-0.059	-0.024	0.085	0.001
12	10.04	12	0.6125	-0.013	0.027	-0.006	-0.091	-0.006	0.022
18	16.51	18	0.5569	0.039	0.053	0.033	-0.076	-0.033	-0.043
24	22.06	24	0.5756	0.069	0.018	0.025	0.075	0.017	0.015



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-427.911	0.0001	-20.36	<.0001		
	1	-425.977	0.0001	-14.57	<.0001		
	2	-509.640	0.0001	-12.67	<.0001		
	3	-551.109	0.0001	-11.01	<.0001		
	4	-354.607	0.0001	-8.90	<.0001		
	5	-368.161	0.0001	-8.23	<.0001		
Single Mean	0	-427.978	0.0001	-20.34	<.0001	206.89	0.0010
	1	-426.151	0.0001	-14.55	<.0001	105.92	0.0010
	2	-510.068	0.0001	-12.66	<.0001	80.10	0.0010
	3	-552.028	0.0001	-11.00	<.0001	60.55	0.0010
	4	-355.264	0.0001	-8.89	<.0001	39.55	0.0010
	5	-369.222	0.0001	-8.23	<.0001	33.83	0.0010
Trend	0	-428.150	0.0001	-20.33	<.0001	206.63	0.0010
	1	-426.625	0.0001	-14.55	<.0001	105.83	0.0010
	2	-511.296	0.0001	-12.65	<.0001	80.06	0.0010
	3	-554.272	0.0001	-11.00	<.0001	60.52	0.0010
	4	-356.952	0.0001	-8.89	<.0001	39.55	0.0010
	5	-371.552	0.0001	-8.23	<.0001	33.83	0.0010

6.3.3 Variable: I44

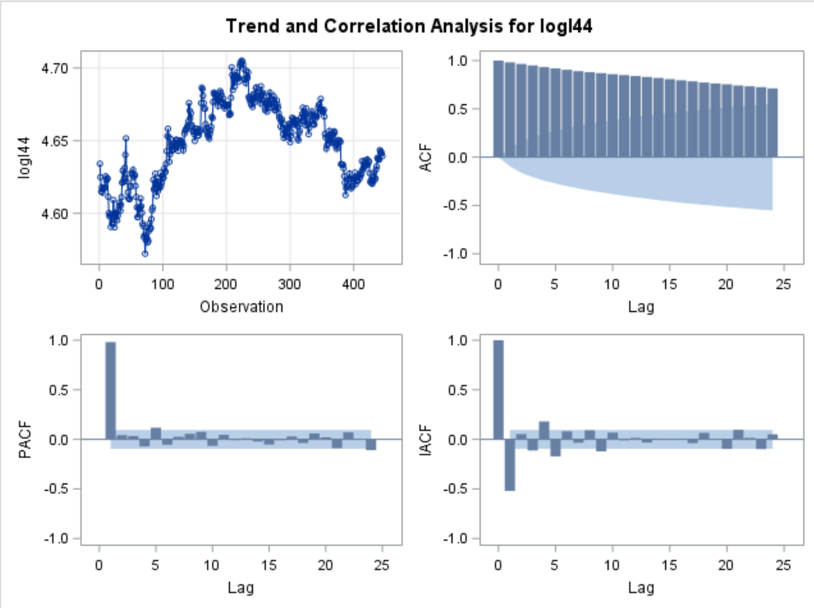
Stationarity analysis on logI44

PROC ARIMA: Variable = logI44

The ARIMA Procedure

Name of Variable = logI44	
Mean of Working Series	4.648208
Standard Deviation	0.028526
Number of Observations	445

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	2400.26	6	<.0001	0.981	0.965	0.950	0.932	0.919	0.905
12	4450.63	12	<.0001	0.891	0.880	0.870	0.859	0.850	0.840
18	6238.51	18	<.0001	0.830	0.820	0.808	0.796	0.785	0.773
24	7775.61	24	<.0001	0.763	0.754	0.742	0.734	0.725	0.712



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	0.0027	0.6833	0.12	0.7199		
	2	0.0047	0.6838	0.22	0.7488		
	3	0.0045	0.6837	0.19	0.7426		
	4	0.0049	0.6838	0.24	0.7556		
	5	0.0047	0.6838	0.22	0.7496		
Single Mean	1	-7.4564	0.2457	-1.96	0.3037	1.93	0.5764
	2	-6.9712	0.2756	-1.94	0.3154	1.90	0.5848
	3	-8.0087	0.2153	-2.05	0.2653	2.12	0.5278
	4	-6.3384	0.3198	-1.85	0.3581	1.73	0.6272
	5	-6.9751	0.2754	-1.91	0.3269	1.85	0.5969
Trend	1	-7.6353	0.6106	-1.90	0.6558	1.93	0.7915
	2	-6.8842	0.6714	-1.80	0.7019	1.87	0.8030
	3	-8.0416	0.5782	-1.94	0.6319	2.10	0.7578
	4	-6.1434	0.7315	-1.69	0.7550	1.71	0.8354
	5	-6.8706	0.6725	-1.78	0.7153	1.82	0.8125

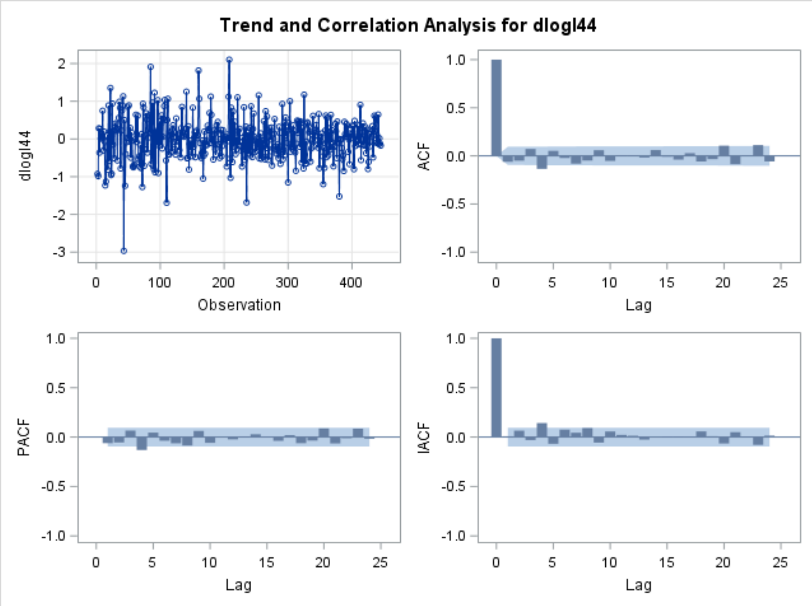
Stationarity analysis on first difference of logI44, ΔlogI44

PROC ARIMA: Variable = dlogI44

The ARIMA Procedure

Name of Variable = dlogI44	
Mean of Working Series	0.001157
Standard Deviation	0.543649
Number of Observations	444

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	14.81	6	0.0218	-0.061	-0.050	0.072	-0.135	0.052	-0.022
12	21.67	12	0.0414	-0.081	-0.049	0.058	-0.052	0.005	0.004
18	26.13	18	0.0967	-0.017	0.060	-0.008	-0.039	0.028	-0.058
24	42.91	24	0.0102	-0.034	0.106	-0.087	-0.003	0.112	-0.058



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-526.683	0.0001	-16.34	<.0001		
	2	-428.211	0.0001	-12.02	<.0001		
	3	-796.191	0.0001	-11.91	<.0001		
	4	-582.475	0.0001	-9.84	<.0001		
	5	-790.946	0.0001	-9.22	<.0001		
Single Mean	1	-526.760	0.0001	-16.32	<.0001	133.16	0.0010
	2	-428.375	0.0001	-12.01	<.0001	72.07	0.0010
	3	-797.104	0.0001	-11.90	<.0001	70.77	0.0010
	4	-583.331	0.0001	-9.83	<.0001	48.34	0.0010
	5	-793.152	0.0001	-9.21	<.0001	42.45	0.0010
Trend	1	-527.653	0.0001	-16.32	<.0001	133.24	0.0010
	2	-430.044	0.0001	-12.01	<.0001	72.19	0.0010
	3	-805.208	0.0001	-11.91	<.0001	70.98	0.0010
	4	-592.071	0.0001	-9.85	<.0001	48.53	0.0010
	5	-816.980	0.0001	-9.24	<.0001	42.67	0.0010

6.3.4 Variable: USD

Stationarity analysis on logUSD

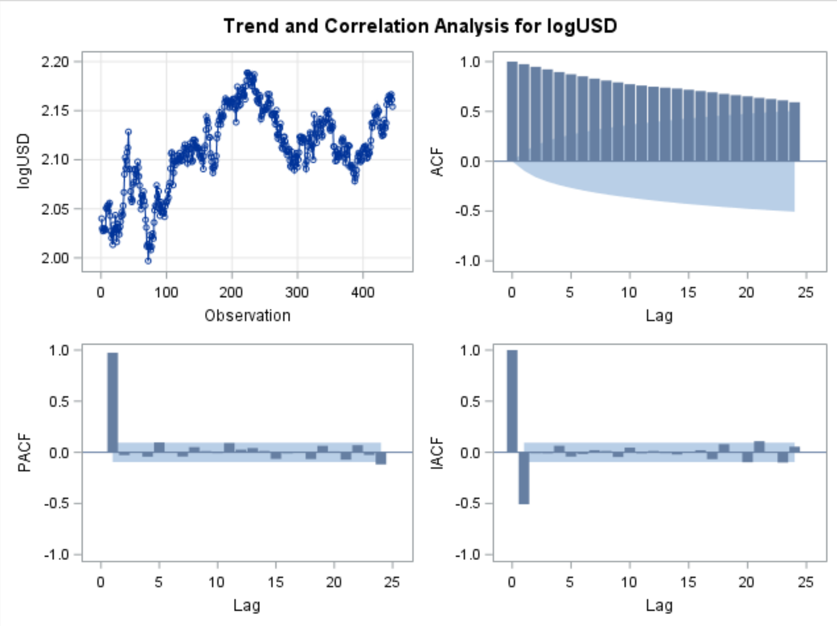
PROC ARIMA: Variable = logUSD

The ARIMA Procedure

Name of Variable = logUSD	
Mean of Working Series	2.109606
Standard Deviation	0.041338
Number of Observations	445

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	2246.72	6	<.0001	0.974	0.948	0.922	0.895	0.873	0.852
12	3939.21	12	<.0001	0.830	0.810	0.792	0.773	0.760	0.748
18	5340.62	18	<.0001	0.738	0.730	0.718	0.705	0.692	0.676
24	6460.69	24	<.0001	0.664	0.652	0.636	0.625	0.612	0.592



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	0.0548	0.6954	0.66	0.8572		
	2	0.0563	0.6957	0.69	0.8643		
	3	0.0551	0.6955	0.65	0.8555		
	4	0.0563	0.6957	0.76	0.8772		
	5	0.0563	0.6957	0.76	0.8778		
Single Mean	1	-10.6158	0.1148	-2.46	0.1273	3.27	0.2344
	2	-10.4985	0.1181	-2.45	0.1287	3.28	0.2312
	3	-11.5580	0.0912	-2.53	0.1087	3.45	0.1867
	4	-9.2271	0.1606	-2.29	0.1748	2.95	0.3149
	5	-9.3164	0.1572	-2.29	0.1746	2.96	0.3140
Trend	1	-14.6255	0.1940	-2.76	0.2138	3.87	0.4013
	2	-14.3998	0.2023	-2.73	0.2261	3.79	0.4159
	3	-16.1034	0.1465	-2.84	0.1823	4.11	0.3519
	4	-12.6259	0.2790	-2.53	0.3152	3.27	0.5215
	5	-12.7884	0.2710	-2.52	0.3160	3.27	0.5221

Stationarity analysis on first difference of logUSD, ΔlogUSD

PROC ARIMA: Variable = dlogUSD

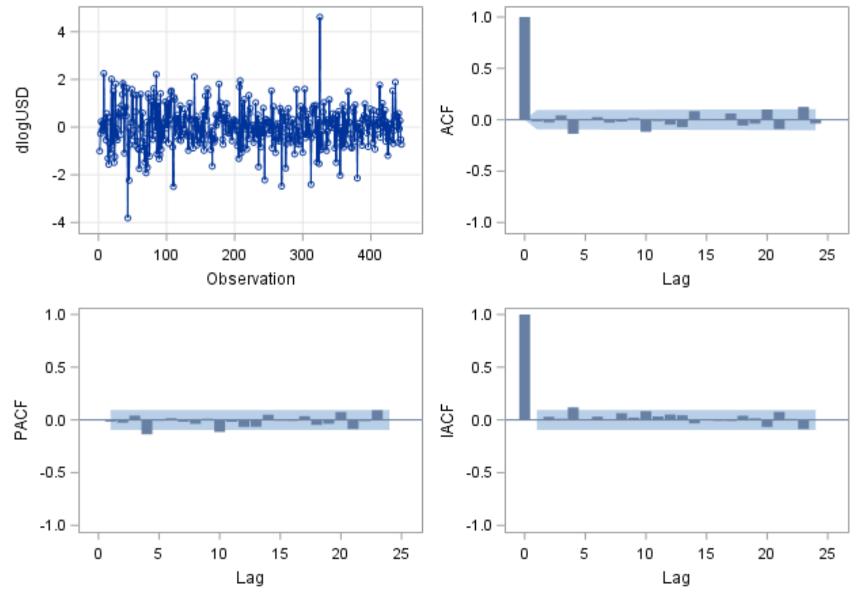
The ARIMA Procedure

Name of Variable = dlogUSD	
Mean of Working Series	0.025686
Standard Deviation	0.850279
Number of Observations	444

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9.91	6	0.1286	-0.016	-0.026	0.042	-0.137	-0.006	0.025
12	17.92	12	0.1180	-0.027	-0.019	0.015	-0.118	-0.012	-0.048
18	26.72	18	0.0845	-0.072	0.083	-0.001	-0.004	0.061	-0.056
24	43.86	24	0.0079	-0.037	0.100	-0.091	0.004	0.125	-0.036

Trend and Correlation Analysis for dlogUSD



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-472.346	0.0001	-15.33	<.0001		
	2	-414.245	0.0001	-11.82	<.0001		
	3	-770.225	0.0001	-11.77	<.0001		
	4	-801.285	0.0001	-10.28	<.0001		
	5	-689.474	0.0001	-9.04	<.0001		
Single Mean	1	-474.044	0.0001	-15.34	<.0001	117.64	0.0010
	2	-417.148	0.0001	-11.83	<.0001	70.01	0.0010
	3	-783.894	0.0001	-11.79	<.0001	69.49	0.0010
	4	-825.409	0.0001	-10.31	<.0001	53.17	0.0010
	5	-718.005	0.0001	-9.08	<.0001	41.19	0.0010
Trend	1	-474.253	0.0001	-15.33	<.0001	117.49	0.0010
	2	-417.557	0.0001	-11.83	<.0001	69.94	0.0010
	3	-785.752	0.0001	-11.78	<.0001	69.43	0.0010
	4	-829.285	0.0001	-10.31	<.0001	53.14	0.0010
	5	-722.779	0.0001	-9.08	<.0001	41.20	0.0010

6.3.5 Variable: I44 interest rate

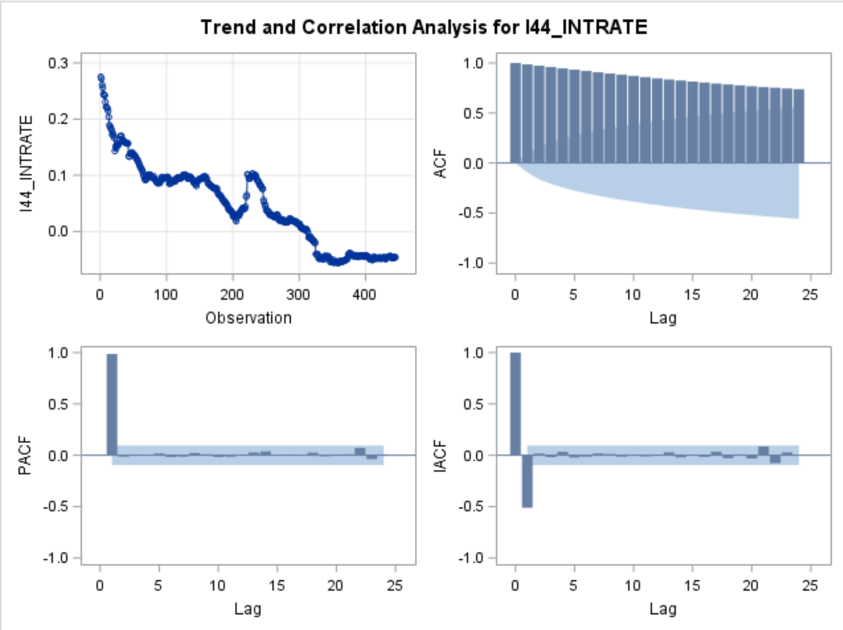
Stationarity analysis on I44_INTRATE

PROC ARIMA: Variable = I44_INTRATE

The ARIMA Procedure

Name of Variable = I44_INTRATE	
Mean of Working Series	0.046539
Standard Deviation	0.074841
Number of Observations	445

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	2456.06	6	<.0001	0.986	0.973	0.959	0.946	0.933	0.920
12	4564.33	12	<.0001	0.907	0.895	0.883	0.871	0.859	0.846
18	6386.84	18	<.0001	0.835	0.825	0.814	0.804	0.795	0.786
24	7999.58	24	<.0001	0.777	0.768	0.759	0.752	0.745	0.738



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-5.2925	0.1134	-4.89	<.0001		
	2	-5.0682	0.1214	-3.99	<.0001		
	3	-5.0085	0.1237	-3.86	0.0001		
	4	-4.6725	0.1371	-3.32	0.0010		
	5	-4.8297	0.1307	-3.09	0.0021		
	10	-4.6706	0.1372	-2.38	0.0168		
	20	-3.3142	0.2108	-2.05	0.0391		
Single Mean	1	-4.6742	0.4662	-3.73	0.0042	12.36	0.0010
	2	-4.4581	0.4886	-3.07	0.0304	8.26	0.0010
	3	-4.3838	0.4964	-2.98	0.0382	7.77	0.0010
	4	-4.0328	0.5346	-2.55	0.1057	5.79	0.0164
	5	-4.2590	0.5098	-2.43	0.1337	4.95	0.0395
	10	-4.2186	0.5141	-1.95	0.3101	2.91	0.3266
	20	-2.4695	0.7212	-1.46	0.5556	2.48	0.4362
Trend	1	-16.3737	0.1390	-4.30	0.0035	12.37	0.0010
	2	-17.2042	0.1181	-3.86	0.0146	9.35	0.0010
	3	-17.4508	0.1125	-3.81	0.0168	9.03	0.0010
	4	-17.4189	0.1132	-3.47	0.0436	7.21	0.0247
	5	-20.7250	0.0576	-3.65	0.0270	7.59	0.0167
	10	-33.8376	0.0031	-3.92	0.0120	8.04	0.0073
	20	-25.9483	0.0186	-2.93	0.1556	4.52	0.2692

Stationarity analysis on first difference of I44_INTRATE, ΔI44_INTRATE

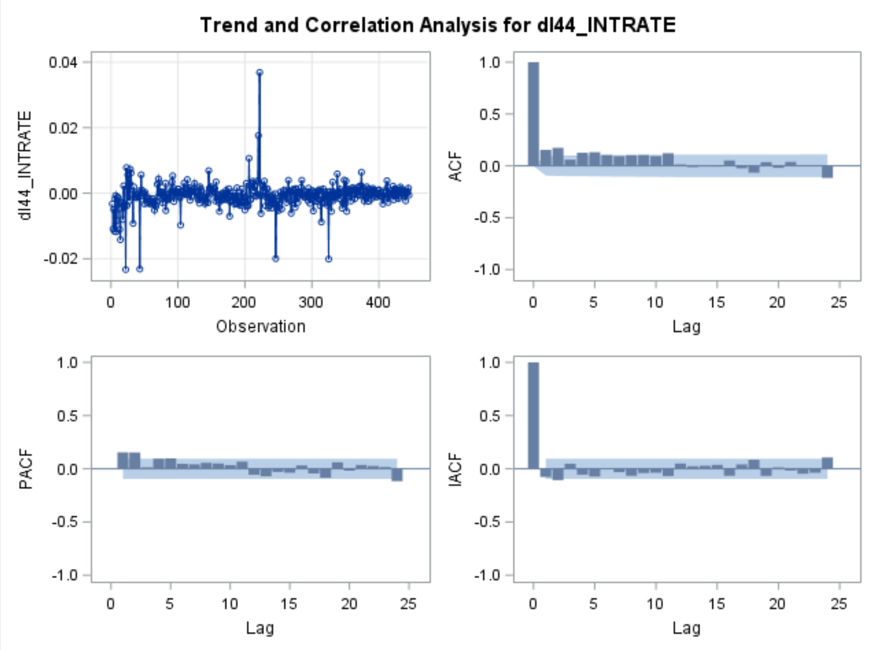
PROC ARIMA: Variable = dI44_INTRATE

The ARIMA Procedure

Name of Variable = dI44_INTRATE	
Mean of Working Series	-0.00072
Standard Deviation	0.003897
Number of Observations	444

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	45.68	6	<.0001	0.154	0.174	0.059	0.127	0.131	0.105
12	70.43	12	<.0001	0.094	0.103	0.105	0.095	0.122	0.014
18	74.04	18	<.0001	-0.012	-0.006	-0.007	0.051	-0.024	-0.066
24	81.93	24	<.0001	0.036	-0.020	0.038	0.005	0.004	-0.117



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-256.523	0.0001	-11.44	<.0001		
	2	-238.280	0.0001	-9.79	<.0001		
	3	-179.286	0.0001	-8.24	<.0001		
	4	-128.392	0.0001	-6.86	<.0001		
	5	-105.981	0.0001	-6.08	<.0001		
	10	-49.3163	<.0001	-4.30	<.0001		
	20	-246.186	0.0001	-5.57	<.0001		
Single Mean	1	-275.399	0.0001	-11.82	<.0001	69.81	0.0010
	2	-265.938	0.0001	-10.18	<.0001	51.84	0.0010
	3	-204.699	0.0001	-8.57	<.0001	36.75	0.0010
	4	-148.829	0.0001	-7.16	<.0001	25.64	0.0010
	5	-125.148	0.0001	-6.38	<.0001	20.35	0.0010
	10	-59.1106	0.0017	-4.48	0.0003	10.09	0.0010
	20	-3893.96	0.0001	-5.83	<.0001	17.28	0.0010
Trend	1	-286.082	0.0001	-12.00	<.0001	72.07	0.0010
	2	-282.108	0.0001	-10.37	<.0001	53.83	0.0010
	3	-218.831	0.0001	-8.71	<.0001	37.97	0.0010
	4	-160.258	0.0001	-7.28	<.0001	26.57	0.0010
	5	-136.352	0.0001	-6.51	<.0001	21.21	0.0010
	10	-63.2906	0.0007	-4.50	0.0017	10.23	0.0010
	20	4580.959	0.9999	-5.74	<.0001	17.05	0.0010

6.3.6 Variable: LIBOR_USD

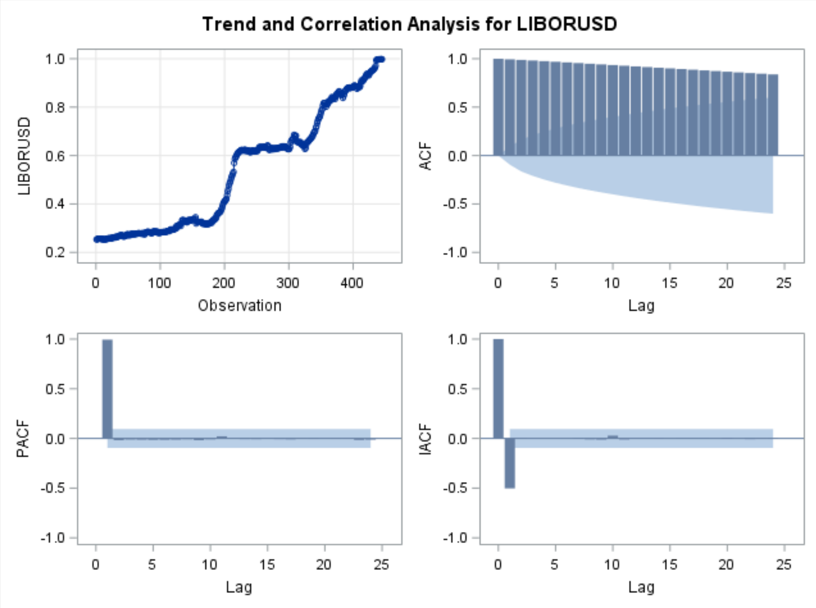
Stationarity analysis on LIBOR_USD

PROC ARIMA: Variable = LIBORUSD

The ARIMA Procedure

Name of Variable = LIBORUSD	
Mean of Working Series	0.53494
Standard Deviation	0.239839
Number of Observations	445

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	2587.00	6	<.0001	0.994	0.988	0.982	0.975	0.969	0.962
12	4998.90	12	<.0001	0.955	0.949	0.942	0.934	0.928	0.921
18	7235.01	18	<.0001	0.914	0.907	0.901	0.894	0.887	0.880
24	9297.75	24	<.0001	0.873	0.866	0.859	0.852	0.845	0.838



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	1.3283	0.9534	5.29	0.9999		
	2	1.3122	0.9518	4.48	0.9999		
	3	1.3008	0.9507	3.89	0.9999		
	4	1.2824	0.9489	3.31	0.9998		
	5	1.2709	0.9477	3.05	0.9995		
	10	1.2093	0.9409	1.95	0.9881		
	20	1.1942	0.9392	2.10	0.9918		
Single Mean	1	0.9955	0.9888	1.70	0.9997	14.19	0.0010
	2	0.9633	0.9882	1.45	0.9992	10.18	0.0010
	3	0.8882	0.9868	1.19	0.9981	7.73	0.0010
	4	0.7923	0.9848	0.93	0.9959	5.69	0.0186
	5	0.7348	0.9835	0.81	0.9942	4.88	0.0416
	10	0.2387	0.9679	0.18	0.9713	2.26	0.4923
	20	0.3883	0.9735	0.33	0.9798	2.52	0.4244
Trend	1	-3.9462	0.8891	-1.74	0.7315	4.00	0.3737
	2	-4.8608	0.8297	-1.90	0.6557	3.82	0.4110
	3	-5.6361	0.7717	-1.96	0.6192	3.48	0.4781
	4	-6.8879	0.6711	-2.11	0.5415	3.39	0.4972
	5	-7.6364	0.6104	-2.18	0.4985	3.40	0.4953
	10	-14.6514	0.1930	-2.71	0.2347	4.07	0.3600
	20	-15.4784	0.1650	-2.62	0.2721	3.92	0.3895

Stationarity analysis on first difference of LIBOR_USD, ΔLIBOR_USD

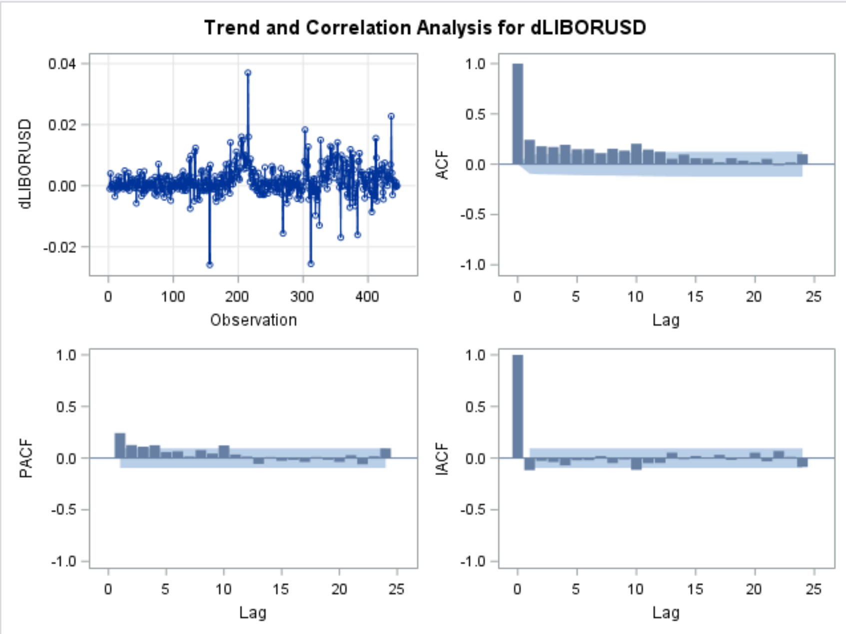
PROC ARIMA: Variable = dLIBORUSD

The ARIMA Procedure

Name of Variable = dLIBORUSD	
Mean of Working Series	0.001676
Standard Deviation	0.005209
Number of Observations	444

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	90.53	6	<.0001	0.243	0.178	0.171	0.193	0.149	0.150
12	150.61	12	<.0001	0.109	0.154	0.135	0.204	0.146	0.124
18	160.96	18	<.0001	0.054	0.096	0.059	0.055	0.019	0.059
24	167.76	24	<.0001	0.035	0.019	0.052	-0.011	0.018	0.098



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-213.344	0.0001	-10.31	<.0001		
	2	-149.262	0.0001	-7.96	<.0001		
	3	-100.546	0.0001	-6.37	<.0001		
	4	-81.1616	<.0001	-5.61	<.0001		
	5	-64.4155	<.0001	-4.95	<.0001		
	9	-26.7714	0.0001	-3.23	0.0013		
Single Mean	1	-259.248	0.0001	-11.34	<.0001	64.34	0.0010
	2	-195.804	0.0001	-8.91	<.0001	39.67	0.0010
	3	-138.311	0.0001	-7.21	<.0001	25.99	0.0010
	4	-116.748	0.0001	-6.41	<.0001	20.56	0.0010
	5	-95.8826	0.0017	-5.73	<.0001	16.41	0.0010
	9	-42.7180	0.0017	-3.88	0.0025	7.51	0.0010
Trend	1	-269.915	0.0001	-11.56	<.0001	66.79	0.0010
	2	-207.473	0.0001	-9.10	<.0001	41.40	0.0010
	3	-148.280	0.0001	-7.38	<.0001	27.23	0.0010
	4	-126.648	0.0001	-6.57	<.0001	21.61	0.0010
	5	-104.677	0.0001	-5.87	<.0001	17.25	0.0010
	9	-46.9825	0.0007	-3.97	0.0103	7.91	0.0100

6.3.7 Variable: NIBOR

Stationarity analysis on NIBOR

PROC ARIMA: Variable = NIBOR

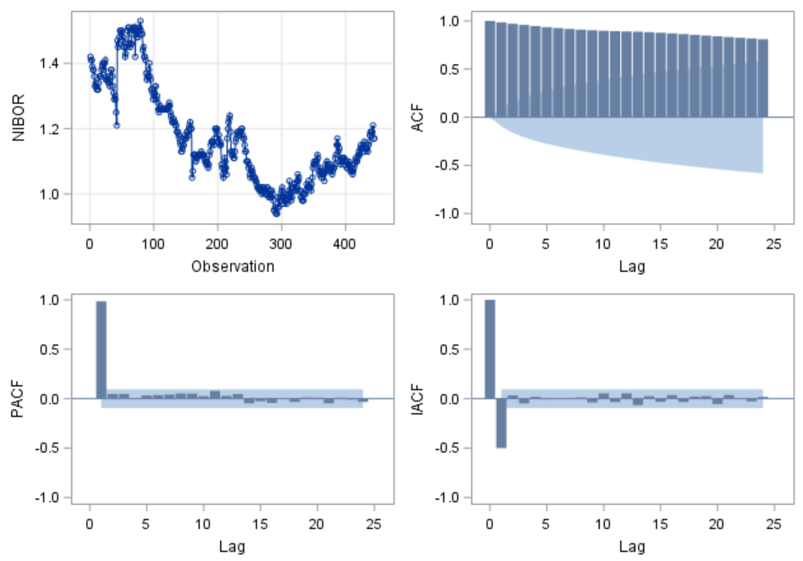
The ARIMA Procedure

Name of Variable = NIBOR	
Mean of Working Series	1.173865
Standard Deviation	0.148975
Number of Observations	445

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	2460.18	6	<.0001	0.985	0.971	0.959	0.947	0.936	0.926
12	4690.22	12	<.0001	0.917	0.910	0.903	0.898	0.894	0.891
18	6808.53	18	<.0001	0.888	0.883	0.878	0.871	0.864	0.855
24	8745.79	24	<.0001	0.848	0.841	0.833	0.825	0.818	0.810

Trend and Correlation Analysis for NIBOR



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-0.3175	0.6105	-0.76	0.3861		
	1	-0.2987	0.6147	-0.76	0.3875		
	2	-0.2872	0.6173	-0.78	0.3783		
	3	-0.2709	0.6211	-0.73	0.4029		
	4	-0.2572	0.6242	-0.71	0.4079		
	5	-0.2504	0.6257	-0.73	0.4012		
Single Mean	0	-6.7944	0.2874	-2.07	0.2579	2.27	0.4907
	1	-6.1723	0.3324	-1.97	0.2995	2.08	0.5393
	2	-5.6167	0.3778	-1.90	0.3308	1.96	0.5690
	3	-5.6092	0.3784	-1.86	0.3526	1.85	0.5980
	4	-5.2482	0.4106	-1.79	0.3852	1.73	0.6295
	5	-4.8888	0.4448	-1.74	0.4098	1.65	0.6489
Trend	0	-11.1538	0.3591	-2.19	0.4943	2.76	0.6231
	1	-9.9318	0.4381	-2.02	0.5877	2.43	0.6904
	2	-8.5688	0.5372	-1.83	0.6884	2.13	0.7506
	3	-9.0560	0.5005	-1.87	0.6701	2.12	0.7525
	4	-8.3817	0.5516	-1.77	0.7206	1.94	0.7897
	5	-7.4672	0.6240	-1.63	0.7794	1.75	0.8267

Stationarity analysis on first difference of NIBOR, ΔNIBOR

PROC ARIMA: Variable = dNIBOR

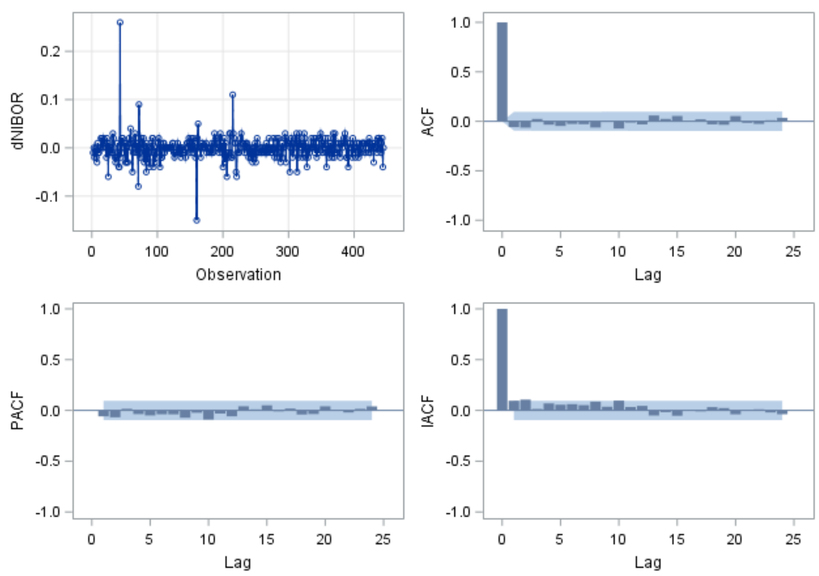
The ARIMA Procedure

Name of Variable = dNIBOR	
Mean of Working Series	-0.00056
Standard Deviation	0.023325
Number of Observations	444

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	5.45	6	0.4879	-0.059	-0.064	0.024	-0.034	-0.047	-0.026
12	10.58	12	0.5655	-0.029	-0.063	-0.006	-0.073	-0.012	-0.031
18	14.38	18	0.7037	0.059	0.024	0.054	0.000	0.020	-0.030
24	17.33	24	0.8344	-0.035	0.053	-0.015	-0.026	0.010	0.035

Trend and Correlation Analysis for dNIBOR



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-468.660	0.0001	-22.28	<.0001		
	1	-535.127	0.0001	-16.29	<.0001		
	2	-507.366	0.0001	-12.65	<.0001		
	3	-596.126	0.0001	-11.21	<.0001		
	4	-831.253	0.0001	-10.35	<.0001		
	5	-1297.12	0.0001	-9.64	<.0001		
Single Mean	0	-468.923	0.0001	-22.27	<.0001	248.00	0.0010
	1	-536.027	0.0001	-16.29	<.0001	132.67	0.0010
	2	-509.079	0.0001	-12.64	<.0001	79.94	0.0010
	3	-599.888	0.0001	-11.21	<.0001	62.83	0.0010
	4	-841.801	0.0001	-10.35	<.0001	53.61	0.0010
	5	-1330.40	0.0001	-9.64	<.0001	46.50	0.0010
Trend	0	-469.673	0.0001	-22.28	<.0001	248.25	0.0010
	1	-539.322	0.0001	-16.31	<.0001	133.09	0.0010
	2	-515.240	0.0001	-12.67	<.0001	80.26	0.0010
	3	-613.240	0.0001	-11.24	<.0001	63.17	0.0010
	4	-880.952	0.0001	-10.39	<.0001	54.01	0.0010
	5	-1464.40	0.0001	-9.68	<.0001	46.88	0.0010

6.4 Sample 3.1

6.4.1 Autocorrelation analysis

Columns market by stars in correspondence with lag 1-10 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market **dark** green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Cells market with **light** green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis - Breusch-Godfrey test Sample 3.1											
Variable	0 lag	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag
logI44		***	***	***	***	insig	insig	insig	insig	insig	insig
logUSD	*	insig	**	*	*	insig	insig	***	insig	insig	insig
logBrent	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
I44_intrate		***	***	***	***	***	**	**	**	***	*
LIBORUSD		***	***	**	***	***	***	***	***	***	***
NIBOR		**	***	***	***	***	***	***	***	**	*
ΔlogI44		***	***	***	insig	insig	insig	insig	insig	insig	insig
ΔlogUSD		**	*	*	insig	insig	***	insig	insig	insig	insig
ΔlogBrent	insig	insig	insig	**	**	***	*	*	***	***	*
ΔI44_INTRATE		***	***	***	***	**	**	**	***	*	*
ΔLIBORUSD		***	***	***	***	***	***	***	***	***	*
ΔNIBOR		***	***	***	***	***	***	***	***	*	*

6.4.2 Variable: Brent

Stationarity analysis on logBrent

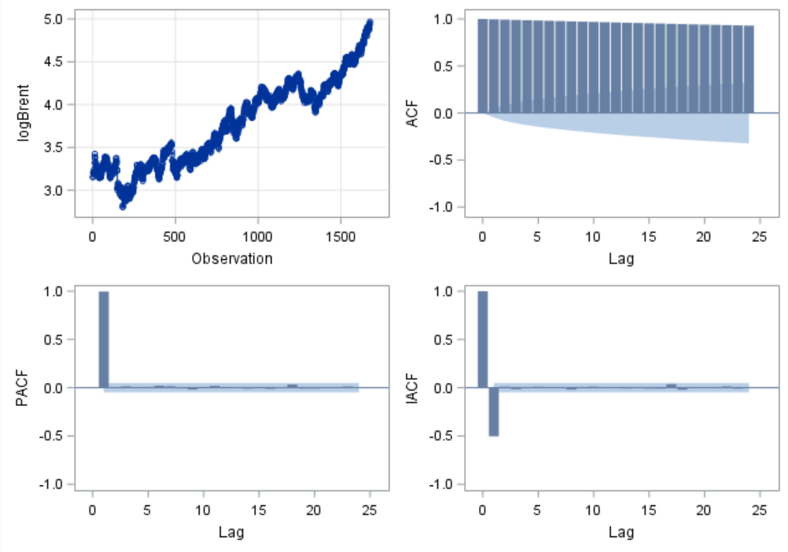
The ARIMA Procedure

Name of Variable = logBrent	
Mean of Working Series	3.762416
Standard Deviation	0.495882
Number of Observations	1676

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9859.88	6	<.0001	0.997	0.993	0.990	0.987	0.984	0.981
12	9999.99	12	<.0001	0.978	0.975	0.972	0.969	0.966	0.963
18	9999.99	18	<.0001	0.960	0.957	0.955	0.952	0.949	0.946
24	9999.99	24	<.0001	0.943	0.940	0.938	0.935	0.932	0.929

Trend and Correlation Analysis for logBrent



Augmented Dickey-Fuller Unit Root Tests

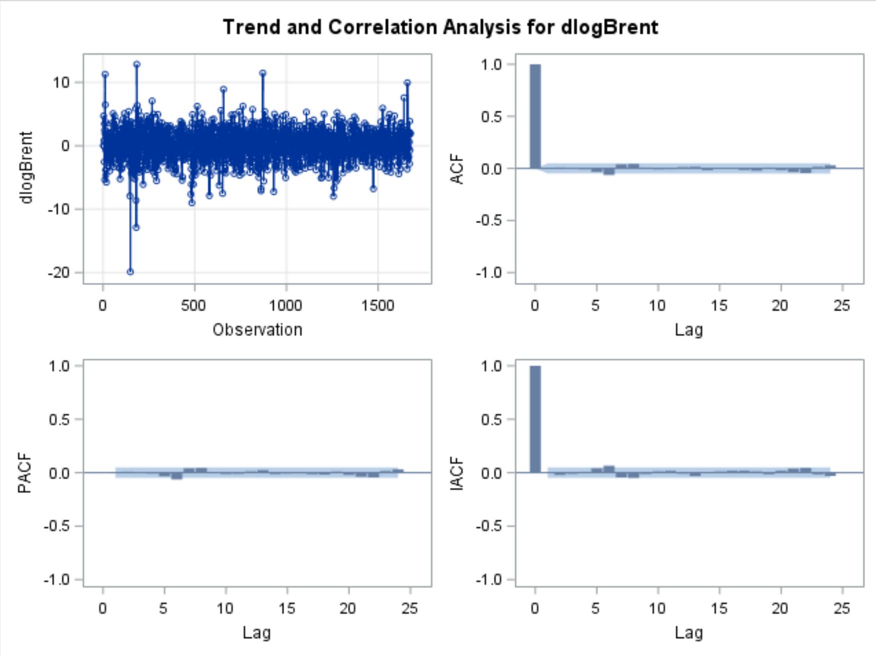
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.4797	0.8022	1.88	0.9861		
	1	0.4791	0.8020	1.86	0.9855		
	2	0.4680	0.7992	1.80	0.9833		
	3	0.4663	0.7987	1.80	0.9830		
	4	0.4670	0.7989	1.81	0.9836		
	5	0.4739	0.8007	1.90	0.9866		
Single Mean	0	0.3089	0.9709	0.16	0.9699	1.77	0.6168
	1	0.2824	0.9699	0.14	0.9689	1.74	0.6248
	2	0.3650	0.9730	0.18	0.9716	1.63	0.6540
	3	0.3842	0.9736	0.19	0.9722	1.61	0.6577
	4	0.4081	0.9744	0.21	0.9731	1.64	0.6508
	5	0.4549	0.9760	0.24	0.9749	1.80	0.6099
Trend	0	-18.4105	0.0958	-2.86	0.1767	4.66	0.2371
	1	-18.9402	0.0861	-2.89	0.1654	4.75	0.2192
	2	-20.0508	0.0688	-3.01	0.1309	5.17	0.1341
	3	-20.3911	0.0642	-3.03	0.1251	5.25	0.1179
	4	-20.2922	0.0655	-3.01	0.1308	5.19	0.1298
	5	-18.8223	0.0882	-2.86	0.1766	4.74	0.2214

Stationarity analysis on first difference of logBrent, ΔlogBrent

The ARIMA Procedure

Name of Variable = dlogBrent	
Mean of Working Series	0.108385
Standard Deviation	2.363907
Number of Observations	1675

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	8.98	6	0.1745	0.007	0.009	-0.000	-0.008	-0.034	-0.063
12	15.23	12	0.2290	0.039	0.043	0.009	-0.009	-0.007	0.013
18	17.34	18	0.5000	0.016	-0.017	-0.004	-0.002	-0.015	-0.022
24	25.22	24	0.3936	0.009	-0.016	-0.035	-0.044	0.015	0.030



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1621.50	0.0001	-28.48	<.0001		
	2	-1613.49	0.0001	-23.32	<.0001		
	3	-1651.70	0.0001	-20.36	<.0001		
	4	-1938.63	0.0001	-18.76	<.0001		
	5	-3164.93	0.0001	-18.13	<.0001		
	10	-1737.47	0.0001	-12.49	<.0001		
	20	-32866.2	0.0001	-9.25	<.0001		
Single Mean	1	-1631.15	0.0001	-28.55	<.0001	407.60	0.0010
	2	-1632.32	0.0001	-23.40	<.0001	273.86	0.0010
	3	-1684.04	0.0001	-20.45	<.0001	209.08	0.0010
	4	-2003.10	0.0001	-18.87	<.0001	177.95	0.0010
	5	-3388.63	0.0001	-18.25	<.0001	166.51	0.0010
	10	-1974.65	0.0001	-12.61	<.0001	79.56	0.0010
	20	4928.442	0.9999	-9.44	<.0001	44.60	0.0010
Trend	1	-1634.56	0.0001	-28.58	<.0001	408.32	0.0010
	2	-1639.25	0.0001	-23.43	<.0001	274.58	0.0010
	3	-1696.11	0.0001	-20.48	<.0001	209.80	0.0010
	4	-2025.99	0.0001	-18.90	<.0001	178.64	0.0010
	5	-3477.95	0.0001	-18.30	<.0001	167.38	0.0010
	10	-2123.54	0.0001	-12.70	<.0001	80.79	0.0010
	20	3277.831	0.9999	-9.54	<.0001	45.52	0.0010

6.4.3 Variable: I44

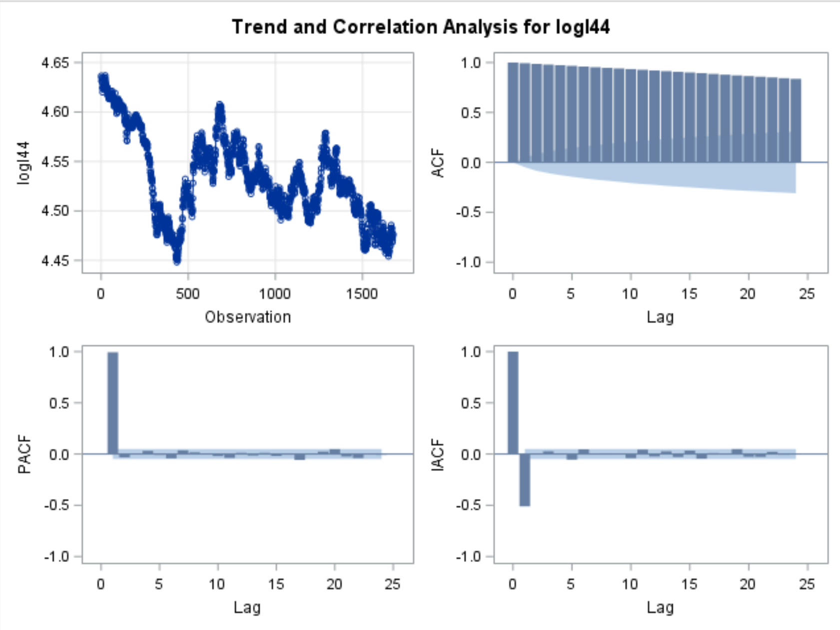
Stationarity analysis on logI44

The ARIMA Procedure

Name of Variable = logI44	
Mean of Working Series	4.533207
Standard Deviation	0.042377
Number of Observations	1676

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9621.22	6	<.0001	0.993	0.986	0.980	0.973	0.967	0.960
12	9999.99	12	<.0001	0.953	0.947	0.941	0.934	0.927	0.921
18	9999.99	18	<.0001	0.914	0.907	0.900	0.893	0.886	0.878
24	9999.99	24	<.0001	0.871	0.865	0.858	0.851	0.843	0.836



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.0358	0.6749	-0.96	0.3000		
	2	-0.0351	0.6750	-0.94	0.3078		
	3	-0.0350	0.6751	-1.00	0.2846		
	4	-0.0356	0.6749	-1.02	0.2772		
	5	-0.0345	0.6752	-0.91	0.3207		
Single Mean	1	-9.9387	0.1370	-2.49	0.1186	3.54	0.1618
	2	-9.8017	0.1416	-2.45	0.1291	3.42	0.1924
	3	-8.9594	0.1732	-2.36	0.1532	3.27	0.2324
	4	-9.0730	0.1685	-2.39	0.1434	3.37	0.2065
	5	-10.0552	0.1332	-2.45	0.1291	3.39	0.1994
Trend	1	-13.2583	0.2533	-2.72	0.2291	3.80	0.4120
	2	-13.1664	0.2575	-2.69	0.2412	3.71	0.4309
	3	-11.9247	0.3192	-2.57	0.2948	3.40	0.4932
	4	-12.0047	0.3149	-2.59	0.2858	3.46	0.4802
	5	-13.6353	0.2369	-2.71	0.2341	3.74	0.4237

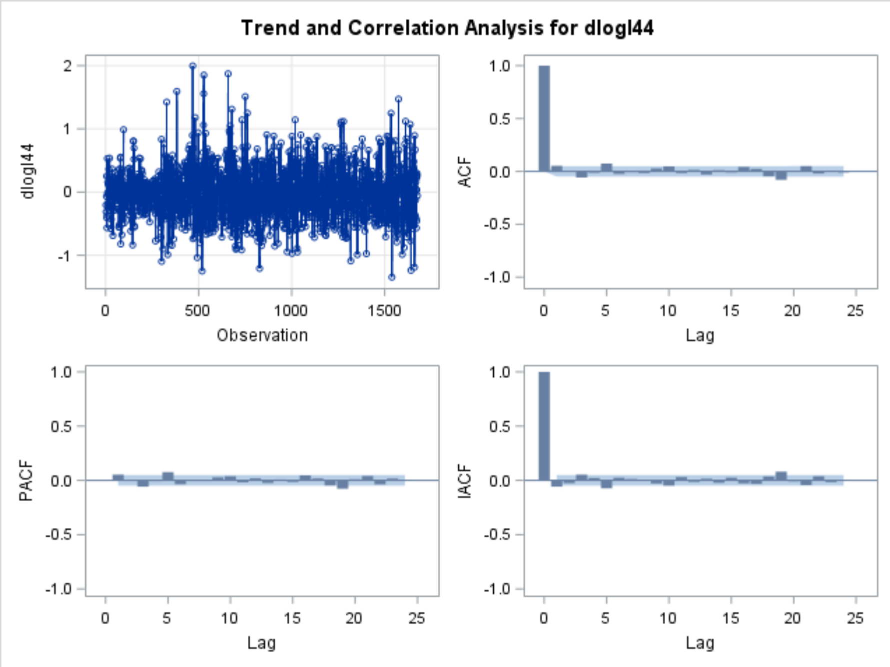
Stationarity analysis on first difference of logI44, ΔlogI44

The ARIMA Procedure

Name of Variable = dlogI44	
Mean of Working Series	-0.00959
Standard Deviation	0.390717
Number of Observations	1675

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	20.87	6	0.0019	0.053	0.001	-0.058	-0.012	0.074	-0.023
12	27.16	12	0.0073	-0.007	-0.015	0.028	0.047	-0.015	0.014
18	36.56	18	0.0060	-0.029	0.012	-0.009	0.042	0.024	-0.047
24	52.37	24	0.0007	-0.080	-0.004	0.050	-0.020	0.006	-0.009



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1586.11	0.0001	-28.15	<.0001		
	2	-1887.54	0.0001	-24.54	<.0001		
	3	-1930.62	0.0001	-21.13	<.0001		
	4	-1329.43	0.0001	-17.38	<.0001		
	5	-1614.42	0.0001	-16.58	<.0001		
Single Mean	1	-1588.71	0.0001	-28.17	<.0001	396.68	0.0010
	2	-1894.20	0.0001	-24.56	<.0001	301.62	0.0010
	3	-1942.82	0.0001	-21.16	<.0001	223.78	0.0010
	4	-1339.21	0.0001	-17.40	<.0001	151.40	0.0010
	5	-1632.28	0.0001	-16.60	<.0001	137.77	0.0010
Trend	1	-1589.28	0.0001	-28.16	<.0001	396.58	0.0010
	2	-1895.55	0.0001	-24.56	<.0001	301.58	0.0010
	3	-1945.26	0.0001	-21.16	<.0001	223.79	0.0010
	4	-1340.99	0.0001	-17.40	<.0001	151.40	0.0010
	5	-1635.23	0.0001	-16.60	<.0001	137.76	0.0010

6.4.4 Variable: USD

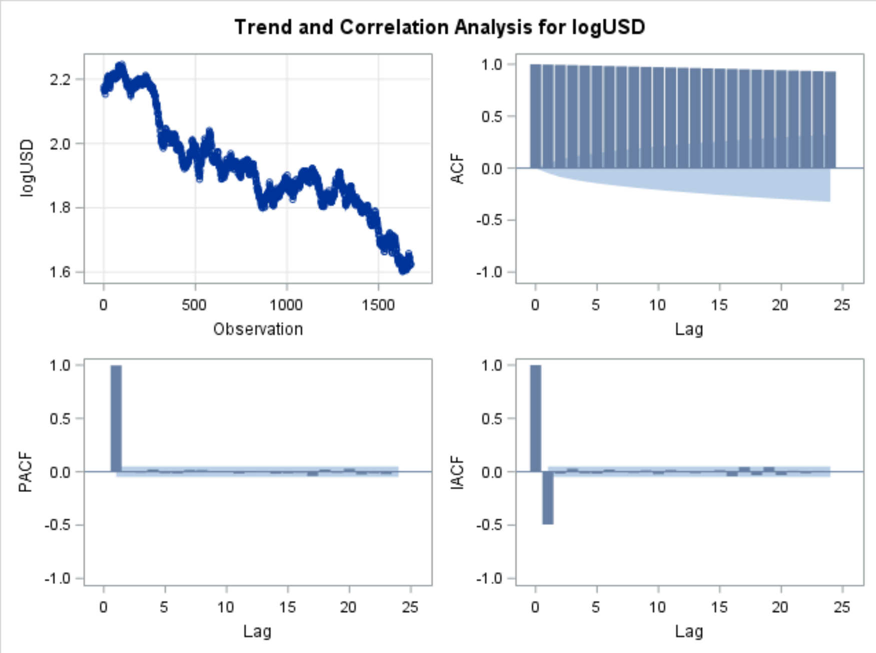
Stationarity analysis on logUSD

The ARIMA Procedure

Name of Variable = logUSD	
Mean of Working Series	1.923026
Standard Deviation	0.154717
Number of Observations	1676

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9887.40	6	<.0001	0.997	0.994	0.991	0.989	0.986	0.983
12	9999.99	12	<.0001	0.980	0.977	0.975	0.972	0.969	0.966
18	9999.99	18	<.0001	0.964	0.961	0.958	0.955	0.952	0.949
24	9999.99	24	<.0001	0.946	0.943	0.940	0.937	0.933	0.930



Augmented Dickey-Fuller Unit Root Tests

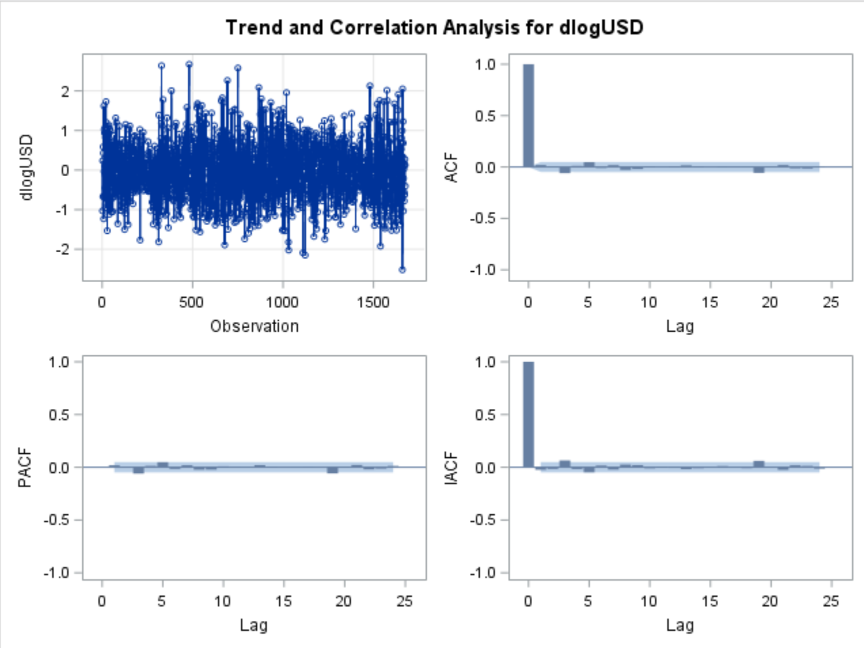
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.2877	0.6176	-1.93	0.0512		
	2	-0.2893	0.6172	-1.93	0.0514		
	3	-0.2845	0.6183	-2.01	0.0424		
	4	-0.2878	0.6175	-2.00	0.0432		
	5	-0.2915	0.6167	-1.93	0.0512		
Single Mean	1	-1.0716	0.8796	-0.58	0.8734	1.95	0.5696
	2	-1.1229	0.8747	-0.60	0.8684	1.96	0.5682
	3	-0.8653	0.8984	-0.49	0.8907	2.08	0.5373
	4	-0.9684	0.8892	-0.54	0.8810	2.08	0.5370
	5	-1.1804	0.8691	-0.63	0.8625	1.98	0.5641
Trend	1	-12.9945	0.2654	-2.51	0.3249	3.20	0.5332
	2	-13.2413	0.2541	-2.52	0.3162	3.24	0.5255
	3	-11.7668	0.3278	-2.37	0.3945	2.89	0.5971
	4	-12.1945	0.3049	-2.41	0.3749	2.96	0.5820
	5	-13.5976	0.2385	-2.54	0.3089	3.27	0.5194

Stationarity analysis on first difference of logUSD, $\Delta logUSD$

The ARIMA Procedure

Name of Variable = dlogUSD	
Mean of Working Series	-0.03307
Standard Deviation	0.687755
Number of Observations	1675

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	10.81	6	0.0945	0.019	0.006	-0.059	0.011	0.048	-0.010
12	13.50	12	0.3338	0.018	-0.028	-0.020	0.007	-0.001	0.006
18	14.08	18	0.7239	0.016	0.006	-0.000	-0.005	-0.003	0.002
24	20.91	24	0.6438	-0.057	0.005	0.019	-0.013	-0.015	0.004



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1612.10	0.0001	-28.38	<.0001		
	2	-1923.47	0.0001	-24.70	<.0001		
	3	-1793.78	0.0001	-20.78	<.0001		
	4	-1401.14	0.0001	-17.59	<.0001		
	5	-1510.77	0.0001	-16.37	<.0001		
Single Mean	1	-1622.70	0.0001	-28.46	<.0001	405.05	0.0010
	2	-1950.59	0.0001	-24.80	<.0001	307.53	0.0010
	3	-1836.49	0.0001	-20.89	<.0001	218.13	0.0010
	4	-1444.74	0.0001	-17.70	<.0001	156.69	0.0010
	5	-1578.45	0.0001	-16.49	<.0001	135.91	0.0010
Trend	1	-1622.97	0.0001	-28.46	<.0001	404.89	0.0010
	2	-1951.44	0.0001	-24.80	<.0001	307.45	0.0010
	3	-1837.78	0.0001	-20.88	<.0001	218.07	0.0010
	4	-1445.94	0.0001	-17.70	<.0001	156.65	0.0010
	5	-1580.53	0.0001	-16.49	<.0001	135.90	0.0010

6.4.5 Variable: I44 interest rate

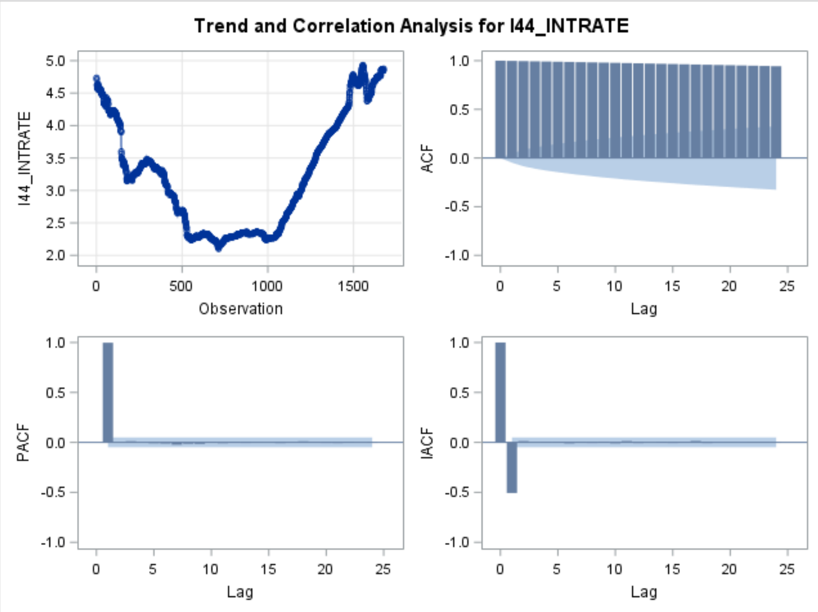
Stationarity analysis on I44_INTRATE

The ARIMA Procedure

Name of Variable = I44_INTRATE	
Mean of Working Series	3.220811
Standard Deviation	0.865259
Number of Observations	1676

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9938.23	6	<.0001	0.998	0.996	0.994	0.991	0.989	0.987
12	9999.99	12	<.0001	0.985	0.983	0.980	0.978	0.975	0.973
18	9999.99	18	<.0001	0.970	0.968	0.966	0.963	0.961	0.958
24	9999.99	24	<.0001	0.956	0.953	0.951	0.948	0.946	0.943



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	0.0514	0.6950	0.22	0.7502		
	2	0.0988	0.7062	0.37	0.7904		
	3	0.1156	0.7101	0.40	0.7989		
	4	0.1182	0.7108	0.37	0.7918		
	5	0.0963	0.7056	0.30	0.7714		
	10	0.0546	0.6957	0.12	0.7223		
	20	0.0367	0.6916	0.08	0.7074		
Single Mean	1	-0.0234	0.9564	-0.03	0.9551	0.03	0.9900
	2	0.1036	0.9625	0.10	0.9658	0.07	0.9900
	3	0.1212	0.9632	0.11	0.9664	0.08	0.9900
	4	0.0422	0.9596	0.03	0.9605	0.07	0.9900
	5	-0.0794	0.9535	-0.06	0.9515	0.05	0.9900
	10	-0.7111	0.9113	-0.42	0.9040	0.12	0.9900
	20	-0.9969	0.8866	-0.53	0.8835	0.16	0.9900
Trend	1	-1.7720	0.9756	-2.02	0.5908	28.37	0.0010
	2	-1.5799	0.9795	-1.60	0.7923	20.14	0.0010
	3	-1.5345	0.9803	-1.48	0.8367	17.32	0.0010
	4	-1.5947	0.9792	-1.42	0.8548	14.49	0.0010
	5	-1.7266	0.9766	-1.53	0.8204	14.64	0.0010
	10	-2.2780	0.9628	-1.60	0.7940	9.40	0.0010
	20	-2.4551	0.9573	-1.72	0.7431	9.11	0.0010

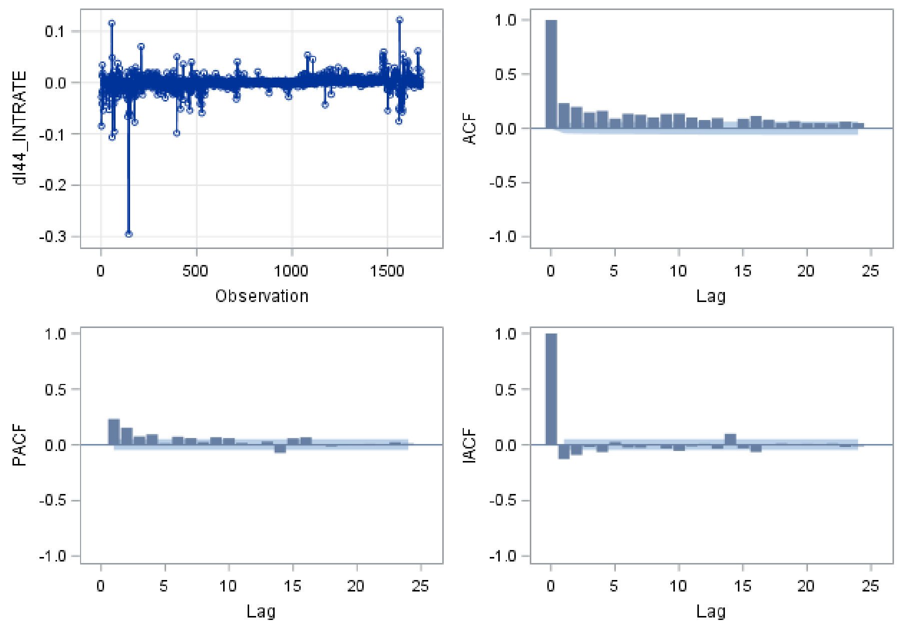
Stationarity analysis on first difference of I44_INTRATE, ΔI44_INTRATE

The ARIMA Procedure

Name of Variable = dl44_INTRATE	
Mean of Working Series	0.000083
Standard Deviation	0.01509
Number of Observations	1675

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	278.14	6	<.0001	0.231	0.199	0.146	0.159	0.091	0.134
12	407.60	12	<.0001	0.124	0.102	0.131	0.134	0.101	0.073
18	472.90	18	<.0001	0.096	0.001	0.090	0.114	0.078	0.047
24	500.41	24	<.0001	0.065	0.046	0.047	0.044	0.060	0.047

Trend and Correlation Analysis for dl44_INTRATE



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-948.816	0.0001	-22.05	<.0001		
	2	-784.404	0.0001	-18.09	<.0001		
	3	-599.158	0.0001	-15.03	<.0001		
	4	-563.946	0.0001	-13.75	<.0001		
	5	-430.442	0.0001	-11.92	<.0001		
	10	-219.380	0.0001	-8.35	<.0001		
	20	-157.937	0.0001	-6.39	<.0001		
Single Mean	1	-948.935	0.0001	-22.05	<.0001	243.03	0.0010
	2	-784.594	0.0001	-18.09	<.0001	163.58	0.0010
	3	-599.383	0.0001	-15.03	<.0001	113.03	0.0010
	4	-564.195	0.0001	-13.75	<.0001	94.51	0.0010
	5	-430.629	0.0001	-11.92	<.0001	71.05	0.0010
	10	-219.627	0.0001	-8.35	<.0001	34.86	0.0010
	20	-158.130	0.0001	-6.39	<.0001	20.42	0.0010
Trend	1	-1046.96	0.0001	-23.12	<.0001	267.18	0.0010
	2	-907.500	0.0001	-19.12	<.0001	182.85	0.0010
	3	-720.134	0.0001	-16.01	<.0001	128.24	0.0010
	4	-714.081	0.0001	-14.79	<.0001	109.44	0.0010
	5	-562.180	0.0001	-12.96	<.0001	84.04	0.0010
	10	-317.136	0.0001	-9.25	<.0001	42.75	0.0010
	20	-329.341	0.0001	-7.51	<.0001	28.20	0.0010

6.4.6 Variable: LIBOR_USD

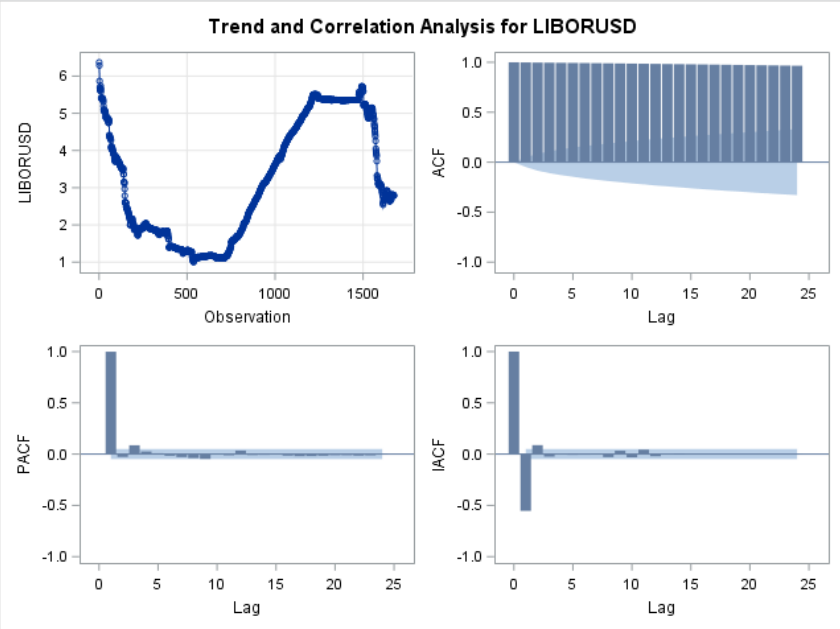
Stationarity analysis on LIBOR_USD

The ARIMA Procedure

Name of Variable = LIBORUSD	
Mean of Working Series	3.195176
Standard Deviation	1.611189
Number of Observations	1676

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9998.66	6	<.0001	0.999	0.997	0.996	0.995	0.994	0.993
12	9999.99	12	<.0001	0.991	0.990	0.989	0.987	0.986	0.984
18	9999.99	18	<.0001	0.983	0.981	0.980	0.979	0.977	0.975
24	9999.99	24	<.0001	0.974	0.972	0.971	0.969	0.967	0.965



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1.3505	0.4169	-2.62	0.0087		
	2	-1.0507	0.4644	-2.06	0.0376		
	3	-1.0196	0.4696	-1.97	0.0465		
	4	-1.0078	0.4717	-1.80	0.0688		
	5	-1.0418	0.4659	-1.72	0.0820		
	10	-1.2083	0.4387	-1.33	0.1719		
	20	-1.2730	0.4286	-1.28	0.1860		
Single Mean	1	-2.4145	0.7288	-2.11	0.2391	3.97	0.0881
	2	-1.7250	0.8109	-1.53	0.5185	2.35	0.4669
	3	-1.6705	0.8170	-1.46	0.5537	2.15	0.5192
	4	-1.7128	0.8122	-1.38	0.5931	1.82	0.6041
	5	-1.8602	0.7953	-1.39	0.5914	1.70	0.6338
	10	-2.8691	0.6730	-1.42	0.5734	1.30	0.7372
	20	-3.2653	0.6248	-1.47	0.5474	1.32	0.7327
Trend	1	-5.6378	0.7730	-4.22	0.0042	12.07	0.0010
	2	-4.1807	0.8758	-3.16	0.0937	6.85	0.0334
	3	-4.0546	0.8834	-3.02	0.1263	6.25	0.0500
	4	-4.0609	0.8830	-2.80	0.1991	5.22	0.1237
	5	-4.2947	0.8686	-2.74	0.2222	4.88	0.1923
	10	-5.6671	0.7707	-2.42	0.3713	3.35	0.5032
	20	-6.4642	0.7074	-2.50	0.3267	3.51	0.4705

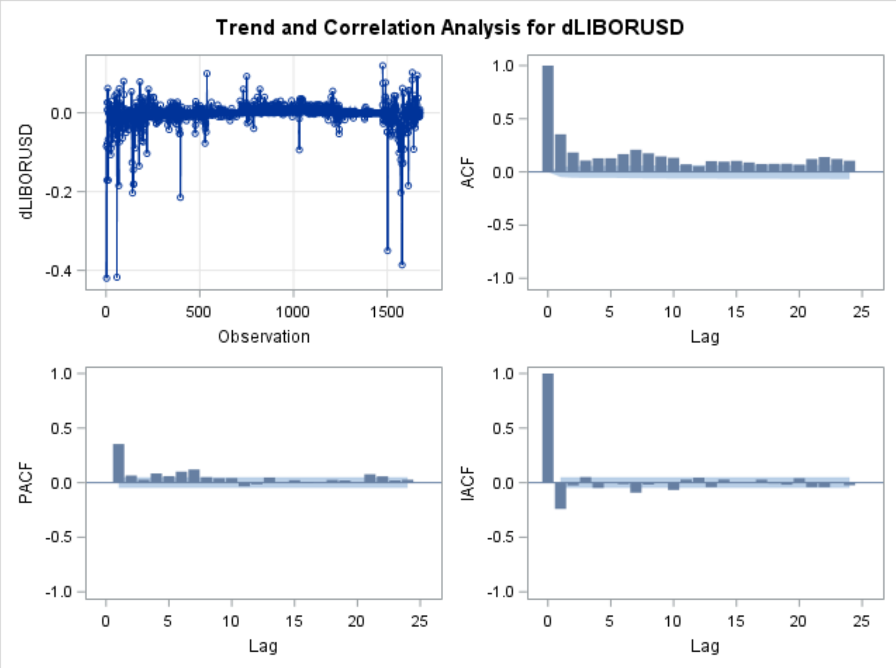
Stationarity analysis on first difference of LIBOR_USD, ΔLIBOR_USD

The ARIMA Procedure

Name of Variable = dLIBORUSD	
Mean of Working Series	-0.00214
Standard Deviation	0.031205
Number of Observations	1675

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	389.45	6	<.0001	0.354	0.183	0.107	0.129	0.129	0.168
12	594.08	12	<.0001	0.209	0.175	0.146	0.133	0.072	0.054
18	678.48	18	<.0001	0.101	0.097	0.104	0.089	0.075	0.076
24	798.99	24	<.0001	0.077	0.068	0.121	0.140	0.122	0.105



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-956.174	0.0001	-23.57	<.0001		
	2	-895.123	0.0001	-20.11	<.0001		
	3	-699.206	0.0001	-16.63	<.0001		
	4	-557.461	0.0001	-14.19	<.0001		
	5	-387.309	0.0001	-11.83	<.0001		
	10	-221.970	0.0001	-8.64	<.0001		
	20	-99.1622	<.0001	-5.67	<.0001		
Single Mean	1	-962.829	0.0001	-23.63	<.0001	279.17	0.0010
	2	-904.356	0.0001	-20.17	<.0001	203.41	0.0010
	3	-708.108	0.0001	-16.68	<.0001	139.12	0.0010
	4	-565.794	0.0001	-14.24	<.0001	101.48	0.0010
	5	-393.343	0.0001	-11.88	<.0001	70.58	0.0010
	10	-225.897	0.0001	-8.67	<.0001	37.64	0.0010
	20	-101.452	0.0001	-5.70	<.0001	16.27	0.0010
Trend	1	-974.113	0.0001	-23.71	<.0001	281.40	0.0010
	2	-919.933	0.0001	-20.26	<.0001	205.31	0.0010
	3	-722.973	0.0001	-16.76	<.0001	140.52	0.0010
	4	-579.782	0.0001	-14.32	<.0001	102.67	0.0010
	5	-403.432	0.0001	-11.95	<.0001	71.48	0.0010
	10	-232.037	0.0001	-8.71	<.0001	37.99	0.0010
	20	-105.132	0.0001	-5.75	<.0001	16.54	0.0010

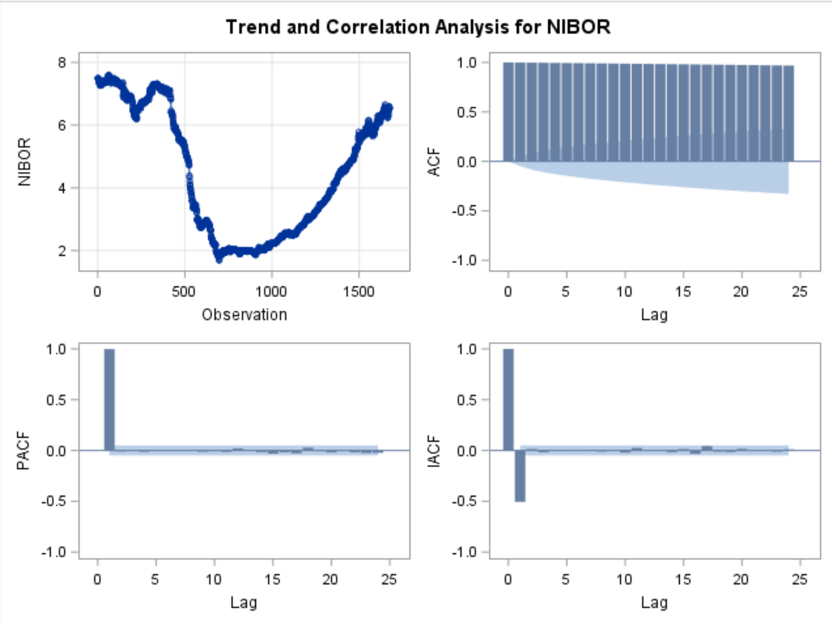
6.4.7 Variable: NIBOR

Stationarity analysis on NIBOR

The ARIMA Procedure

Name of Variable = NIBOR	
Mean of Working Series	4.438932
Standard Deviation	2.011264
Number of Observations	1676

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	9999.99	6	<.0001	0.999	0.998	0.996	0.995	0.994	0.993
12	9999.99	12	<.0001	0.991	0.990	0.989	0.988	0.986	0.985
18	9999.99	18	<.0001	0.984	0.983	0.981	0.980	0.978	0.977
24	9999.99	24	<.0001	0.976	0.974	0.973	0.971	0.970	0.968



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.3472	0.6041	-0.98	0.2931		
	2	-0.3343	0.6070	-0.94	0.3090		
	3	-0.3449	0.6046	-0.92	0.3163		
	4	-0.3230	0.6096	-0.83	0.3586		
	5	-0.3279	0.6084	-0.79	0.3757		
	10	-0.3698	0.5990	-0.69	0.4169		
	20	-0.3980	0.5927	-0.55	0.4798		
Single Mean	1	-0.9832	0.8879	-1.14	0.7007	0.81	0.8644
	2	-0.9529	0.8906	-1.11	0.7150	0.75	0.8782
	3	-1.0009	0.8862	-1.11	0.7151	0.74	0.8808
	4	-0.9715	0.8889	-1.03	0.7445	0.63	0.9137
	5	-1.0197	0.8845	-1.01	0.7498	0.60	0.9233
	10	-1.3229	0.8547	-1.03	0.7453	0.57	0.9312
	20	-1.8328	0.7985	-1.04	0.7413	0.55	0.9387
Trend	1	0.8414	0.9988	0.93	0.9999	14.30	0.0010
	2	0.8715	0.9988	0.98	0.9999	14.36	0.0010
	3	0.8332	0.9988	0.90	0.9999	13.25	0.0010
	4	0.8420	0.9988	0.89	0.9999	11.88	0.0010
	5	0.7959	0.9987	0.80	0.9998	10.53	0.0010
	10	0.5669	0.9982	0.47	0.9992	7.04	0.0282
	20	0.1131	0.9968	0.07	0.9970	3.81	0.4094

Stationarity analysis on first difference of NIBOR, ΔNIBOR

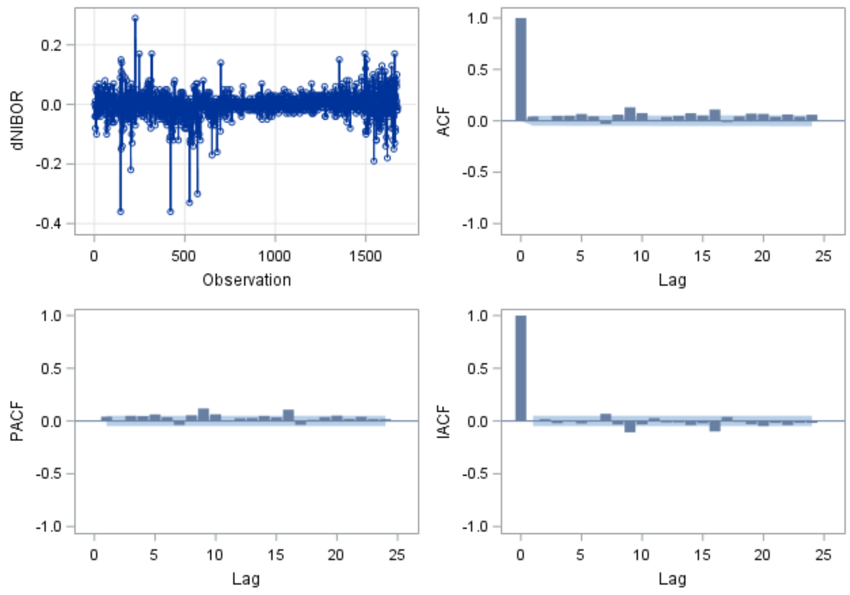
The ARIMA Procedure

Name of Variable = dNIBOR	
Mean of Working Series	-0.00057
Standard Deviation	0.040493
Number of Observations	1675

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	21.65	6	0.0014	0.042	0.002	0.049	0.050	0.066	0.043
12	70.27	12	<.0001	-0.030	0.060	0.131	0.075	0.010	0.038
18	111.83	18	<.0001	0.049	0.074	0.052	0.110	-0.012	0.043
24	145.58	24	<.0001	0.070	0.067	0.040	0.062	0.040	0.059

Trend and Correlation Analysis for dNIBOR



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1601.20	0.0001	-28.28	<.0001		
	2	-1389.36	0.0001	-22.13	<.0001		
	3	-1181.48	0.0001	-18.61	<.0001		
	4	-924.308	0.0001	-15.89	<.0001		
	5	-797.983	0.0001	-14.29	<.0001		
	10	-331.047	0.0001	-9.30	<.0001		
	20	-100.739	0.0001	-5.59	<.0001		
Single Mean	1	-1602.05	0.0001	-28.28	<.0001	399.95	0.0010
	2	-1390.72	0.0001	-22.13	<.0001	244.95	0.0010
	3	-1182.97	0.0001	-18.61	<.0001	173.11	0.0010
	4	-925.741	0.0001	-15.89	<.0001	126.23	0.0010
	5	-799.379	0.0001	-14.29	<.0001	102.14	0.0010
	10	-331.791	0.0001	-9.30	<.0001	43.29	0.0010
	20	-100.946	0.0001	-5.59	<.0001	15.63	0.0010
Trend	1	-1685.36	0.0001	-28.99	<.0001	420.24	0.0010
	2	-1529.79	0.0001	-22.87	<.0001	261.41	0.0010
	3	-1360.56	0.0001	-19.33	<.0001	186.88	0.0010
	4	-1102.15	0.0001	-16.61	<.0001	137.93	0.0010
	5	-986.468	0.0001	-15.01	<.0001	112.69	0.0010
	10	-449.722	0.0001	-10.02	<.0001	50.23	0.0010
	20	-144.383	0.0001	-6.23	<.0001	19.44	0.0010

6.5 Sample 3.2

6.5.1 Autocorrelation analysis

Columns market by stars in correspondence with lag 1-10 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market **dark** green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Cells market with **light** green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis - Breusch Godfrey-test Sample 3.2											
Variable	0 lag	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag
logI44	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
logUSD	insig	*	insig	insig	insig	insig	insig	insig	insig	insig	insig
logBrent	insig	insig	insig	*	**	insig	**	insig	insig	insig	insig
I44_intrate		***	***	***	***	***	***	***	***	***	***
LIBORUSD		***	***	***	***	***	***	***	***	***	***
NIBOR		***	***	***	***	***	***	***	***	***	***
ΔlogI44	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
ΔlogUSD	insig	insig	insig	insig	insig	insig	insig	insig	*	**	*
ΔlogBrent		insig	*	***	insig	**	insig	insig	insig	insig	insig
ΔI44_INTRATE		***	***	***	***	***	***	***	***	***	***
ΔLIBORUSD		***	***	***	***	***	***	***	***	***	***
ΔNIBOR		***	***	***	***	***	***	***	***	***	***

6.5.2 Variable: Brent

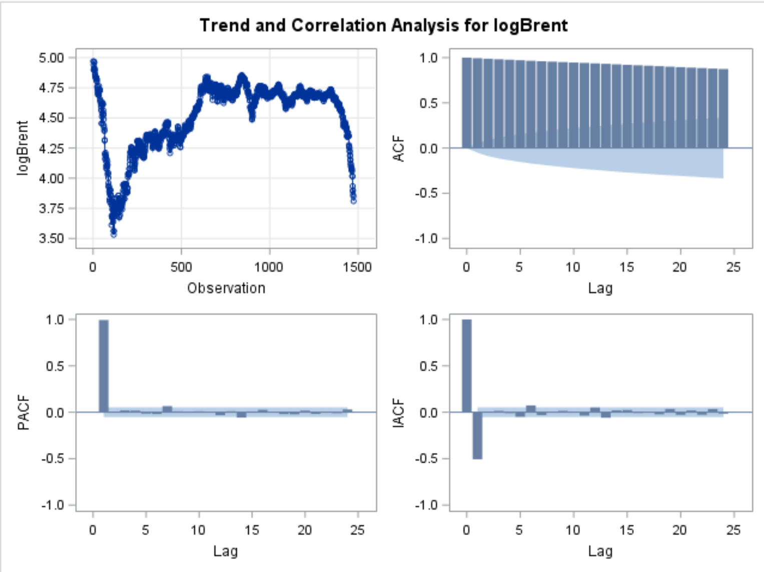
Stationarity analysis on logBrent

PROC ARIMA: Variable = logBRENT

The ARIMA Procedure

Name of Variable = logBrent	
Mean of Working Series	4.507556
Standard Deviation	0.282395
Number of Observations	1474

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	8517.10	6	<.0001	0.994	0.988	0.982	0.977	0.971	0.965
12	9999.99	12	<.0001	0.960	0.955	0.951	0.946	0.941	0.936
18	9999.99	18	<.0001	0.932	0.926	0.921	0.916	0.911	0.906
24	9999.99	24	<.0001	0.900	0.895	0.890	0.884	0.879	0.874



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.2615	0.6235	-1.33	0.1710		
	2	-0.2516	0.6258	-1.29	0.1833		
	3	-0.2513	0.6258	-1.29	0.1829		
	4	-0.2551	0.6250	-1.30	0.1805		
	5	-0.2716	0.6212	-1.33	0.1705		
	6	-0.2648	0.6227	-1.37	0.1579		
Single Mean	1	-3.0701	0.6484	-0.97	0.7656	1.28	0.7436
	2	-2.8027	0.6810	-0.89	0.7918	1.16	0.7745
	3	-2.7900	0.6826	-0.89	0.7931	1.16	0.7749
	4	-2.9530	0.6626	-0.93	0.7801	1.20	0.7637
	5	-3.6384	0.5807	-1.10	0.7193	1.40	0.7121
	6	-3.0991	0.6449	-0.99	0.7594	1.35	0.7241
Trend	1	-3.1046	0.9326	-0.82	0.9628	0.47	0.9900
	2	-2.5280	0.9549	-0.67	0.9745	0.40	0.9900
	3	-2.5115	0.9554	-0.66	0.9749	0.40	0.9900
	4	-2.8226	0.9443	-0.73	0.9700	0.43	0.9900
	5	-4.1292	0.8789	-1.02	0.9395	0.62	0.9900
	6	-3.3544	0.9212	-0.88	0.9571	0.49	0.9900

Stationarity analysis on first difference of logBrent, $\Delta logBrent$

PROC ARIMA: Variable = dlogBRENT

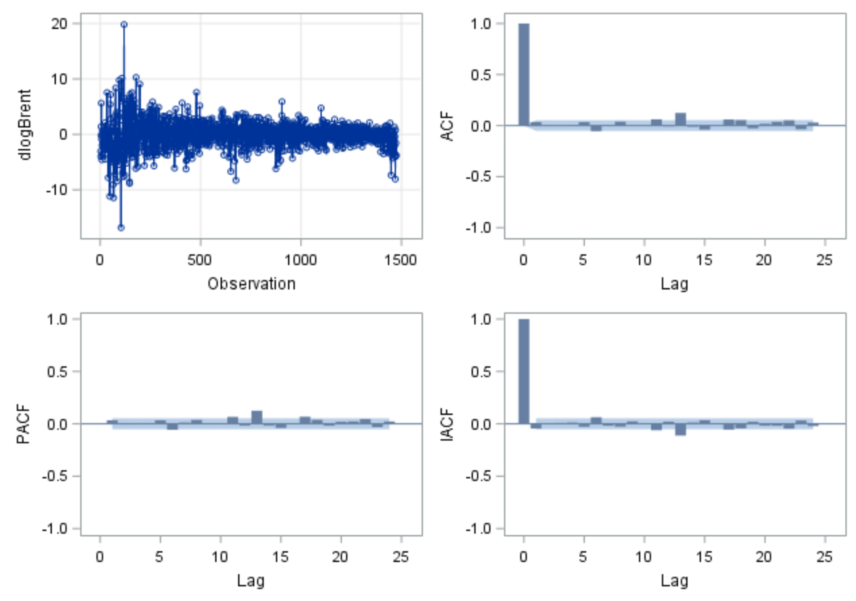
The ARIMA Procedure

Name of Variable = dlogBrent	
Mean of Working Series	-0.07875
Standard Deviation	2.238074
Number of Observations	1473

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	7.94	6	0.2427	0.034	-0.005	-0.003	0.007	0.034	-0.055
12	15.87	12	0.1974	0.008	0.038	-0.002	0.001	0.061	-0.008
18	50.84	18	<.0001	0.124	-0.011	-0.039	0.004	0.060	0.054
24	61.45	24	<.0001	-0.026	0.017	0.037	0.051	-0.036	0.030

Trend and Correlation Analysis for dlogBrent



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1434.70	0.0001	-26.78	<.0001		
	2	-1442.19	0.0001	-21.94	<.0001		
	3	-1392.70	0.0001	-18.83	<.0001		
	4	-1165.63	0.0001	-16.23	<.0001		
	5	-1621.41	0.0001	-15.75	<.0001		
	10	-686.934	0.0001	-10.24	<.0001		
	20	-211.278	0.0001	-6.29	<.0001		
Single Mean	1	-1439.28	0.0001	-26.82	<.0001	359.58	0.0010
	2	-1451.10	0.0001	-21.98	<.0001	241.61	0.0010
	3	-1406.77	0.0001	-18.88	<.0001	178.18	0.0010
	4	-1181.97	0.0001	-16.28	<.0001	132.59	0.0010
	5	-1659.15	0.0001	-15.81	<.0001	124.97	0.0010
	10	-710.071	0.0001	-10.30	<.0001	53.03	0.0010
	20	-219.182	0.0001	-6.35	<.0001	20.20	0.0010
Trend	1	-1439.98	0.0001	-26.82	<.0001	359.61	0.0010
	2	-1452.45	0.0001	-21.99	<.0001	241.69	0.0010
	3	-1408.86	0.0001	-18.88	<.0001	178.26	0.0010
	4	-1183.79	0.0001	-16.29	<.0001	132.61	0.0010
	5	-1662.74	0.0001	-15.81	<.0001	125.01	0.0010
	10	-712.131	0.0001	-10.31	<.0001	53.21	0.0010
	20	-219.382	0.0001	-6.37	<.0001	20.47	0.0010

6.5.3 Variable: I44

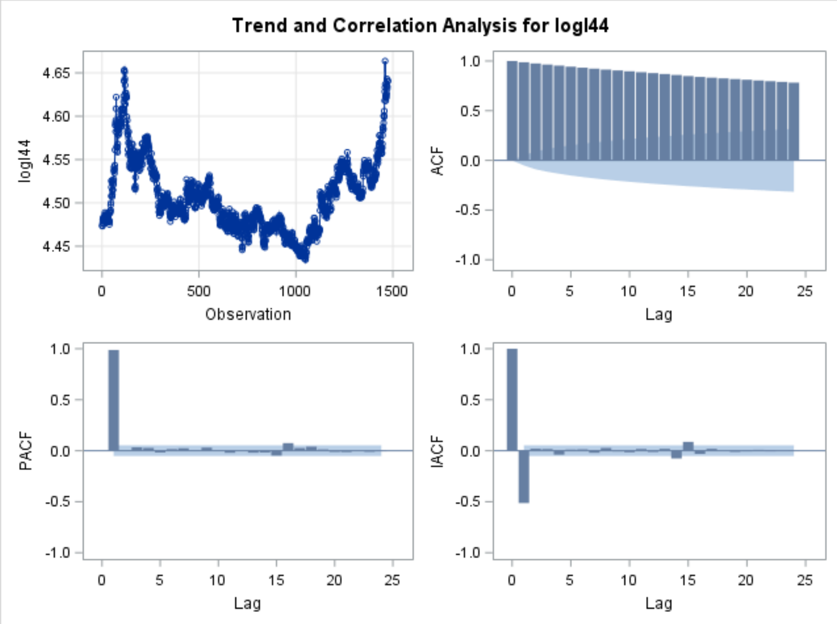
Stationarity analysis on logI44

PROC ARIMA: Variable = logI44

The ARIMA Procedure

Name of Variable = logI44	
Mean of Working Series	4.506573
Standard Deviation	0.041125
Number of Observations	1474

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	8175.20	6	<.0001	0.988	0.975	0.964	0.954	0.943	0.933
12	9999.99	12	<.0001	0.923	0.914	0.905	0.897	0.887	0.878
18	9999.99	18	<.0001	0.869	0.859	0.849	0.840	0.832	0.825
24	9999.99	24	<.0001	0.818	0.812	0.804	0.797	0.790	0.782



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.0364	0.6915	0.79	0.8836		
	1	0.0366	0.6915	0.81	0.8867		
	2	0.0358	0.6914	0.82	0.8884		
	3	0.0350	0.6912	0.83	0.8905		
	4	0.0346	0.6911	0.83	0.8910		
	5	0.0352	0.6912	0.85	0.8945		
Single Mean	0	-7.7272	0.2320	-1.53	0.5188	1.49	0.6878
	1	-7.3867	0.2515	-1.48	0.5460	1.43	0.7049
	2	-6.6095	0.3018	-1.36	0.6058	1.26	0.7470
	3	-5.7881	0.3648	-1.22	0.6665	1.10	0.7882
	4	-5.4521	0.3937	-1.16	0.6920	1.04	0.8061
	5	-5.3490	0.4029	-1.15	0.6997	1.03	0.8072
Trend	0	-7.2733	0.6420	-1.43	0.8531	1.38	0.9027
	1	-6.9123	0.6711	-1.37	0.8696	1.30	0.9167
	2	-6.0810	0.7381	-1.24	0.9019	1.18	0.9402
	3	-5.2029	0.8059	-1.09	0.9290	1.07	0.9576
	4	-4.8230	0.8333	-1.02	0.9395	1.03	0.9626
	5	-4.7137	0.8409	-1.00	0.9422	1.00	0.9671

Stationarity analysis on first difference of logI44, ΔlogI44

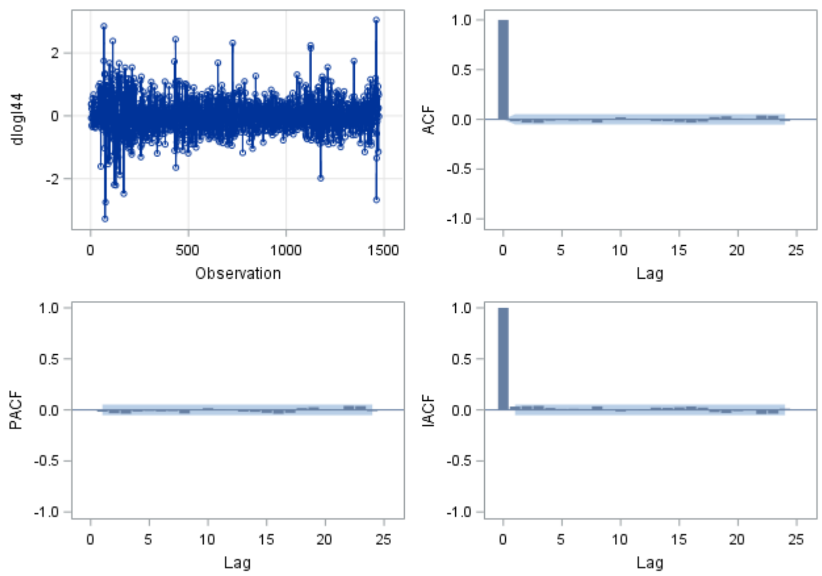
PROC ARIMA: Variable = dlogl44

The ARIMA Procedure

Name of Variable = dlogl44	
Mean of Working Series	0.011326
Standard Deviation	0.53952
Number of Observations	1473

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	4.44	6	0.6175	-0.018	-0.033	-0.035	-0.014	-0.007	-0.013
12	6.90	12	0.8644	-0.009	-0.033	0.006	0.021	0.006	0.001
18	12.26	18	0.8333	-0.018	-0.019	-0.027	-0.033	-0.024	0.024
24	18.44	24	0.7810	0.031	0.009	0.002	0.039	0.036	-0.016

Trend and Correlation Analysis for dlogl44



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-1497.25	0.0001	-39.02	<.0001		
	1	-1596.69	0.0001	-28.23	<.0001		
	2	-1788.14	0.0001	-23.55	<.0001		
	3	-1917.87	0.0001	-20.37	<.0001		
	4	-2023.57	0.0001	-18.13	<.0001		
	5	-2270.71	0.0001	-16.61	<.0001		
Single Mean	0	-1497.92	0.0001	-39.02	<.0001	761.36	0.0010
	1	-1598.81	0.0001	-28.24	<.0001	398.79	0.0010
	2	-1793.21	0.0001	-23.57	<.0001	277.68	0.0010
	3	-1927.95	0.0001	-20.39	<.0001	207.82	0.0010
	4	-2041.07	0.0001	-18.15	<.0001	164.66	0.0010
	5	-2301.42	0.0001	-16.63	<.0001	138.25	0.0010
Trend	0	-1498.65	0.0001	-39.03	<.0001	761.58	0.0010
	1	-1601.23	0.0001	-28.25	<.0001	399.17	0.0010
	2	-1799.31	0.0001	-23.59	<.0001	278.15	0.0010
	3	-1940.95	0.0001	-20.41	<.0001	208.33	0.0010
	4	-2063.22	0.0001	-18.17	<.0001	165.16	0.0010
	5	-2340.42	0.0001	-16.66	<.0001	138.76	0.0010

6.5.4 Variable: USD

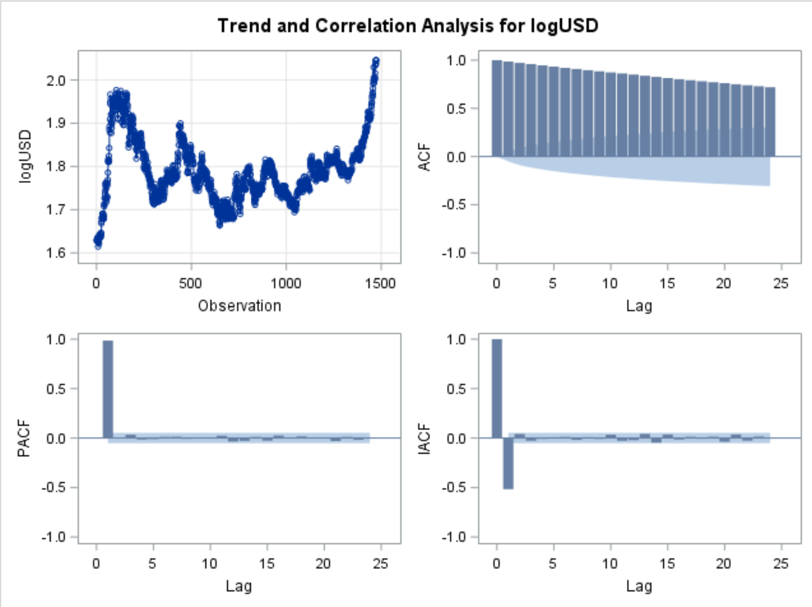
Stationarity analysis on logUSD

PROC ARIMA: Variable = logUSD

The ARIMA Procedure

Name of Variable = logUSD	
Mean of Working Series	1.790457
Standard Deviation	0.07244
Number of Observations	1474

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	8062.11	6	<.0001	0.986	0.972	0.959	0.946	0.933	0.920
12	9999.99	12	<.0001	0.908	0.896	0.884	0.873	0.862	0.851
18	9999.99	18	<.0001	0.838	0.827	0.814	0.803	0.792	0.782
24	9999.99	24	<.0001	0.771	0.761	0.750	0.740	0.729	0.719



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.2191	0.7354	1.10	0.9301		
	1	0.2189	0.7354	1.11	0.9317		
	2	0.2200	0.7357	1.18	0.9391		
	3	0.2183	0.7352	1.15	0.9360		
	4	0.2176	0.7351	1.16	0.9367		
	5	0.2219	0.7361	1.20	0.9417		
Single Mean	0	-8.4735	0.1943	-1.71	0.4237	2.15	0.5181
	1	-8.2391	0.2055	-1.67	0.4445	2.10	0.5325
	2	-7.1230	0.2676	-1.51	0.5276	1.91	0.5806
	3	-7.4731	0.2464	-1.55	0.5082	1.94	0.5739
	4	-7.3062	0.2563	-1.52	0.5253	1.89	0.5858
	5	-7.2170	0.2617	-1.52	0.5260	1.95	0.5720
Trend	0	-8.4764	0.5472	-1.71	0.7452	1.57	0.8630
	1	-8.2325	0.5660	-1.67	0.7636	1.51	0.8765
	2	-7.1074	0.6553	-1.51	0.8263	1.26	0.9250
	3	-7.4473	0.6280	-1.55	0.8136	1.32	0.9140
	4	-7.2698	0.6423	-1.51	0.8260	1.27	0.9231
	5	-7.1746	0.6499	-1.51	0.8269	1.25	0.9268

Stationarity analysis on first difference of logUSD, $\Delta logUSD$

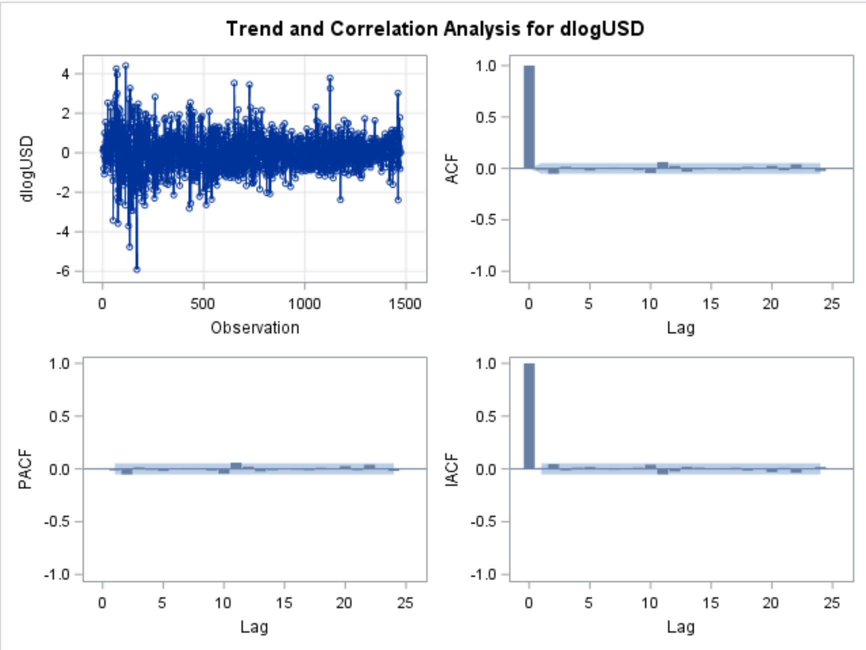
PROC ARIMA: Variable = dlogUSD

The ARIMA Procedure

Name of Variable = dlogUSD	
Mean of Working Series	0.028342
Standard Deviation	0.929605
Number of Observations	1473

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	5.32	6	0.5029	-0.013	-0.052	0.016	-0.007	-0.021	-0.001
12	15.45	12	0.2178	0.009	0.004	-0.015	-0.045	0.062	0.024
18	17.80	18	0.4692	-0.031	-0.009	0.003	-0.010	-0.014	0.015
24	22.54	24	0.5473	0.002	0.025	-0.017	0.040	0.004	-0.025



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1649.35	0.0001	-28.69	<.0001		
	2	-1569.93	0.0001	-22.60	<.0001		
	3	-1622.83	0.0001	-19.61	<.0001		
	4	-1793.33	0.0001	-17.76	<.0001		
	5	-1809.51	0.0001	-16.11	<.0001		
	10	-1450.15	0.0001	-11.42	<.0001		
Single Mean	1	-1654.10	0.0001	-28.73	<.0001	412.58	0.0010
	2	-1579.24	0.0001	-22.63	<.0001	256.09	0.0010
	3	-1639.58	0.0001	-19.65	<.0001	193.03	0.0010
	4	-1824.16	0.0001	-17.81	<.0001	158.56	0.0010
	5	-1854.25	0.0001	-16.16	<.0001	130.64	0.0010
	10	-1550.31	0.0001	-11.50	<.0001	66.08	0.0010
Trend	1	-1654.81	0.0001	-28.72	<.0001	412.49	0.0010
	2	-1580.67	0.0001	-22.63	<.0001	256.08	0.0010
	3	-1642.31	0.0001	-19.65	<.0001	193.06	0.0010
	4	-1828.68	0.0001	-17.81	<.0001	158.59	0.0010
	5	-1860.35	0.0001	-16.17	<.0001	130.68	0.0010
	10	-1561.14	0.0001	-11.50	<.0001	66.14	0.0010

6.5.5 Variable: I44 interest rate

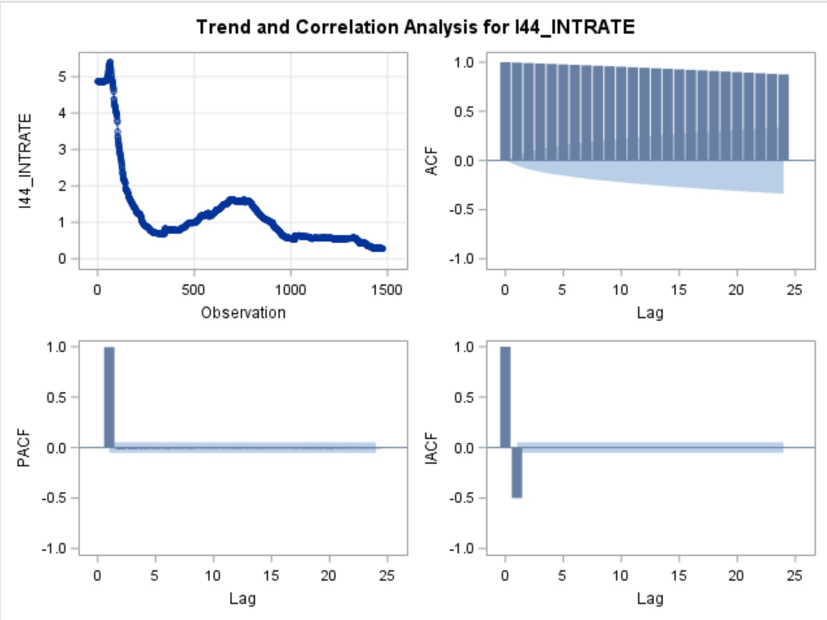
Stationarity analysis on I44_INTRATE

PROC ARIMA: Variable = I44_INTRATE

The ARIMA Procedure

Name of Variable = I44_INTRATE	
Mean of Working Series	1.218883
Standard Deviation	1.090309
Number of Observations	1474

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	8608.77	6	<.0001	0.996	0.992	0.987	0.983	0.978	0.973
12	9999.99	12	<.0001	0.969	0.964	0.959	0.954	0.949	0.944
18	9999.99	18	<.0001	0.938	0.933	0.928	0.922	0.917	0.911
24	9999.99	24	<.0001	0.905	0.900	0.894	0.888	0.882	0.876



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-4.6607	0.1381	-7.05	<.0001		
	2	-4.8789	0.1292	-5.33	<.0001		
	3	-5.0357	0.1231	-4.76	<.0001		
	4	-5.1404	0.1193	-4.52	<.0001		
	5	-5.2758	0.1145	-4.35	<.0001		
	10	-5.7161	0.1001	-3.90	0.0001		
	20	-7.9351	0.0514	-3.44	0.0006		
Single Mean	1	-5.7693	0.3664	-5.94	<.0001	26.14	0.0010
	2	-6.2520	0.3279	-4.68	0.0002	15.26	0.0010
	3	-6.6004	0.3024	-4.28	0.0006	12.34	0.0010
	4	-6.8319	0.2865	-4.13	0.0010	11.25	0.0010
	5	-7.1186	0.2679	-4.04	0.0014	10.52	0.0010
	10	-8.1078	0.2120	-3.82	0.0029	8.86	0.0010
	20	-13.2108	0.0619	-3.98	0.0017	8.43	0.0010
Trend	1	-5.0947	0.8139	-4.08	0.0069	17.98	0.0010
	2	-5.8817	0.7539	-3.44	0.0464	10.99	0.0010
	3	-6.4448	0.7089	-3.28	0.0700	9.18	0.0010
	4	-6.8081	0.6795	-3.24	0.0777	8.54	0.0010
	5	-7.2426	0.6444	-3.24	0.0781	8.16	0.0034
	10	-8.7758	0.5245	-3.27	0.0717	7.38	0.0202
	20	-17.3977	0.1167	-4.01	0.0088	8.85	0.0010

Stationarity analysis on first difference of I44_INTRATE, ΔI44_INTRATE

PROC ARIMA: Variable = dl44_INTRATE

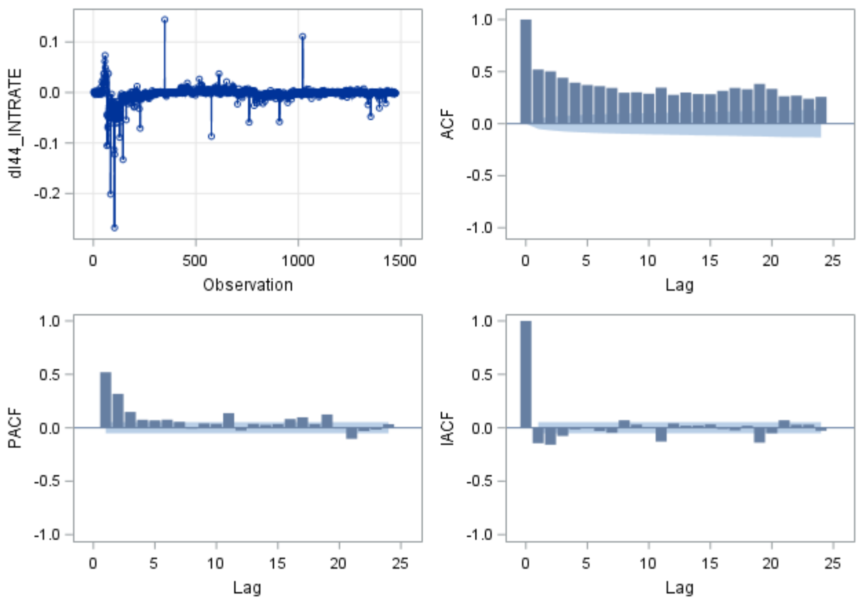
The ARIMA Procedure

Name of Variable = dl44_INTRATE	
Mean of Working Series	-0.00312
Standard Deviation	0.016186
Number of Observations	1473

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1684.58	6	<.0001	0.520	0.502	0.441	0.394	0.371	0.360
12	2538.56	12	<.0001	0.343	0.297	0.301	0.288	0.346	0.276
18	3398.32	18	<.0001	0.299	0.285	0.283	0.315	0.343	0.330
24	4179.52	24	<.0001	0.382	0.334	0.263	0.269	0.239	0.257

Trend and Correlation Analysis for dl44_INTRATE



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-346.584	0.0001	-13.16	<.0001		
	2	-246.519	0.0001	-10.65	<.0001		
	3	-205.402	0.0001	-9.48	<.0001		
	4	-172.361	0.0001	-8.55	<.0001		
	5	-142.294	0.0001	-7.70	<.0001		
	10	-70.9596	<.0001	-5.38	<.0001		
	20	-32.4087	<.0001	-3.63	0.0003		
Single Mean	1	-365.626	0.0001	-13.51	<.0001	91.23	0.0010
	2	-262.480	0.0001	-10.96	<.0001	60.08	0.0010
	3	-220.359	0.0001	-9.77	<.0001	47.74	0.0010
	4	-186.090	0.0001	-8.82	<.0001	38.94	0.0010
	5	-154.336	0.0001	-7.97	<.0001	31.73	0.0010
	10	-78.1683	0.0019	-5.59	<.0001	15.63	0.0010
	20	-36.2016	0.0019	-3.80	0.0032	7.21	0.0010
Trend	1	-388.095	0.0001	-13.92	<.0001	96.82	0.0010
	2	-281.785	0.0001	-11.32	<.0001	64.12	0.0010
	3	-238.826	0.0001	-10.12	<.0001	51.20	0.0010
	4	-203.386	0.0001	-9.16	<.0001	41.97	0.0010
	5	-169.743	0.0001	-8.29	<.0001	34.35	0.0010
	10	-87.9950	0.0008	-5.87	<.0001	17.24	0.0010
	20	-41.8512	0.0008	-4.04	0.0078	8.17	0.0031

6.5.6 Variable: LIBOR_USD

Stationarity analysis on LIBOR_USD

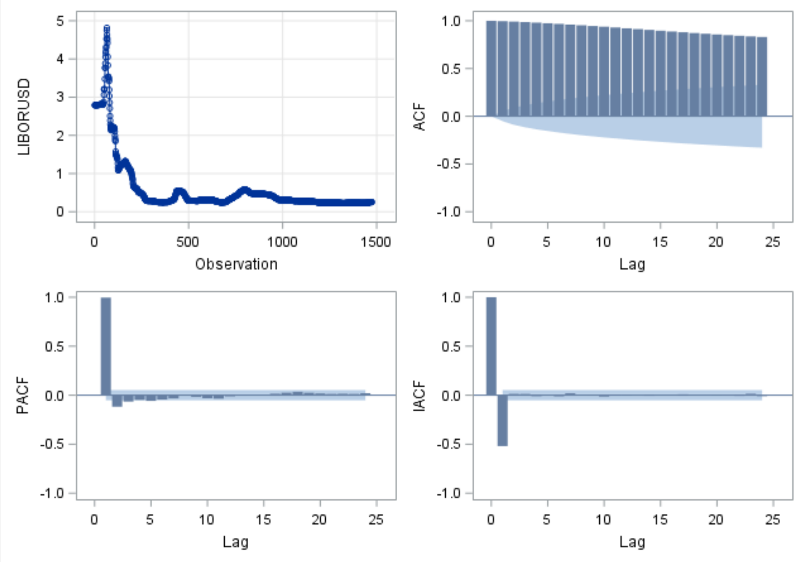
PROC ARIMA: Variable = LIBORUSD

The ARIMA Procedure

Name of Variable = LIBORUSD	
Mean of Working Series	0.57979
Standard Deviation	0.733905
Number of Observations	1474

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	8572.03	6	<.0001	0.996	0.991	0.986	0.980	0.974	0.967
12	9999.99	12	<.0001	0.960	0.953	0.946	0.938	0.930	0.921
18	9999.99	18	<.0001	0.913	0.905	0.896	0.888	0.880	0.872
24	9999.99	24	<.0001	0.864	0.857	0.850	0.843	0.836	0.830



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-7.2595	0.0629	-3.07	0.0022		
	2	-7.3761	0.0607	-3.06	0.0022		
	3	-7.9888	0.0506	-3.04	0.0024		
	4	-10.3071	0.0257	-3.04	0.0024		
	5	-9.7884	0.0298	-3.04	0.0024		
	10	-11.6601	0.0176	-3.15	0.0017		
	20	-7.2058	0.0639	-3.41	0.0007		
Single Mean	1	-9.0538	0.1692	-3.01	0.0346	5.19	0.0309
	2	-9.2498	0.1615	-3.02	0.0344	5.17	0.0316
	3	-10.2416	0.1273	-3.06	0.0308	5.20	0.0307
	4	-14.0679	0.0501	-3.25	0.0181	5.59	0.0203
	5	-13.2114	0.0619	-3.21	0.0201	5.51	0.0220
	10	-16.4177	0.0280	-3.43	0.0105	6.16	0.0072
	20	-8.9419	0.1738	-3.28	0.0165	6.30	0.0041
Trend	1	-9.6644	0.4599	-2.63	0.2647	4.58	0.2544
	2	-9.9475	0.4405	-2.66	0.2551	4.59	0.2511
	3	-11.3922	0.3488	-2.78	0.2038	4.78	0.2127
	4	-17.1870	0.1217	-3.23	0.0793	5.76	0.0770
	5	-15.8394	0.1576	-3.14	0.0988	5.54	0.0892
	10	-20.7238	0.0598	-3.48	0.0424	6.55	0.0417
	20	-9.0003	0.5077	-2.72	0.2272	5.37	0.0981

Stationarity analysis on first difference of LIBOR_USD, ΔLIBOR_USD

PROC ARIMA: Variable = dLIBORUSD

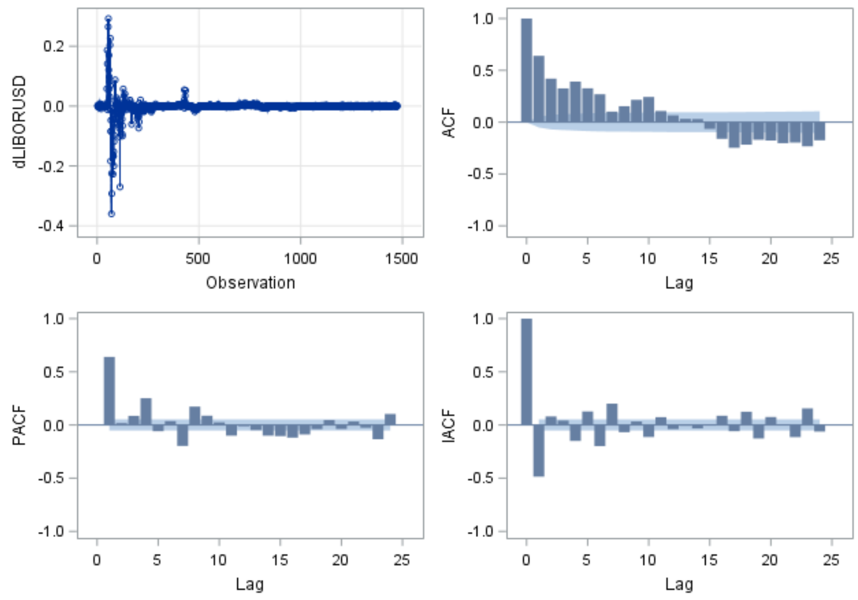
The ARIMA Procedure

Name of Variable = dLIBORUSD	
Mean of Working Series	-0.00172
Standard Deviation	0.027141
Number of Observations	1473

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1515.26	6	<.0001	0.640	0.420	0.326	0.392	0.327	0.270
12	1746.68	12	<.0001	0.102	0.154	0.216	0.243	0.108	0.066
18	1956.24	18	<.0001	0.032	0.030	-0.065	-0.161	-0.247	-0.217
24	2293.16	24	<.0001	-0.170	-0.177	-0.203	-0.197	-0.233	-0.175

Trend and Correlation Analysis for dLIBORUSD



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-508.178	0.0001	-15.93	<.0001		
	2	-415.375	0.0001	-13.48	<.0001		
	3	-222.533	0.0001	-9.82	<.0001		
	4	-257.066	0.0001	-10.07	<.0001		
	5	-232.772	0.0001	-9.38	<.0001		
	10	-235.966	0.0001	-8.24	<.0001		
	20	961.6637	0.9999	-9.46	<.0001		
Single Mean	1	-511.106	0.0001	-15.97	<.0001	127.52	0.0010
	2	-418.463	0.0001	-13.52	<.0001	91.33	0.0010
	3	-224.301	0.0001	-9.85	<.0001	48.48	0.0010
	4	-259.482	0.0001	-10.11	<.0001	51.07	0.0010
	5	-235.192	0.0001	-9.41	<.0001	44.31	0.0010
	10	-240.244	0.0001	-8.28	<.0001	34.25	0.0010
	20	870.4233	0.9999	-9.55	<.0001	45.65	0.0010
Trend	1	-516.068	0.0001	-16.04	<.0001	128.67	0.0010
	2	-423.737	0.0001	-13.59	<.0001	92.29	0.0010
	3	-227.346	0.0001	-9.90	<.0001	49.02	0.0010
	4	-263.668	0.0001	-10.17	<.0001	51.69	0.0010
	5	-239.409	0.0001	-9.48	<.0001	44.89	0.0010
	10	-247.938	0.0001	-8.35	<.0001	34.88	0.0010
	20	750.4930	0.9999	-9.72	<.0001	47.28	0.0010

6.5.7 Variable: NIBOR

Stationarity analysis on NIBOR

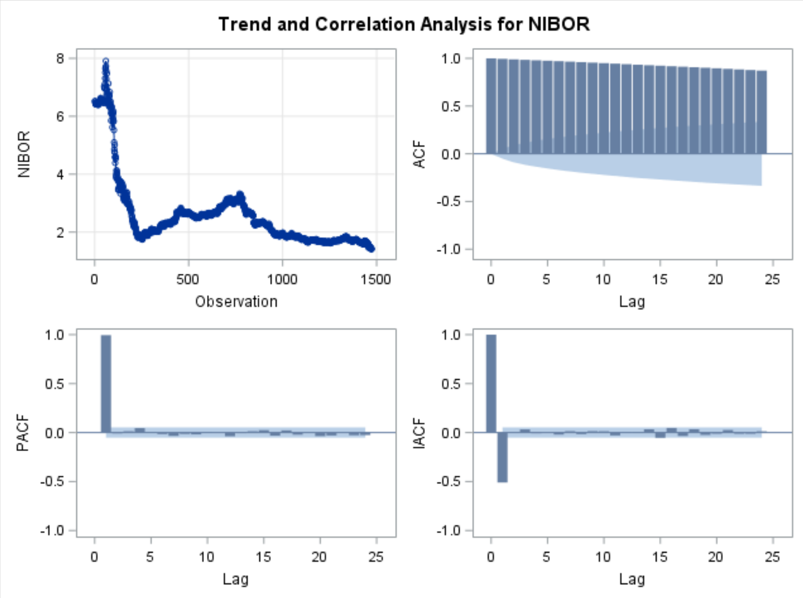
PROC ARIMA: Variable = NIBOR

The ARIMA Procedure

Name of Variable = NIBOR	
Mean of Working Series	2.571316
Standard Deviation	1.225531
Number of Observations	1474

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	8566.68	6	<.0001	0.995	0.989	0.984	0.980	0.975	0.970
12	9999.99	12	<.0001	0.965	0.960	0.955	0.950	0.945	0.939
18	9999.99	18	<.0001	0.933	0.928	0.923	0.918	0.912	0.907
24	9999.99	24	<.0001	0.902	0.896	0.890	0.884	0.878	0.872



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-2.8999	0.2423	-3.25	0.0012		
	2	-2.8429	0.2470	-3.28	0.0011		
	3	-2.7295	0.2567	-3.71	0.0002		
	4	-2.7095	0.2584	-3.71	0.0002		
	5	-2.7378	0.2560	-3.59	0.0004		
	10	-2.9357	0.2394	-3.25	0.0012		
	20	-3.2268	0.2173	-2.74	0.0061		
Single Mean	1	-6.9457	0.2790	-3.35	0.0132	7.64	0.0010
	2	-6.7274	0.2936	-3.35	0.0136	7.69	0.0010
	3	-6.1485	0.3358	-3.60	0.0062	9.34	0.0010
	4	-6.0860	0.3407	-3.60	0.0062	9.36	0.0010
	5	-6.2449	0.3285	-3.53	0.0076	8.88	0.0010
	10	-7.2373	0.2605	-3.46	0.0095	7.91	0.0010
	20	-9.0434	0.1696	-3.32	0.0149	6.59	0.0010
Trend	1	-7.6159	0.6145	-2.78	0.2066	5.69	0.0807
	2	-7.2840	0.6411	-2.74	0.2215	5.64	0.0833
	3	-6.2693	0.7230	-2.78	0.2066	6.46	0.0441
	4	-6.1731	0.7307	-2.77	0.2102	6.46	0.0442
	5	-6.4268	0.7104	-2.76	0.2113	6.25	0.0502
	10	-7.9170	0.5907	-2.89	0.1653	6.06	0.0604
	20	-10.9863	0.3729	-3.07	0.1145	5.80	0.0747

Stationarity analysis on first difference of NIBOR, ΔNIBOR

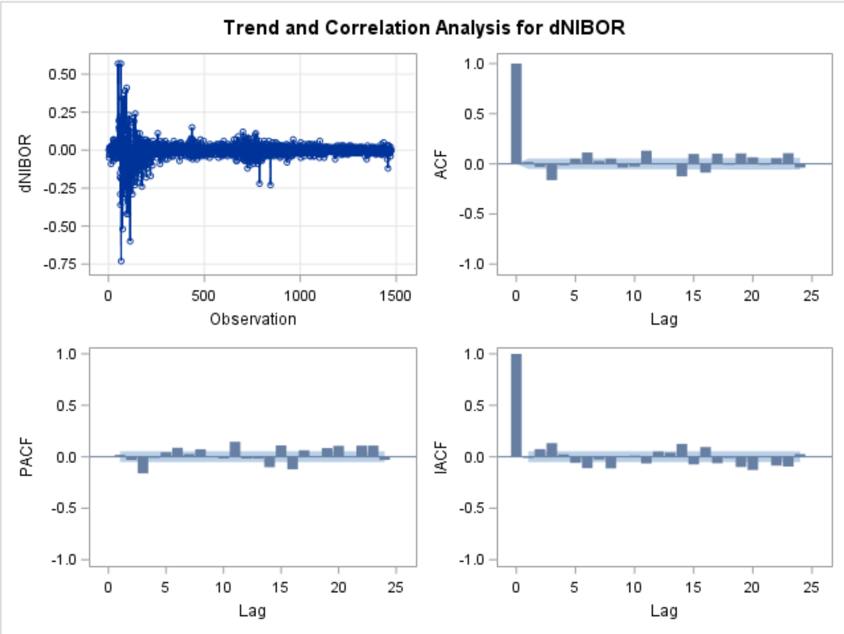
PROC ARIMA: Variable = dNIBOR

The ARIMA Procedure

Name of Variable = dNIBOR	
Mean of Working Series	-0.00346
Standard Deviation	0.06505
Number of Observations	1473

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	64.02	6	<.0001	0.018	-0.030	-0.163	-0.014	0.051	0.113
12	97.80	12	<.0001	0.029	0.052	-0.037	-0.027	0.131	0.004
18	162.73	18	<.0001	-0.004	-0.125	0.099	-0.088	0.102	-0.009
24	209.11	24	<.0001	0.104	0.065	-0.009	0.056	0.106	-0.038



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-1522.56	0.0001	-27.58	<.0001		
	2	-2601.51	0.0001	-26.25	<.0001		
	3	-2691.15	0.0001	-21.78	<.0001		
	4	-1963.76	0.0001	-18.05	<.0001		
	5	-1131.36	0.0001	-14.89	<.0001		
	10	-335.280	0.0001	-9.05	<.0001		
	20	-159.536	0.0001	-6.20	<.0001		
Single Mean	1	-1535.34	0.0001	-27.68	<.0001	383.18	0.0010
	2	-2662.58	0.0001	-26.40	<.0001	348.55	0.0010
	3	-2819.02	0.0001	-21.95	<.0001	240.81	0.0010
	4	-2086.09	0.0001	-18.22	<.0001	165.94	0.0010
	5	-1199.82	0.0001	-15.05	<.0001	113.29	0.0010
	10	-360.610	0.0001	-9.21	<.0001	42.38	0.0010
	20	-179.282	0.0001	-6.37	<.0001	20.31	0.0010
Trend	1	-1547.03	0.0001	-27.78	<.0001	385.79	0.0010
	2	-2720.07	0.0001	-26.54	<.0001	352.15	0.0010
	3	-2944.02	0.0001	-22.10	<.0001	244.12	0.0010
	4	-2209.80	0.0001	-18.37	<.0001	168.79	0.0010
	5	-1269.19	0.0001	-15.20	<.0001	115.57	0.0010
	10	-387.864	0.0001	-9.36	<.0001	43.81	0.0010
	20	-203.112	0.0001	-6.55	<.0001	21.43	0.0010

6.6 Robustness sample

6.6.1 Autocorrelation analysis

Columns market by stars in correspondence with lag 1-10 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market **dark** green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Cells market with **light** green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis - Breusch-Godfrey test Robustness sample										
Variable	0 lag	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag
logI44		**	*	**	insig	**	**	*	*	insig	insig
logUSD	***	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
logBrent	**	insig	insig	insig	insig	*	insig	insig	**	insig	**
I44_INTRATE	***	insig	insig	insig	insig	insig	*	**	insig	insig	insig
LIBORUSD		insig	insig	*	***	***	***	***	***	***	insig
NIBOR		***	***	***	***	insig	insig	*	insig	insig	insig
logINDPRO_I44		***	***	insig	insig	insig	insig	*	insig	insig	insig
logINDPRO_USD		***	***	***	insig	insig	*	insig	insig	*	insig
logINDPRO_NOK		***	***	**	**	insig	insig	insig	insig	***	***
CPI_I44		insig	insig	insig	insig	insig	*	**	***	***	***
CPI_USD		**	insig	*	insig	insig	insig	insig	insig	***	***
CPI_NOK		insig	insig	insig	insig	insig	insig	***	***	***	***

Autocorrelation analysis - Breusch-Godfrey test
Robustness sample

Variable	0 lag	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag
ΔlogI44		*	*	insig	*	*	insig	**	insig	insig	insig
ΔlogUSD	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig	insig
ΔlogBrent	insig	insig	insig	insig	**	insig	insig	insig	insig	*	insig
ΔI44_INTRATE	insig	insig	insig	insig	insig	*	*	insig	insig	insig	insig
ΔLIBORUSD		insig	insig	***	***	***	***	***	***	insig	insig
ΔNIBOR		***	***	***	*	**	**	insig	insig	insig	insig
ΔlogINDPRO_I44		***	insig	insig	insig	insig	insig	*'	insig	insig	*
ΔlogINDPRO_USD		***	***	insig	*	*	insig	insig	*	insig	insig
ΔlogINDPRO_NOK		***	***	**	insig	insig	insig	***	***	***	**
ΔCPI_I44		insig	insig	insig	insig	insig	insig	***	***	**	***
ΔCPI_USD		insig	insig	insig	insig	insig	insig	***	***	***	***
ΔCPI_NOK		**	**	insig	insig	insig	*	***	***	***	***

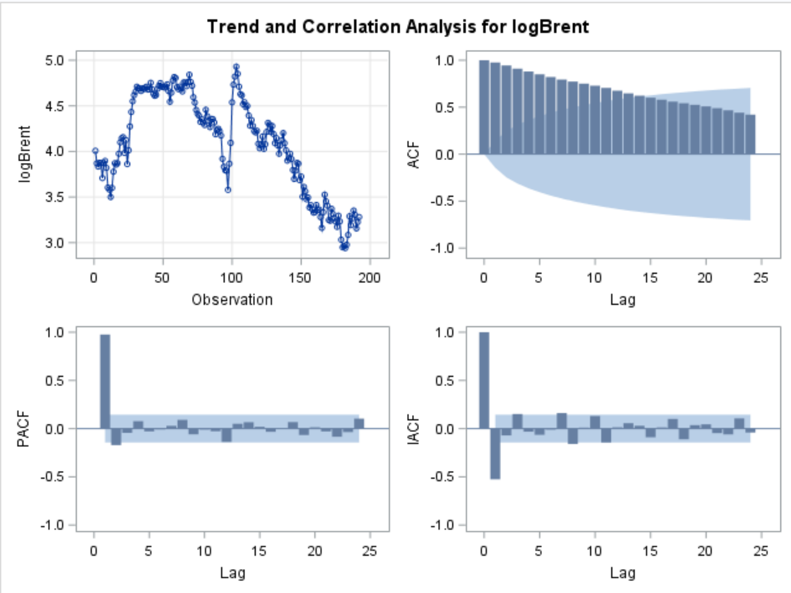
6.6.2 Variable: Brent

Stationarity analysis on logBrent

The ARIMA Procedure

Name of Variable = logBrent	
Mean of Working Series	4.078931
Standard Deviation	0.530967
Number of Observations	192

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	956.44	6	<.0001	0.976	0.944	0.910	0.880	0.850	0.821
12	1624.77	12	<.0001	0.794	0.773	0.751	0.729	0.705	0.676
18	2069.76	18	<.0001	0.647	0.623	0.601	0.580	0.559	0.542
24	2367.31	24	<.0001	0.525	0.508	0.489	0.467	0.442	0.421



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-0.2140	0.6334	-0.63	0.4443		
	1	-0.1977	0.6371	-0.48	0.5042		
	2	-0.1944	0.6379	-0.47	0.5087		
	3	-0.2014	0.6363	-0.52	0.4915		
	4	-0.1982	0.6370	-0.50	0.4995		
	5	-0.1493	0.6481	-0.40	0.5366		
	10	-0.1153	0.6557	-0.38	0.5470		
	20	-0.2317	0.6293	-0.71	0.4077		
Single Mean	0	-2.3674	0.7325	-0.89	0.7894	0.53	0.9434
	1	-4.0969	0.5251	-1.26	0.6463	0.85	0.8534
	2	-4.2903	0.5039	-1.28	0.6372	0.87	0.8479
	3	-3.7897	0.5599	-1.17	0.6863	0.76	0.8778
	4	-4.1204	0.5225	-1.22	0.6664	0.80	0.8658
	5	-3.6162	0.5800	-1.14	0.7001	0.68	0.8963
	10	-2.4100	0.7272	-0.85	0.8026	0.40	0.9733
	20	-2.7532	0.6845	-0.73	0.8364	0.47	0.9590
Trend	0	-6.6467	0.6872	-1.99	0.6029	2.57	0.6632
	1	-10.0738	0.4212	-2.48	0.3390	3.65	0.4479
	2	-10.7117	0.3792	-2.54	0.3085	3.83	0.4124
	3	-9.9315	0.4314	-2.41	0.3742	3.48	0.4819
	4	-10.9193	0.3661	-2.51	0.3238	3.74	0.4293
	5	-11.0758	0.3565	-2.69	0.2403	4.61	0.2565
	10	-10.4578	0.3950	-2.95	0.1490	6.24	0.0553
	20	-12.4329	0.2799	-2.83	0.1885	4.95	0.1874

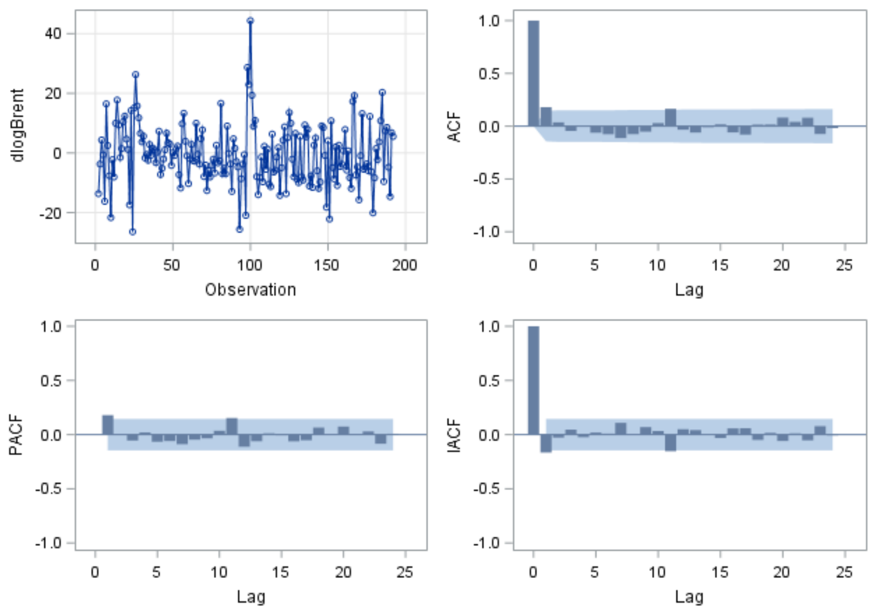
Stationarity analysis on first difference of logBrent, ΔlogBrent

The ARIMA Procedure

Name of Variable = dlogBrent	
Mean of Working Series	-0.38014
Standard Deviation	10.1338
Number of Observations	191

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	8.85	6	0.1823	0.180	0.036	-0.045	0.002	-0.062	-0.076
12	19.04	12	0.0876	-0.113	-0.075	-0.052	0.029	0.164	-0.033
18	22.02	18	0.2311	-0.061	-0.009	0.017	-0.059	-0.080	0.015
24	26.52	24	0.3272	0.016	0.081	0.040	0.080	-0.074	-0.018

Trend and Correlation Analysis for dlogBrent



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-155.598	0.0001	-11.50	<.0001		
	1	-153.301	0.0001	-8.72	<.0001		
	2	-177.579	0.0001	-7.70	<.0001		
	3	-163.662	0.0001	-6.53	<.0001		
	4	-236.018	0.0001	-6.34	<.0001		
	5	-344.493	0.0001	-5.95	<.0001		
Single Mean	0	-155.777	0.0001	-11.47	<.0001	65.81	0.0010
	1	-153.717	0.0001	-8.70	<.0001	37.89	0.0010
	2	-178.513	0.0001	-7.69	<.0001	29.58	0.0010
	3	-164.857	0.0001	-6.53	<.0001	21.30	0.0010
	4	-238.365	0.0001	-6.33	<.0001	20.04	0.0010
	5	-355.385	0.0001	-5.95	<.0001	17.70	0.0010
Trend	0	-157.001	0.0001	-11.52	<.0001	66.41	0.0010
	1	-157.026	0.0001	-8.77	<.0001	38.50	0.0010
	2	-185.397	0.0001	-7.77	<.0001	30.17	0.0010
	3	-175.280	0.0001	-6.62	<.0001	21.90	0.0010
	4	-275.931	0.0001	-6.49	<.0001	21.07	0.0010
	5	-466.250	0.0001	-6.07	<.0001	18.45	0.0010

6.6.3 Variable: I44

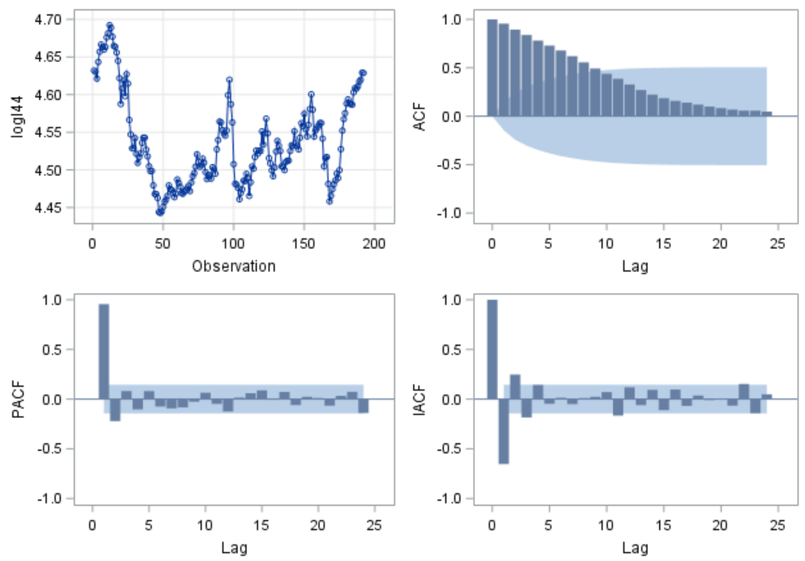
Stationarity analysis on logI44

The ARIMA Procedure

Name of Variable = logI44	
Mean of Working Series	4.536618
Standard Deviation	0.05919
Number of Observations	192

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	792.55	6	<.0001	0.956	0.894	0.839	0.781	0.729	0.678
12	1073.98	12	<.0001	0.620	0.556	0.492	0.437	0.386	0.327
18	1119.36	18	<.0001	0.270	0.223	0.186	0.158	0.139	0.120
24	1125.94	24	<.0001	0.099	0.084	0.068	0.058	0.057	0.047

Trend and Correlation Analysis for logI44



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.0020	0.6816	-0.03	0.6712		
	2	0.0003	0.6821	0.01	0.6838		
	3	-0.0069	0.6804	-0.12	0.6407		
	4	-0.0075	0.6803	-0.16	0.6279		
	5	-0.0106	0.6796	-0.21	0.6108		
	9	-0.0134	0.6789	-0.28	0.5829		
Single Mean	1	-11.3205	0.0937	-2.36	0.1535	2.79	0.3592
	2	-8.5962	0.1837	-2.01	0.2841	2.01	0.5584
	3	-11.6440	0.0864	-2.40	0.1420	2.89	0.3334
	4	-8.9693	0.1676	-2.15	0.2247	2.32	0.4787
	5	-11.7925	0.0832	-2.46	0.1277	3.04	0.2971
	9	-15.3097	0.0338	-2.71	0.0748	3.70	0.1273
Trend	1	-10.5595	0.3890	-2.20	0.4862	3.14	0.5496
	2	-7.7444	0.5970	-1.82	0.6929	2.52	0.6746
	3	-10.3961	0.3995	-2.19	0.4907	3.49	0.4806
	4	-7.5880	0.6096	-1.89	0.6550	3.34	0.5091
	5	-9.9311	0.4313	-2.20	0.4850	4.01	0.3768
	9	-11.8360	0.3122	-2.45	0.3519	5.12	0.1532

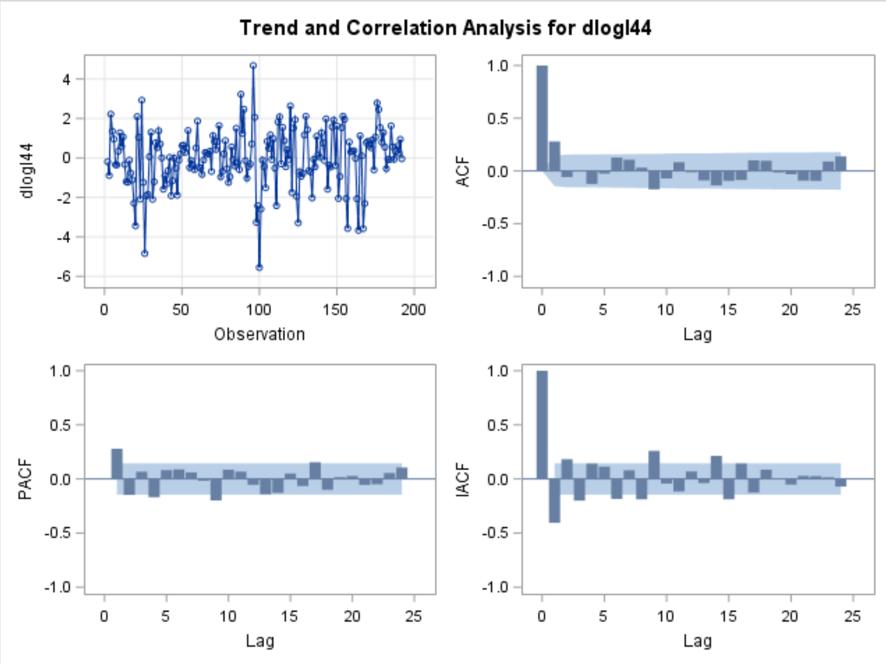
Stationarity analysis on first difference of logI44, ΔlogI44

The ARIMA Procedure

Name of Variable = dlogI44	
Mean of Working Series	-0.00179
Standard Deviation	1.482269
Number of Observations	191

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	22.11	6	0.0012	0.279	-0.058	0.000	-0.123	-0.026	0.127
12	33.20	12	0.0009	0.107	0.031	-0.174	-0.072	0.082	-0.012
18	46.27	18	0.0003	-0.090	-0.137	-0.094	-0.086	0.100	0.096
24	56.23	24	0.0002	-0.014	-0.031	-0.092	-0.094	0.089	0.137



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-183.615	0.0001	-9.54	<.0001		
	2	-149.458	0.0001	-7.28	<.0001		
	3	-311.996	0.0001	-7.60	<.0001		
	4	-191.420	0.0001	-6.10	<.0001		
	5	-119.146	0.0001	-5.03	<.0001		
	8	-4088.75	0.0001	-4.98	<.0001		
Single Mean	1	-183.611	0.0001	-9.51	<.0001	45.25	0.0010
	2	-149.475	0.0001	-7.27	<.0001	26.40	0.0010
	3	-312.170	0.0001	-7.58	<.0001	28.76	0.0010
	4	-191.656	0.0001	-6.09	<.0001	18.55	0.0010
	5	-119.290	0.0001	-5.02	<.0001	12.60	0.0010
	8	-4962.46	0.0001	-4.97	0.0001	12.35	0.0010
Trend	1	-188.982	0.0001	-9.62	<.0001	46.27	0.0010
	2	-158.967	0.0001	-7.43	<.0001	27.62	0.0010
	3	-366.444	0.0001	-7.82	<.0001	30.61	0.0010
	4	-235.840	0.0001	-6.37	<.0001	20.31	0.0010
	5	-147.940	0.0001	-5.28	0.0001	13.95	0.0010
	8	466.8140	0.9999	-5.40	<.0001	14.63	0.0010

6.6.4 Variable: USD

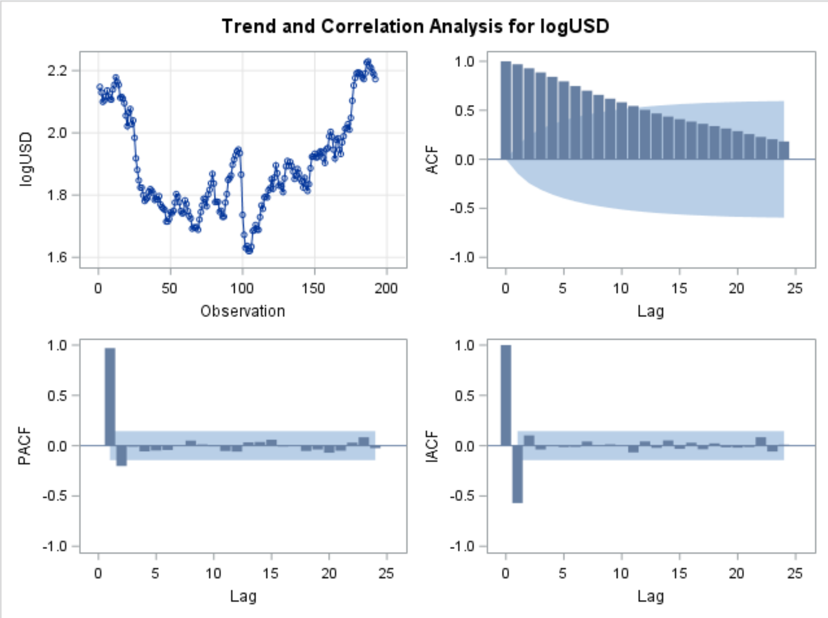
Stationarity analysis on logUSD

The ARIMA Procedure

Name of Variable = logUSD	
Mean of Working Series	1.892937
Standard Deviation	0.155589
Number of Observations	192

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	885.95	6	<.0001	0.970	0.929	0.886	0.842	0.796	0.748
12	1333.15	12	<.0001	0.700	0.658	0.619	0.582	0.544	0.504
18	1537.58	18	<.0001	0.468	0.436	0.409	0.385	0.362	0.339
24	1619.22	24	<.0001	0.314	0.288	0.258	0.228	0.205	0.182



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.0157	0.6784	-0.05	0.6643		
	2	0.0103	0.6844	0.04	0.6943		
	3	-0.0061	0.6806	-0.02	0.6749		
	4	-0.0156	0.6784	-0.05	0.6644		
	5	-0.0261	0.6760	-0.09	0.6508		
Single Mean	1	-6.0863	0.3361	-1.66	0.4486	1.39	0.7177
	2	-5.0625	0.4252	-1.44	0.5607	1.05	0.8024
	3	-6.0122	0.3419	-1.59	0.4854	1.27	0.7468
	4	-6.8774	0.2786	-1.70	0.4314	1.44	0.7032
	5	-6.9099	0.2764	-1.71	0.4248	1.46	0.6983
Trend	1	-7.1964	0.6418	-2.02	0.5874	3.35	0.5084
	2	-6.0902	0.7327	-1.80	0.7001	2.99	0.5798
	3	-6.9653	0.6608	-1.96	0.6197	3.35	0.5088
	4	-7.7058	0.6001	-2.07	0.5585	3.60	0.4581
	5	-7.6473	0.6048	-2.13	0.5267	4.12	0.3544

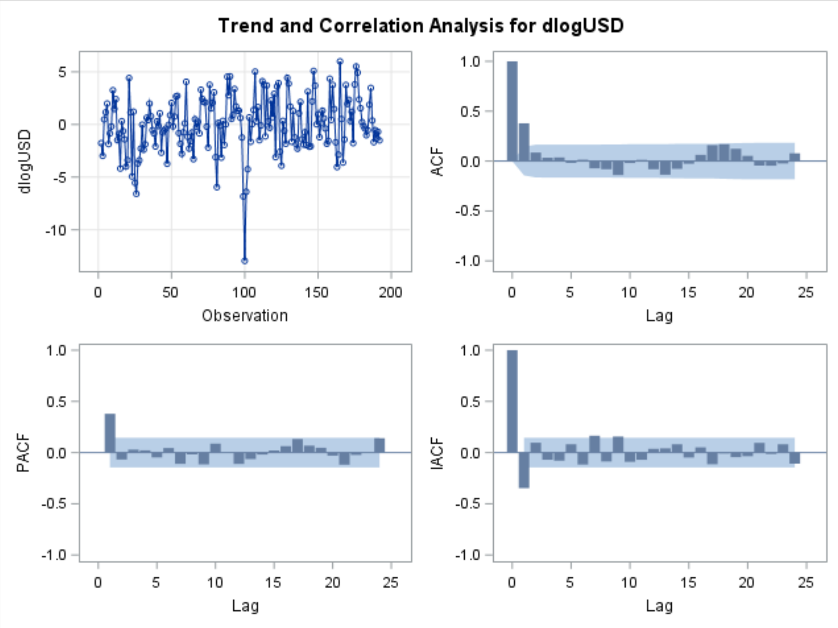
Stationarity analysis on first difference of logUSD, $\Delta logUSD$

The ARIMA Procedure

Name of Variable = dlogUSD	
Mean of Working Series	0.013068
Standard Deviation	2.672595
Number of Observations	191

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	29.87	6	<.0001	0.379	0.086	0.034	0.037	-0.018	0.014
12	37.69	12	0.0002	-0.073	-0.081	-0.140	-0.019	0.012	-0.082
18	55.31	18	<.0001	-0.136	-0.078	-0.027	0.062	0.160	0.169
24	61.52	24	<.0001	0.123	0.052	-0.045	-0.047	-0.024	0.078



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-117.886	0.0001	-9.22	<.0001		
	1	-134.553	0.0001	-8.19	<.0001		
	2	-123.016	0.0001	-6.75	<.0001		
	3	-113.368	0.0001	-5.87	<.0001		
	4	-134.751	0.0001	-5.60	<.0001		
	5	-110.575	0.0001	-4.92	<.0001		
Single Mean	0	-117.894	0.0001	-9.20	<.0001	42.31	0.0010
	1	-134.593	0.0001	-8.17	<.0001	33.40	0.0010
	2	-123.073	0.0001	-6.73	<.0001	22.66	0.0010
	3	-113.435	0.0001	-5.85	<.0001	17.12	0.0010
	4	-134.814	0.0001	-5.58	<.0001	15.57	0.0010
	5	-110.772	0.0001	-4.91	0.0001	12.06	0.0010
Trend	0	-121.833	0.0001	-9.37	<.0001	43.96	0.0010
	1	-143.372	0.0001	-8.37	<.0001	35.05	0.0010
	2	-137.915	0.0001	-6.97	<.0001	24.29	0.0010
	3	-135.164	0.0001	-6.12	<.0001	18.72	0.0010
	4	-184.188	0.0001	-5.93	<.0001	17.61	0.0010
	5	-159.043	0.0001	-5.22	0.0002	13.64	0.0010

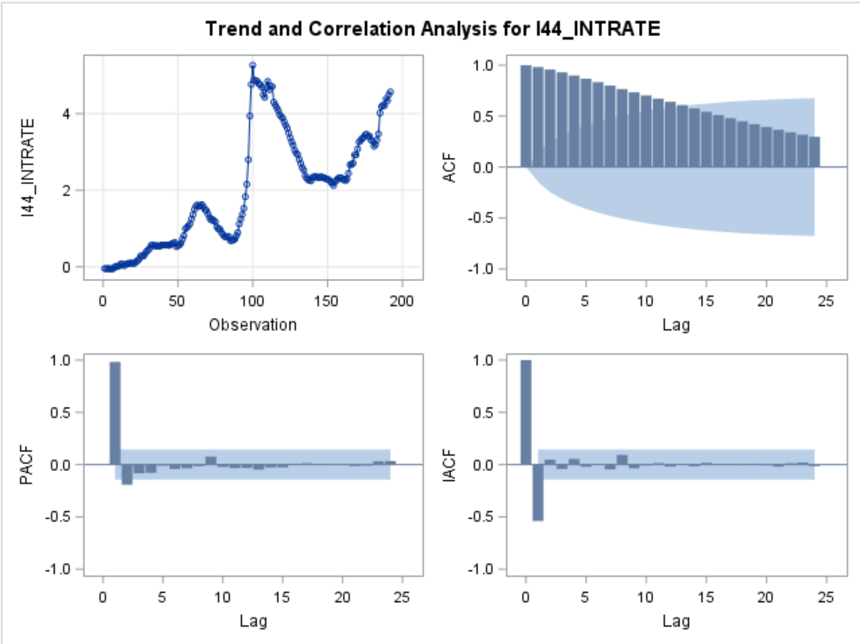
6.6.5 Variable: I44 interest rate

Stationarity analysis on I44_INTRATE

The ARIMA Procedure

Name of Variable = I44_INTRATE	
Mean of Working Series	2.004099
Standard Deviation	1.502894
Number of Observations	192

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	988.16	6	<.0001	0.982	0.958	0.930	0.899	0.867	0.834
12	1624.31	12	<.0001	0.800	0.765	0.734	0.703	0.672	0.641
18	1980.44	18	<.0001	0.609	0.576	0.543	0.511	0.480	0.450
24	2148.62	24	<.0001	0.421	0.393	0.367	0.341	0.318	0.297



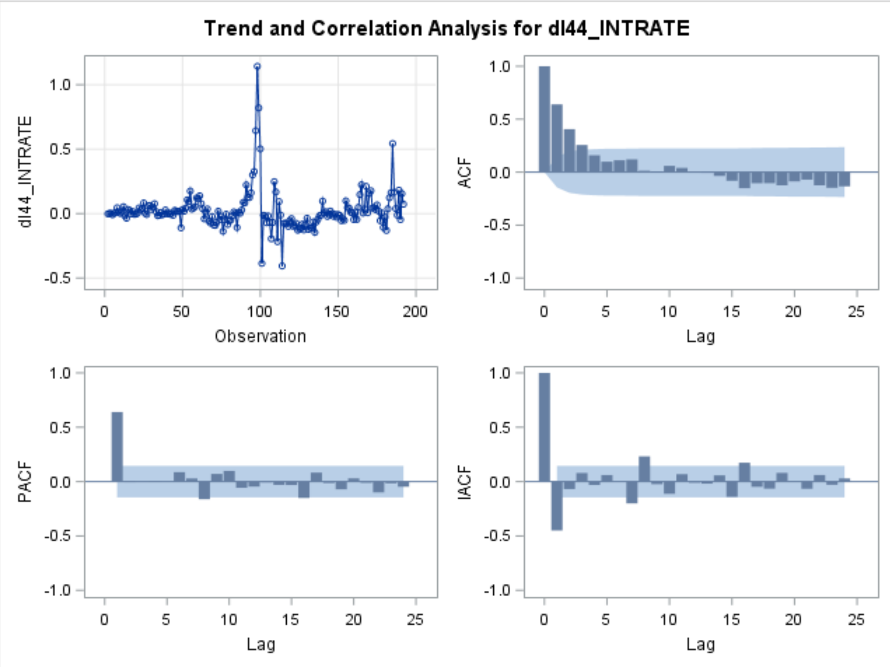
Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	0.0367	0.6905	0.02	0.6883		
	2	0.0357	0.6902	0.02	0.6881		
	3	0.0302	0.6889	0.02	0.6871		
	4	0.0232	0.6873	0.01	0.6859		
	5	0.0112	0.6846	0.01	0.6839		
	8	-0.0200	0.6774	-0.01	0.6786		
Single Mean	1	-4.1272	0.5218	-1.33	0.6163	1.42	0.7096
	2	-4.2231	0.5112	-1.34	0.6134	1.42	0.7082
	3	-4.3529	0.4972	-1.35	0.6084	1.43	0.7054
	4	-4.5190	0.4796	-1.37	0.5979	1.47	0.6967
	5	-4.6683	0.4641	-1.38	0.5935	1.47	0.6957
	8	-4.7931	0.4514	-1.40	0.5830	1.47	0.6964
Trend	1	-11.3844	0.3384	-2.33	0.4129	2.75	0.6288
	2	-11.9349	0.3073	-2.35	0.4062	2.77	0.6233
	3	-12.5937	0.2732	-2.36	0.3976	2.81	0.6159
	4	-13.3514	0.2377	-2.38	0.3873	2.85	0.6074
	5	-14.2673	0.2000	-2.41	0.3754	2.91	0.5965
	8	-16.1175	0.1393	-2.39	0.3831	2.86	0.6058

Stationarity analysis on first difference of I44_INTRATE, ΔI44_INTRATE

The ARIMA Procedure

Name of Variable = dl44_INTRATE	
Mean of Working Series	0.024168
Standard Deviation	0.153519
Number of Observations	191

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	133.91	6	<.0001	0.640	0.406	0.257	0.159	0.098	0.112
12	137.92	12	<.0001	0.121	0.013	0.008	0.059	0.040	0.003
18	149.05	18	<.0001	-0.006	-0.036	-0.082	-0.152	-0.104	-0.104
24	167.25	24	<.0001	-0.124	-0.087	-0.071	-0.124	-0.148	-0.134



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-66.6730	<.0001	-6.34	<.0001		
	1	-66.2615	<.0001	-5.71	<.0001		
	2	-65.6461	<.0001	-5.23	<.0001		
	3	-64.8933	<.0001	-4.83	<.0001		
	4	-63.8366	<.0001	-4.51	<.0001		
	5	-46.9807	<.0001	-3.86	0.0001		
Single Mean	0	-68.3588	0.0013	-6.42	<.0001	20.61	0.0010
	1	-68.6202	0.0013	-5.80	<.0001	16.84	0.0010
	2	-68.8729	0.0013	-5.33	<.0001	14.21	0.0010
	3	-69.0320	0.0013	-4.94	0.0001	12.22	0.0010
	4	-69.0169	0.0013	-4.62	0.0002	10.69	0.0010
	5	-51.1615	0.0013	-3.97	0.0020	7.90	0.0010
Trend	0	-68.4196	0.0006	-6.41	<.0001	20.52	0.0010
	1	-68.6857	0.0006	-5.79	<.0001	16.77	0.0010
	2	-68.9710	0.0006	-5.32	0.0001	14.16	0.0010
	3	-69.1168	0.0005	-4.93	0.0004	12.17	0.0010
	4	-69.1278	0.0005	-4.61	0.0013	10.64	0.0010
	5	-51.2484	0.0005	-3.96	0.0114	7.86	0.0126

6.6.6 Variable: LIBOR_USD

Stationarity analysis on LIBOR_USD

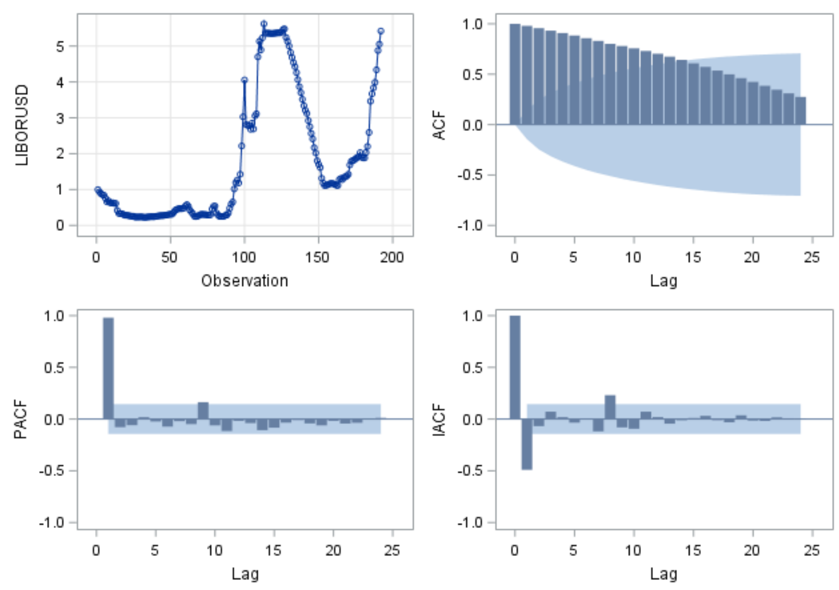
The ARIMA Procedure

Name of Variable = LIBORUSD	
Mean of Working Series	1.784697
Standard Deviation	1.764324
Number of Observations	192

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1004.39	6	<.0001	0.980	0.957	0.932	0.908	0.884	0.857
12	1726.28	12	<.0001	0.830	0.802	0.780	0.757	0.730	0.703
18	2168.73	18	<.0001	0.674	0.642	0.608	0.573	0.536	0.499
24	2349.77	24	<.0001	0.461	0.423	0.385	0.346	0.310	0.275

Trend and Correlation Analysis for LIBORUSD



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	0.9587	0.9046	0.55	0.8341		
	2	0.6925	0.8520	0.35	0.7860		
	3	0.5173	0.8100	0.24	0.7559		
	4	0.2487	0.7414	0.10	0.7149		
	5	-0.2000	0.6366	-0.07	0.6584		
	10	-3.2960	0.2113	-0.51	0.4924		
	20	-2.3119	0.2955	-0.36	0.5518		
Single Mean	1	-0.7578	0.9065	-0.31	0.9204	0.63	0.9113
	2	-1.4068	0.8446	-0.50	0.8866	0.63	0.9124
	3	-1.8854	0.7908	-0.62	0.8626	0.65	0.9052
	4	-2.6422	0.6985	-0.77	0.8260	0.71	0.8900
	5	-4.0557	0.5296	-0.99	0.7576	0.88	0.8471
	10	-20.2573	0.0093	-1.65	0.4550	1.75	0.6249
	20	-87.4256	0.0013	-1.69	0.4345	1.81	0.6096
Trend	1	-3.4619	0.9145	-1.17	0.9128	1.38	0.9010
	2	-4.4192	0.8583	-1.33	0.8782	1.45	0.8885
	3	-5.2158	0.8016	-1.43	0.8495	1.53	0.8712
	4	-6.5626	0.6940	-1.58	0.7979	1.72	0.8347
	5	-8.9843	0.4997	-1.79	0.7041	2.00	0.7772
	10	-75.0202	0.0005	-2.77	0.2121	4.32	0.3143
	20	24.2081	0.9999	-3.60	0.0324	6.94	0.0335

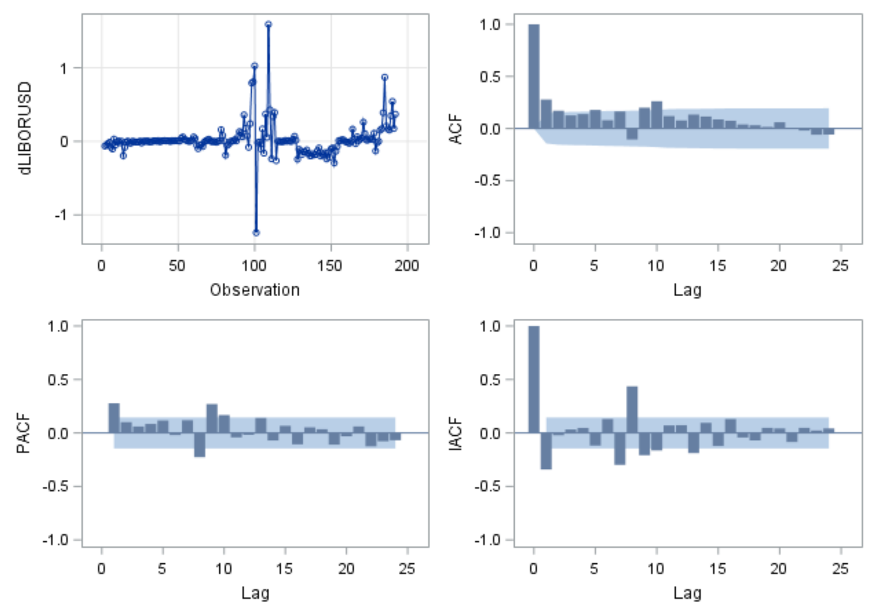
Stationarity analysis on first difference of LIBOR_USD, ΔLIBOR_USD

The ARIMA Procedure

Name of Variable = dLIBORUSD	
Mean of Working Series	0.023159
Standard Deviation	0.230108
Number of Observations	191

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	35.06	6	<.0001	0.278	0.170	0.126	0.138	0.178	0.079
12	68.85	12	<.0001	0.164	-0.105	0.200	0.262	0.119	0.077
18	78.58	18	<.0001	0.134	0.115	0.087	0.074	0.039	0.031
24	81.03	24	<.0001	0.015	0.060	0.005	-0.020	-0.060	-0.059



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-108.212	0.0001	-7.24	<.0001		
	2	-89.4457	<.0001	-5.82	<.0001		
	3	-67.0849	<.0001	-4.72	<.0001		
	4	-45.1972	<.0001	-3.80	0.0002		
	5	-47.0257	<.0001	-3.65	0.0003		
	9	-9.0449	0.0359	-1.45	0.1366		
Single Mean	1	-110.425	0.0001	-7.31	<.0001	26.71	0.0010
	2	-92.1285	0.0013	-5.89	<.0001	17.40	0.0010
	3	-69.6469	0.0013	-4.80	0.0001	11.56	0.0010
	4	-47.2751	0.0013	-3.88	0.0027	7.60	0.0010
	5	-49.5867	0.0013	-3.74	0.0043	7.08	0.0010
	9	-9.9059	0.1329	-1.56	0.5026	1.44	0.7044
Trend	1	-112.959	0.0001	-7.38	<.0001	27.28	0.0010
	2	-95.0240	0.0006	-5.98	<.0001	17.89	0.0010
	3	-72.2844	0.0005	-4.88	0.0005	11.98	0.0010
	4	-49.2033	0.0005	-3.96	0.0116	7.92	0.0114
	5	-51.6719	0.0005	-3.81	0.0179	7.34	0.0231
	9	-10.3656	0.4011	-1.63	0.7794	1.69	0.8402

6.6.7 Variable: NIBOR

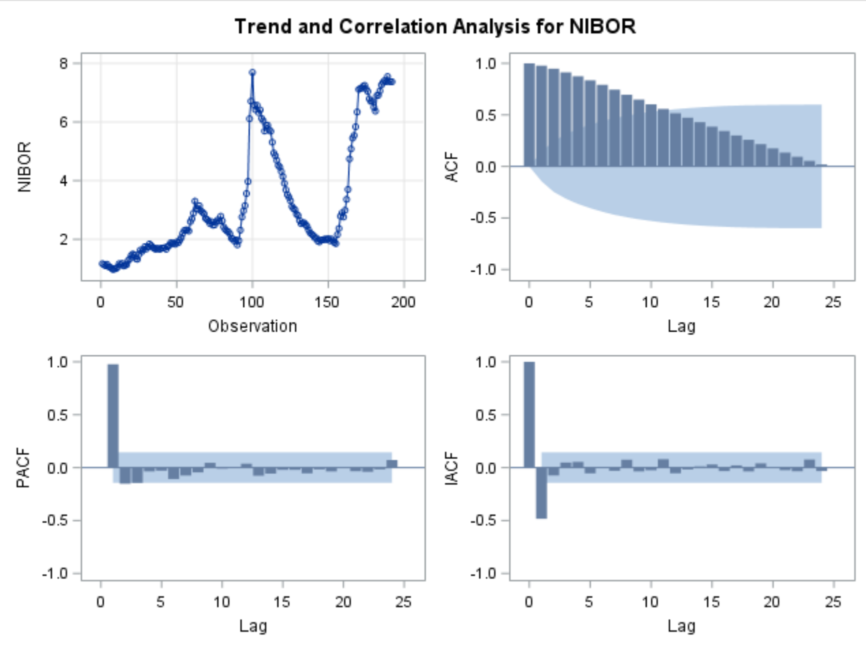
Stationarity analysis on NIBOR

The ARIMA Procedure

Name of Variable = NIBOR	
Mean of Working Series	3.28
Standard Deviation	1.991534
Number of Observations	192

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	942.64	6	<.0001	0.977	0.948	0.913	0.875	0.835	0.792
12	1431.30	12	<.0001	0.745	0.696	0.649	0.602	0.558	0.516
18	1606.07	18	<.0001	0.473	0.429	0.386	0.343	0.300	0.258
24	1629.29	24	<.0001	0.216	0.175	0.134	0.093	0.054	0.019



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	0.8697	0.8888	0.62	0.8496		
	2	0.1600	0.7196	0.09	0.7091		
	3	0.5557	0.8196	0.33	0.7811		
	4	0.4441	0.7914	0.25	0.7586		
	5	-0.5596	0.5564	-0.24	0.6003		
Single Mean	1	-2.0193	0.7749	-0.75	0.8312	0.98	0.8215
	2	-4.9434	0.4367	-1.34	0.6115	1.31	0.7358
	3	-3.4268	0.6025	-1.04	0.7397	1.05	0.8028
	4	-4.2042	0.5133	-1.17	0.6861	1.19	0.7687
	5	-9.2889	0.1549	-1.81	0.3756	1.95	0.5739
Trend	1	-6.1127	0.7309	-1.63	0.7760	1.53	0.8714
	2	-11.7251	0.3189	-2.27	0.4463	2.68	0.6425
	3	-9.1897	0.4845	-1.96	0.6175	2.08	0.7617
	4	-10.7184	0.3787	-2.08	0.5535	2.28	0.7226
	5	-22.1515	0.0391	-2.82	0.1919	4.03	0.3727

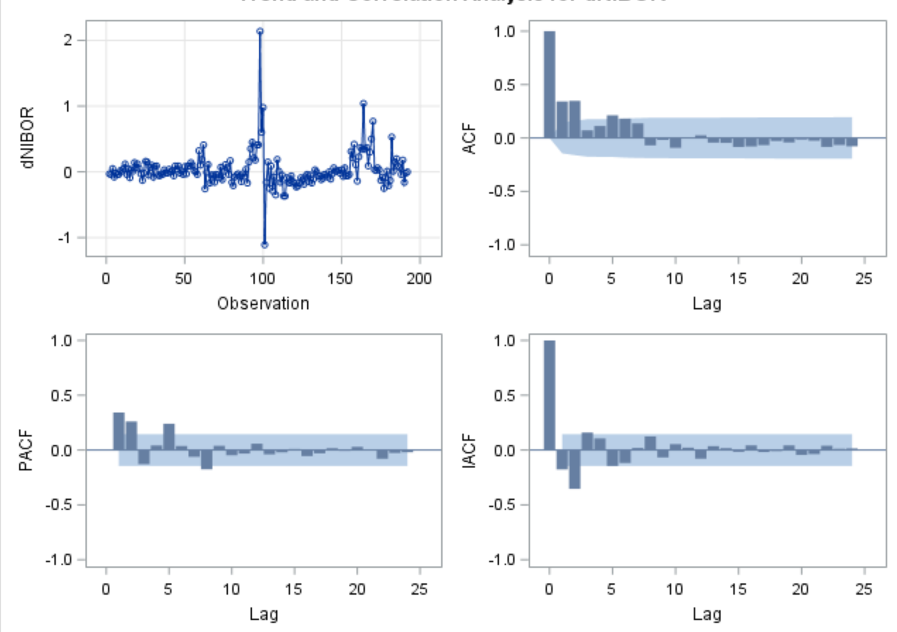
Stationarity analysis on first difference of NIBOR, $\Delta NIBOR$

The ARIMA Procedure

Name of Variable = dNIBOR	
Mean of Working Series	0.032461
Standard Deviation	0.263694
Number of Observations	191

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	65.29	6	<.0001	0.342	0.348	0.072	0.112	0.213	0.181
12	71.92	12	<.0001	0.137	-0.069	-0.018	-0.092	-0.001	0.025
18	76.63	18	<.0001	-0.043	-0.046	-0.084	-0.079	-0.067	-0.027
24	80.96	24	<.0001	-0.042	-0.014	-0.025	-0.083	-0.065	-0.078



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-70.8753	<.0001	-5.92	<.0001		
	2	-95.3488	<.0001	-6.12	<.0001		
	3	-82.4316	<.0001	-5.29	<.0001		
	4	-39.4290	<.0001	-3.82	0.0002		
	5	-35.0990	<.0001	-3.51	0.0005		
	7	-82.5814	<.0001	-4.09	<.0001		
Single Mean	1	-72.8494	0.0013	-5.99	<.0001	17.94	0.0010
	2	-99.4396	0.0013	-6.20	<.0001	19.22	0.0010
	3	-87.2996	0.0013	-5.38	<.0001	14.49	0.0010
	4	-41.7851	0.0013	-3.89	0.0026	7.58	0.0010
	5	-37.4754	0.0013	-3.59	0.0070	6.43	0.0030
	7	-93.9573	0.0013	-4.20	0.0010	8.80	0.0010
Trend	1	-73.3959	0.0006	-5.99	<.0001	17.95	0.0010
	2	-100.830	0.0001	-6.21	<.0001	19.30	0.0010
	3	-88.7461	0.0005	-5.39	<.0001	14.54	0.0010
	4	-42.3567	0.0005	-3.89	0.0142	7.59	0.0181
	5	-38.0415	0.0009	-3.59	0.0339	6.44	0.0473
	7	-97.1956	0.0005	-4.20	0.0055	8.83	0.0010

6.6.8 Variable: INDPRO_I44

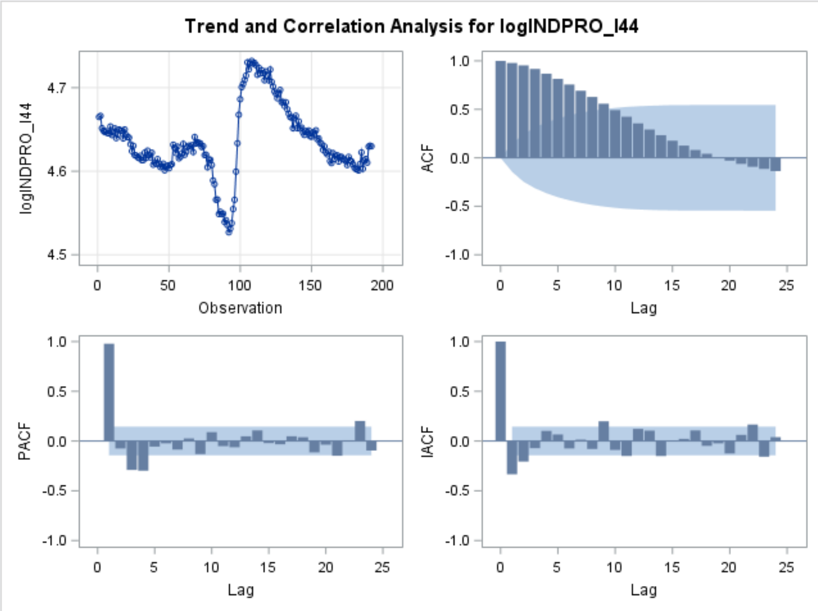
Stationarity analysis on logINDPRO_I44

PROC ARIMA: Variable =logINDPRO_I44

The ARIMA Procedure

Name of Variable = logINDPRO_I44	
Mean of Working Series	4.635955
Standard Deviation	0.042909
Number of Observations	192

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	926.52	6	<.0001	0.978	0.954	0.917	0.868	0.815	0.756
12	1278.66	12	<.0001	0.692	0.628	0.558	0.492	0.424	0.355
18	1319.37	18	<.0001	0.292	0.233	0.176	0.126	0.081	0.041
24	1329.37	24	<.0001	0.004	-0.029	-0.063	-0.093	-0.115	-0.137



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.0083	0.6801	-0.30	0.5781		
	2	-0.0037	0.6812	-0.09	0.6506		
	3	0.0025	0.6826	0.05	0.6971		
	4	0.0014	0.6823	0.03	0.6905		
	5	-0.0025	0.6814	-0.05	0.6655		
Single Mean	1	-4.8080	0.4501	-1.58	0.4908	1.29	0.7422
	2	-9.1097	0.1620	-2.09	0.2485	2.19	0.5132
	3	-18.5999	0.0144	-2.87	0.0507	4.14	0.0802
	4	-20.7758	0.0082	-2.94	0.0435	4.31	0.0693
	5	-20.3253	0.0092	-2.84	0.0555	4.03	0.0869
Trend	1	-4.9227	0.8234	-1.61	0.7856	1.35	0.9073
	2	-9.1858	0.4848	-2.10	0.5448	2.20	0.7387
	3	-18.7618	0.0812	-2.88	0.1714	4.15	0.3485
	4	-21.0421	0.0499	-2.95	0.1501	4.35	0.3089
	5	-20.7575	0.0530	-2.86	0.1771	4.11	0.3563

Stationarity analysis on first difference of logINDPRO_I44, Δ INDPRO_I44

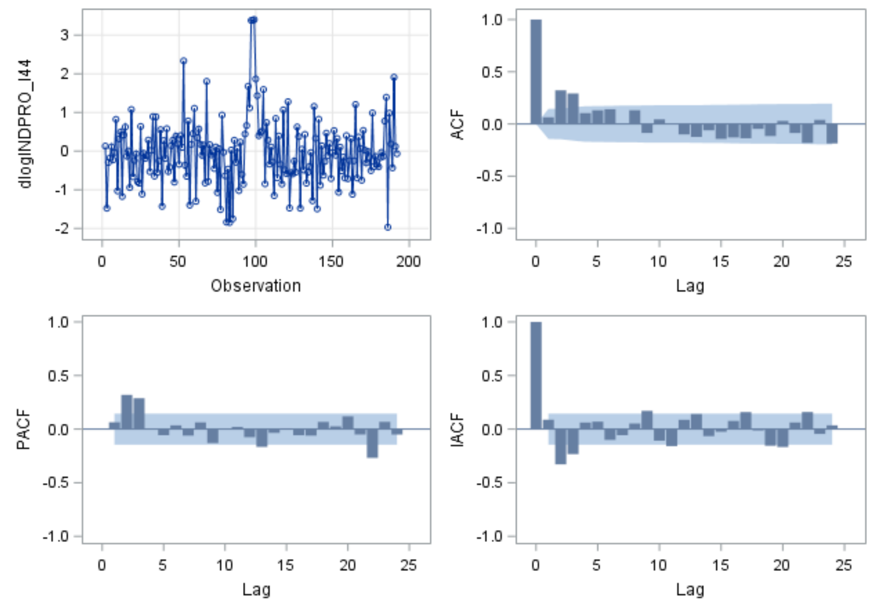
PROC ARIMA: Variable =dlogINDPRO_I44

The ARIMA Procedure

Name of Variable = dlogINDPRO_I44	
Mean of Working Series	-0.01833
Standard Deviation	0.873678
Number of Observations	191

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	47.31	6	<.0001	0.064	0.322	0.292	0.104	0.131	0.141
12	54.73	12	<.0001	-0.002	0.131	-0.086	0.044	0.000	-0.100
18	70.85	18	<.0001	-0.124	-0.060	-0.143	-0.129	-0.136	-0.047
24	90.70	24	<.0001	-0.115	0.029	-0.086	-0.181	0.039	-0.186

Trend and Correlation Analysis for dlogINDPRO_I44



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-90.9857	<.0001	-6.76	<.0001		
	2	-44.2892	<.0001	-4.45	<.0001		
	3	-43.8569	<.0001	-4.18	<.0001		
	4	-51.1841	<.0001	-4.18	<.0001		
	5	-45.4601	<.0001	-3.82	0.0002		
	10	-66.0076	<.0001	-3.39	0.0008		
	20	-704.411	0.0001	-2.76	0.0060		
Single Mean	1	-91.0227	0.0013	-6.74	<.0001	22.73	0.0010
	2	-44.2546	0.0013	-4.43	0.0004	9.83	0.0010
	3	-43.8238	0.0013	-4.16	0.0011	8.67	0.0010
	4	-51.2082	0.0013	-4.17	0.0010	8.70	0.0010
	5	-45.4658	0.0013	-3.81	0.0035	7.25	0.0010
	10	-66.2655	0.0013	-3.38	0.0132	5.71	0.0191
	20	-690.949	0.0001	-2.74	0.0698	3.78	0.1089
Trend	1	-91.0388	0.0006	-6.72	<.0001	22.60	0.0010
	2	-44.2532	0.0006	-4.42	0.0026	9.75	0.0010
	3	-43.8285	0.0005	-4.15	0.0064	8.61	0.0010
	4	-51.2246	0.0005	-4.16	0.0063	8.65	0.0010
	5	-45.4616	0.0005	-3.79	0.0189	7.21	0.0262
	10	-66.0407	0.0005	-3.37	0.0595	5.69	0.0842
	20	-696.040	0.0001	-2.73	0.2260	3.73	0.4324

6.6.9 Variable: INDPRO_USD

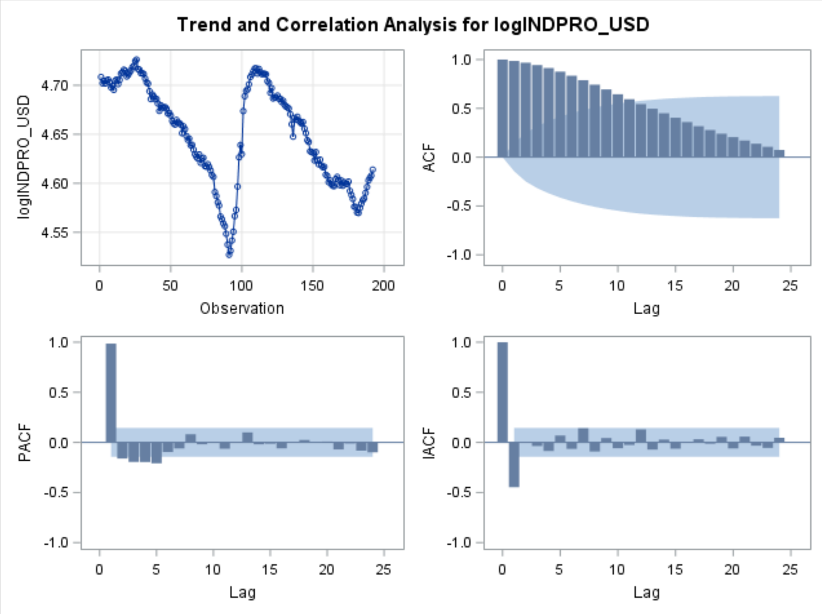
Stationarity analysis on logINDPRO_USD

PROC ARIMA: Variable =logINDPRO_USD

The ARIMA Procedure

Name of Variable = logINDPRO_USD	
Mean of Working Series	4.650525
Standard Deviation	0.050496
Number of Observations	192

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1006.07	6	<.0001	0.986	0.968	0.944	0.913	0.876	0.834
12	1559.69	12	<.0001	0.789	0.743	0.694	0.645	0.594	0.544
18	1753.00	18	<.0001	0.496	0.450	0.404	0.360	0.317	0.278
24	1788.67	24	<.0001	0.240	0.205	0.170	0.138	0.106	0.074



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-0.0184	0.6778	-0.70	0.4142		
	2	-0.0187	0.6777	-0.55	0.4750		
	3	-0.0162	0.6783	-0.36	0.5519		
	4	-0.0162	0.6783	-0.29	0.5800		
	5	-0.0168	0.6781	-0.29	0.5790		
Single Mean	1	-3.2015	0.6297	-1.31	0.6247	1.09	0.7919
	2	-5.3029	0.4027	-1.67	0.4446	1.54	0.6781
	3	-9.2751	0.1555	-2.13	0.2337	2.32	0.4786
	4	-16.1968	0.0269	-2.71	0.0738	3.72	0.1231
	5	-19.3903	0.0117	-2.87	0.0512	4.16	0.0789
Trend	1	-4.1837	0.8735	-1.42	0.8514	1.04	0.9624
	2	-7.0001	0.6579	-1.82	0.6924	1.69	0.8396
	3	-12.8991	0.2584	-2.40	0.3789	2.90	0.5973
	4	-23.0957	0.0317	-3.03	0.1267	4.66	0.2470
	5	-28.4538	0.0093	-3.19	0.0887	5.18	0.1414

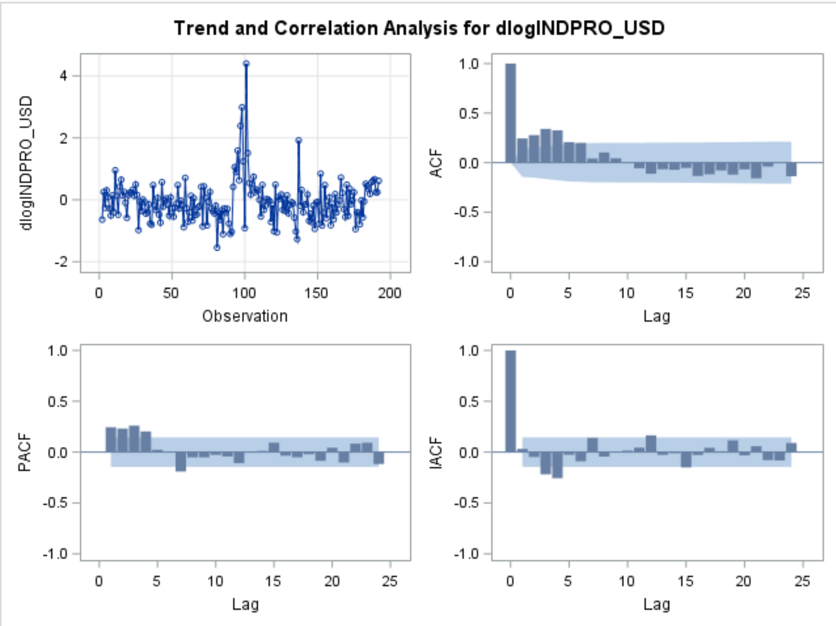
Stationarity analysis on first difference of logINDPRO_USD, Δ INDPRO_USD

PROC ARIMA: Variable =dlogINDPRO_USD

The ARIMA Procedure

Name of Variable = dlogINDPRO_USD	
Mean of Working Series	-0.04944
Standard Deviation	0.687125
Number of Observations	191

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	86.87	6	<.0001	0.245	0.278	0.341	0.327	0.207	0.200
12	92.96	12	<.0001	0.042	0.102	0.044	-0.001	-0.056	-0.112
18	103.65	18	<.0001	-0.067	-0.072	-0.053	-0.135	-0.117	-0.079
24	117.73	24	<.0001	-0.121	-0.068	-0.158	-0.039	0.003	-0.137



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-87.3876	<.0001	-6.55	<.0001		
	2	-46.1774	<.0001	-4.48	<.0001		
	3	-27.4167	<.0001	-3.39	0.0008		
	4	-25.3754	0.0002	-3.16	0.0017		
	5	-25.1202	0.0002	-3.04	0.0025		
	6	-45.0745	<.0001	-3.62	0.0004		
Single Mean	1	-88.2486	0.0013	-6.56	<.0001	21.55	0.0010
	2	-46.6598	0.0013	-4.48	0.0004	10.04	0.0010
	3	-27.7264	0.0014	-3.39	0.0129	5.74	0.0184
	4	-25.7247	0.0023	-3.16	0.0242	5.01	0.0385
	5	-25.4707	0.0025	-3.04	0.0335	4.64	0.0498
	6	-46.0650	0.0013	-3.62	0.0063	6.57	0.0010
Trend	1	-88.3332	0.0006	-6.55	<.0001	21.47	0.0010
	2	-46.7089	0.0006	-4.47	0.0022	10.00	0.0010
	3	-27.7599	0.0109	-3.38	0.0570	5.77	0.0802
	4	-25.7242	0.0175	-3.16	0.0964	5.05	0.1674
	5	-25.4273	0.0187	-3.03	0.1262	4.65	0.2477
	6	-45.9455	0.0005	-3.61	0.0317	6.53	0.0447

6.6.10 Variable: INDPRO_NOK

Stationarity analysis on logINDPRO_NOK

PROC ARIMA: Variable =logINDPRO_NOK

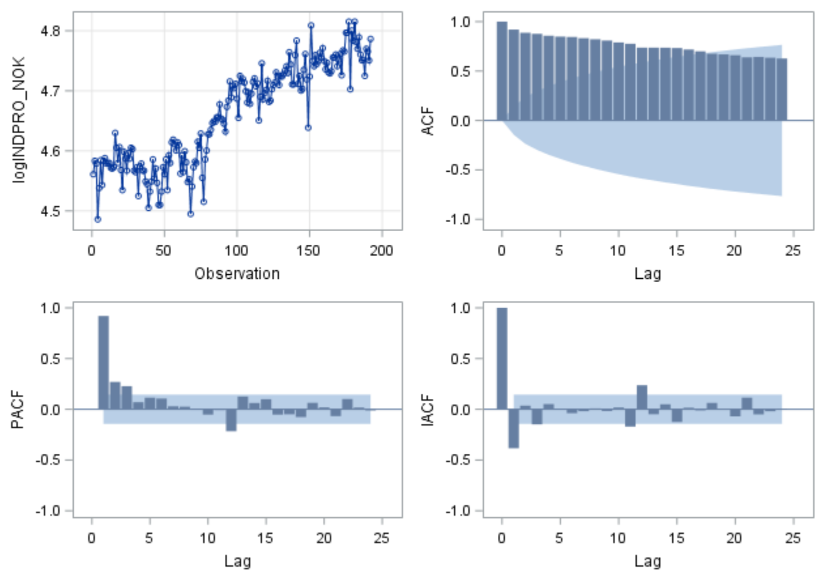
The ARIMA Procedure

Name of Variable = logINDPRO_NOK	
Mean of Working Series	4.660087
Standard Deviation	0.08364
Number of Observations	192

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	902.37	6	<.0001	0.919	0.887	0.876	0.857	0.848	0.845
12	1675.55	12	<.0001	0.832	0.822	0.809	0.789	0.776	0.737
18	2325.75	18	<.0001	0.737	0.736	0.733	0.718	0.699	0.675
24	2871.74	24	<.0001	0.668	0.660	0.639	0.643	0.635	0.627

Trend and Correlation Analysis for logINDPRO_NOK



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	0.0407	0.6914	0.60	0.8440		
	2	0.0412	0.6915	0.81	0.8857		
	3	0.0510	0.6938	1.21	0.9421		
	4	0.0482	0.6931	1.33	0.9541		
	5	0.0444	0.6922	1.43	0.9617		
	10	0.0408	0.6913	1.56	0.9709		
	20	0.0412	0.6913	1.56	0.9706		
Single Mean	1	-7.1104	0.2635	-1.80	0.3786	1.82	0.6064
	2	-3.8666	0.5511	-1.29	0.6341	1.18	0.7702
	3	-3.3253	0.6147	-1.33	0.6161	1.65	0.6509
	4	-2.4111	0.7271	-1.12	0.7074	1.55	0.6770
	5	-1.5769	0.8261	-0.86	0.8005	1.40	0.7133
	10	-0.8756	0.8964	-0.57	0.8725	1.39	0.7156
	20	-0.8641	0.8974	-0.56	0.8752	1.38	0.7197
Trend	1	-58.0237	0.0006	-5.39	<.0001	14.57	0.0010
	2	-39.2179	0.0007	-4.24	0.0048	9.02	0.0010
	3	-28.1718	0.0099	-3.43	0.0502	5.91	0.0728
	4	-21.9898	0.0405	-2.98	0.1413	4.44	0.2897
	5	-17.1151	0.1140	-2.63	0.2658	3.47	0.4842
	10	-15.7799	0.1488	-2.37	0.3962	2.81	0.6152
	20	-33.9639	0.0024	-2.38	0.3877	2.84	0.6100

Stationarity analysis on first difference of logINDPRO_NOK, Δ INDPRO_NOK

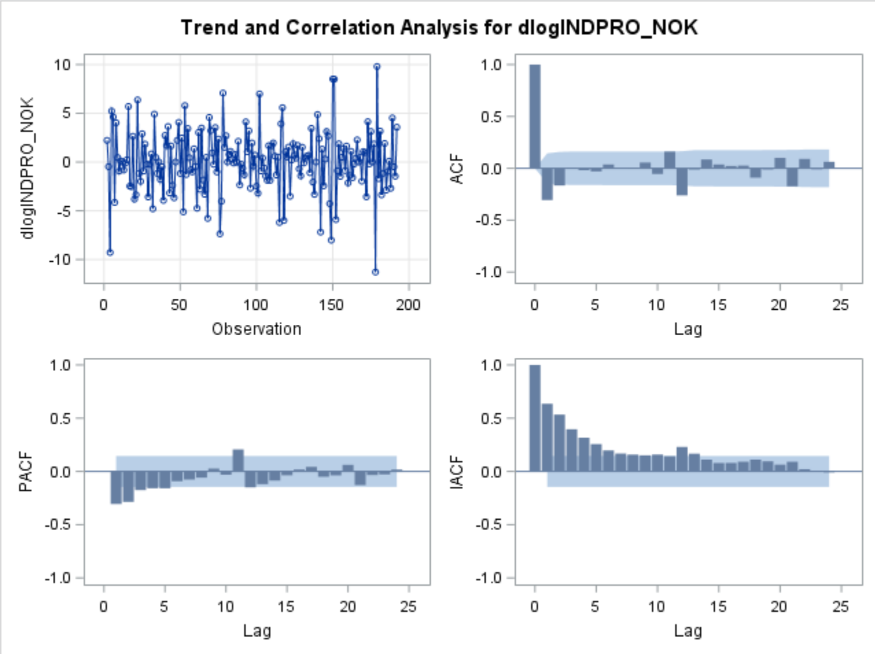
PROC ARIMA: Variable =dlogINDPRO_NOK

The ARIMA Procedure

Name of Variable = dlogINDPRO_NOK	
Mean of Working Series	0.117946
Standard Deviation	3.156444
Number of Observations	191

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	24.04	6	0.0005	-0.306	-0.166	0.007	-0.018	-0.030	0.037
12	44.65	12	<.0001	0.003	-0.005	0.056	-0.054	0.161	-0.261
18	48.46	18	0.0001	-0.012	0.085	0.037	0.022	0.026	-0.090
24	59.86	24	<.0001	-0.011	0.101	-0.174	0.090	-0.009	0.063



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-444.048	0.0001	-14.79	<.0001		
	2	-1126.69	0.0001	-12.06	<.0001		
	3	1322.580	0.9999	-10.39	<.0001		
	4	380.3476	0.9999	-9.50	<.0001		
	5	255.2870	0.9999	-8.39	<.0001		
	10	-125.166	0.0001	-3.81	0.0002		
	20	78.7425	0.9999	-3.19	0.0016		
Single Mean	1	-447.001	0.0001	-14.80	<.0001	109.59	0.0010
	2	-1194.99	0.0001	-12.13	<.0001	73.65	0.0010
	3	1169.939	0.9999	-10.50	<.0001	55.17	0.0010
	4	357.6856	0.9999	-9.64	<.0001	46.43	0.0010
	5	236.5859	0.9999	-8.58	<.0001	36.81	0.0010
	10	-217.809	0.0001	-3.97	0.0020	7.91	0.0010
	20	40.8450	0.9999	-3.66	0.0056	6.70	0.0010
Trend	1	-447.078	0.0001	-14.77	<.0001	109.05	0.0010
	2	-1193.46	0.0001	-12.10	<.0001	73.23	0.0010
	3	1169.646	0.9999	-10.47	<.0001	54.86	0.0010
	4	357.7152	0.9999	-9.61	<.0001	46.18	0.0010
	5	236.4683	0.9999	-8.56	<.0001	36.60	0.0010
	10	-218.712	0.0001	-3.96	0.0116	7.85	0.0127
	20	40.0195	0.9999	-3.66	0.0282	6.71	0.0400

6.6.11 Variable: CPI_I44

Stationarity analysis on CPI_I44

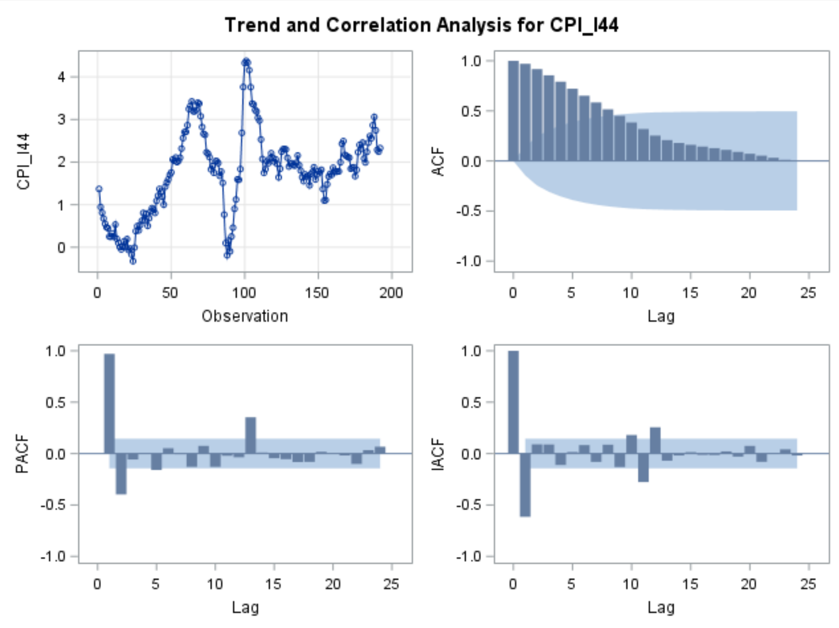
PROC ARIMA: Variable =CPI_I44

The ARIMA Procedure

Name of Variable = CPI_I44	
Mean of Working Series	1.74772
Standard Deviation	0.986844
Number of Observations	192

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	805.50	6	<.0001	0.970	0.918	0.855	0.791	0.721	0.652
12	1033.81	12	<.0001	0.584	0.516	0.450	0.384	0.319	0.253
18	1065.50	18	<.0001	0.208	0.180	0.161	0.144	0.128	0.110
24	1069.23	24	<.0001	0.090	0.072	0.053	0.032	0.011	-0.000



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-2.3082	0.2960	-0.94	0.3074		
	2	-2.4566	0.2810	-0.97	0.2949		
	3	-1.9823	0.3321	-0.84	0.3523		
	4	-2.8404	0.2462	-1.04	0.2697		
	5	-2.3682	0.2898	-0.92	0.3162		
	10	-2.4483	0.2818	-0.90	0.3268		
	20	-0.2649	0.6217	-0.16	0.6263		
Single Mean	1	-12.9740	0.0618	-2.57	0.1017	3.36	0.2148
	2	-14.3474	0.0435	-2.64	0.0870	3.54	0.1679
	3	-13.1107	0.0596	-2.49	0.1198	3.17	0.2622
	4	-19.4521	0.0115	-2.95	0.0425	4.41	0.0632
	5	-17.8798	0.0174	-2.77	0.0649	3.92	0.0935
	10	-34.6846	0.0013	-3.15	0.0251	5.06	0.0368
	20	-27.9982	0.0013	-2.77	0.0657	4.21	0.0757
Trend	1	-16.4256	0.1313	-2.84	0.1856	4.04	0.3700
	2	-18.5610	0.0848	-2.94	0.1535	4.32	0.3134
	3	-17.0395	0.1159	-2.76	0.2159	3.81	0.4160
	4	-25.4511	0.0186	-3.21	0.0858	5.20	0.1389
	5	-23.7998	0.0271	-3.03	0.1273	4.62	0.2533
	10	-60.9456	0.0005	-3.44	0.0499	5.99	0.0684
	20	-50.1537	0.0005	-2.76	0.2156	4.12	0.3530

Stationarity analysis on first difference of CPI_I44, Δ CPI_I44

PROC ARIMA: Variable =dCPI_I44

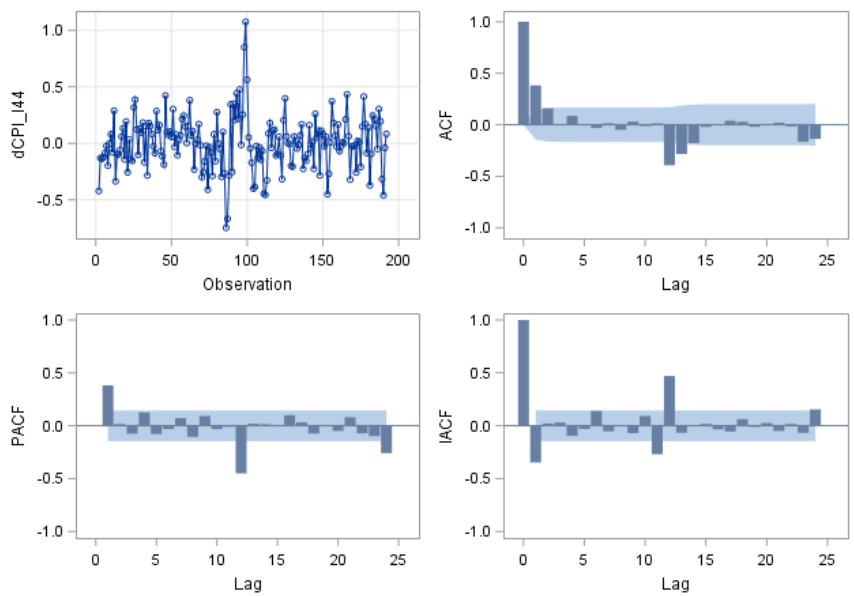
The ARIMA Procedure

Name of Variable = dCPI_I44	
Mean of Working Series	0.005029
Standard Deviation	0.236888
Number of Observations	191

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	34.96	6	<.0001	0.382	0.160	0.002	0.086	-0.003	-0.030
12	67.64	12	<.0001	0.015	-0.049	0.030	-0.012	0.014	-0.394
18	91.54	18	<.0001	-0.284	-0.177	-0.021	-0.002	0.040	0.028
24	101.94	24	<.0001	-0.020	0.001	0.020	-0.016	-0.166	-0.137

Trend and Correlation Analysis for dCPI_I44



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-112.813	0.0001	-7.51	<.0001		
	2	-138.513	0.0001	-7.08	<.0001		
	3	-91.8377	<.0001	-5.51	<.0001		
	4	-121.060	0.0001	-5.47	<.0001		
	5	-142.088	0.0001	-5.21	<.0001		
	10	-114.298	0.0001	-3.73	0.0002		
	20	123.1745	0.9999	-3.04	0.0025		
Single Mean	1	-112.989	0.0001	-7.50	<.0001	28.14	0.0010
	2	-139.065	0.0001	-7.08	<.0001	25.05	0.0010
	3	-92.4740	0.0013	-5.51	<.0001	15.19	0.0010
	4	-122.352	0.0001	-5.47	<.0001	14.96	0.0010
	5	-144.277	0.0001	-5.22	<.0001	13.60	0.0010
	10	-117.897	0.0001	-3.74	0.0044	6.98	0.0010
	20	99.3161	0.9999	-3.12	0.0270	4.89	0.0419
Trend	1	-112.982	0.0001	-7.48	<.0001	28.00	0.0010
	2	-138.974	0.0001	-7.06	<.0001	24.93	0.0010
	3	-92.2775	0.0005	-5.50	<.0001	15.16	0.0010
	4	-122.013	0.0001	-5.46	<.0001	14.92	0.0010
	5	-143.898	0.0001	-5.20	0.0002	13.57	0.0010
	10	-118.686	0.0001	-3.73	0.0228	6.96	0.0330
	20	87.2077	0.9999	-3.19	0.0906	5.09	0.1592

6.6.12 Variable: CPI_USD

Stationarity analysis on CPI_USD

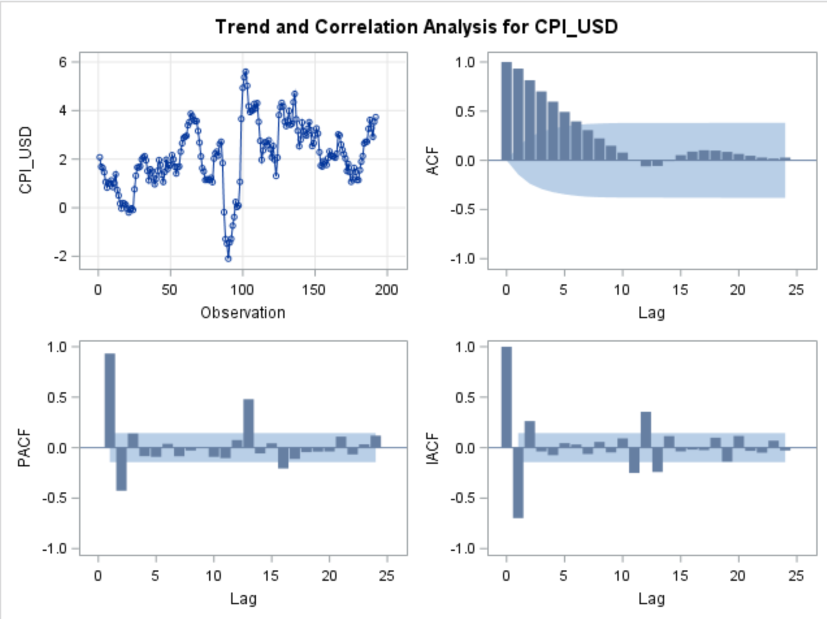
PROC ARIMA: Variable =CPI_USD

The ARIMA Procedure

Name of Variable = CPI_USD	
Mean of Working Series	2.105786
Standard Deviation	1.34571
Number of Observations	192

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	546.89	6	<.0001	0.933	0.815	0.701	0.597	0.493	0.396
12	582.50	12	<.0001	0.307	0.223	0.149	0.079	0.004	-0.061
18	589.82	18	<.0001	-0.058	-0.007	0.053	0.089	0.103	0.099
24	593.24	24	<.0001	0.086	0.065	0.047	0.028	0.018	0.028



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-7.6716	0.0544	-1.82	0.0659		
	2	-4.9141	0.1264	-1.42	0.1448		
	3	-5.0294	0.1220	-1.41	0.1474		
	4	-5.5524	0.1039	-1.46	0.1352		
	5	-4.4136	0.1477	-1.27	0.1873		
	10	-4.9652	0.1244	-1.28	0.1856		
	20	-0.6762	0.5322	-0.37	0.5484		
Single Mean	1	-31.6694	0.0013	-3.89	0.0027	7.58	0.0010
	2	-22.5539	0.0052	-3.17	0.0238	5.05	0.0373
	3	-26.0789	0.0022	-3.28	0.0173	5.43	0.0256
	4	-34.0068	0.0013	-3.56	0.0076	6.39	0.0038
	5	-30.4120	0.0013	-3.29	0.0170	5.47	0.0246
	10	-139.165	0.0001	-3.77	0.0039	7.18	0.0010
	20	-39.5753	0.0013	-2.62	0.0907	3.61	0.1517
Trend	1	-38.5697	0.0008	-4.33	0.0035	9.41	0.0010
	2	-28.5927	0.0090	-3.60	0.0328	6.50	0.0456
	3	-33.6731	0.0027	-3.71	0.0240	6.90	0.0346
	4	-45.1124	0.0005	-3.99	0.0107	7.94	0.0109
	5	-41.7015	0.0005	-3.70	0.0245	6.86	0.0356
	10	504.8109	0.9999	-4.48	0.0021	10.06	0.0010
	20	1805.567	0.9999	-2.88	0.1713	4.31	0.3153

Stationarity analysis on first difference of CPI_USD, Δ CPI_USD

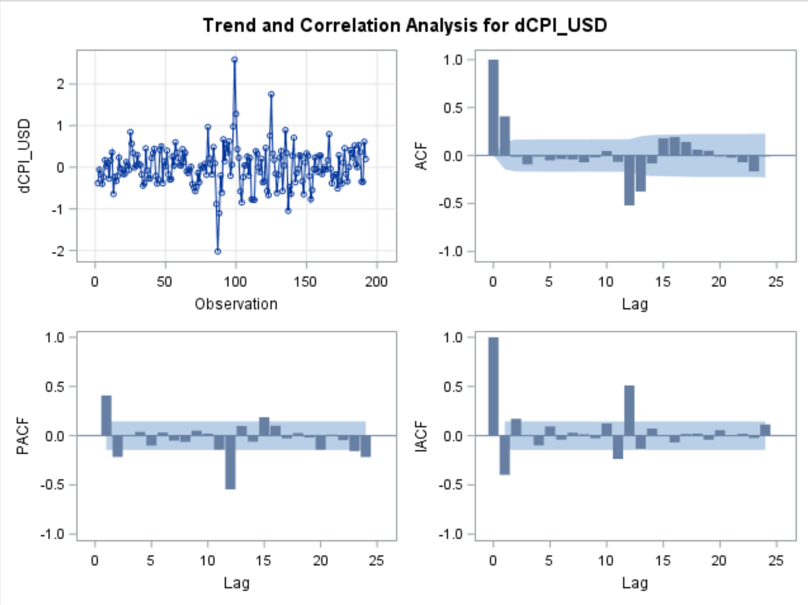
PROC ARIMA: Variable =dCPI_USD

The ARIMA Procedure

Name of Variable = dCPI_USD	
Mean of Working Series	0.008679
Standard Deviation	0.480506
Number of Observations	191

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	34.86	6	<.0001	0.409	-0.013	-0.091	-0.011	-0.050	-0.037
12	93.43	12	<.0001	-0.041	-0.071	-0.020	0.047	-0.066	-0.520
18	143.57	18	<.0001	-0.376	-0.082	0.178	0.192	0.141	0.061
24	151.33	24	<.0001	0.050	-0.009	-0.022	-0.070	-0.165	-0.009



Augmented Dickey-Fuller Unit Root Tests

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-173.477	0.0001	-9.25	<.0001		
	2	-170.265	0.0001	-7.59	<.0001		
	3	-147.556	0.0001	-6.38	<.0001		
	4	-248.751	0.0001	-6.36	<.0001		
	5	-197.504	0.0001	-5.52	<.0001		
	10	306.0560	0.9999	-4.62	<.0001		
	20	45.5465	0.9999	-3.58	0.0004		
Single Mean	1	-173.557	0.0001	-9.22	<.0001	42.55	0.0010
	2	-170.508	0.0001	-7.58	<.0001	28.72	0.0010
	3	-148.012	0.0001	-6.37	<.0001	20.29	0.0010
	4	-250.177	0.0001	-6.36	<.0001	20.21	0.0010
	5	-198.778	0.0001	-5.51	<.0001	15.20	0.0010
	10	302.3851	0.9999	-4.61	0.0002	10.63	0.0010
	20	44.8317	0.9999	-3.61	0.0067	6.53	0.0010
Trend	1	-173.683	0.0001	-9.20	<.0001	42.36	0.0010
	2	-170.717	0.0001	-7.56	<.0001	28.57	0.0010
	3	-148.118	0.0001	-6.35	<.0001	20.17	0.0010
	4	-250.470	0.0001	-6.34	<.0001	20.09	0.0010
	5	-199.116	0.0001	-5.50	<.0001	15.12	0.0010
	10	303.6655	0.9999	-4.60	0.0014	10.58	0.0010
	20	43.0756	0.9999	-3.65	0.0288	6.65	0.0413

6.6.13 Variable: CPI_NOK

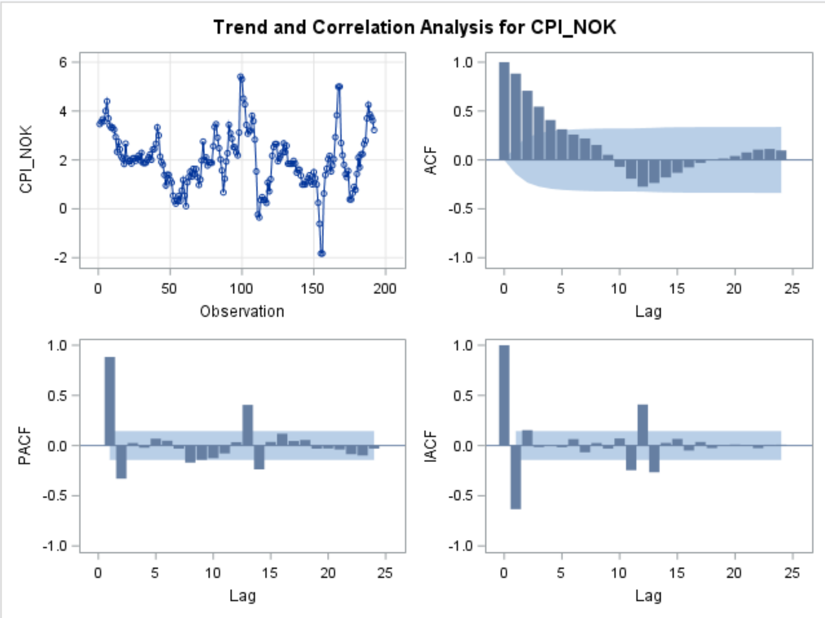
Stationarity analysis on CPI_NOK

PROC ARIMA: Variable =CPI_NOK

The ARIMA Procedure

Name of Variable = CPI_NOK	
Mean of Working Series	2.004955
Standard Deviation	1.172592
Number of Observations	192

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	375.02	6	<.0001	0.883	0.708	0.545	0.409	0.314	0.259
12	414.19	12	<.0001	0.220	0.154	0.052	-0.071	-0.192	-0.274
18	437.54	18	<.0001	-0.236	-0.179	-0.132	-0.076	-0.031	-0.001
24	446.56	24	<.0001	0.014	0.040	0.077	0.106	0.112	0.098



Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-9.9350	0.0276	-2.25	0.0237		
	2	-7.9582	0.0498	-2.00	0.0436		
	3	-7.1306	0.0641	-1.86	0.0596		
	4	-5.3791	0.1095	-1.66	0.0919		
	5	-4.6608	0.1367	-1.58	0.1070		
	10	-6.9331	0.0680	-1.66	0.0921		
	20	-1.1446	0.4478	-0.73	0.4000		
Single Mean	1	-42.9629	0.0013	-4.63	0.0002	10.72	0.0010
	2	-39.6375	0.0013	-4.23	0.0008	8.95	0.0010
	3	-41.6395	0.0013	-4.10	0.0013	8.41	0.0010
	4	-33.4012	0.0013	-3.65	0.0058	6.66	0.0010
	5	-30.8810	0.0013	-3.47	0.0099	6.05	0.0116
	10	205.8572	0.9999	-4.89	0.0001	11.97	0.0010
	20	-41.2260	0.0013	-2.43	0.1362	2.94	0.3206
Trend	1	-43.2791	0.0006	-4.60	0.0014	10.68	0.0010
	2	-39.7668	0.0006	-4.18	0.0058	8.91	0.0010
	3	-41.8061	0.0006	-4.04	0.0090	8.36	0.0024
	4	-32.6848	0.0034	-3.53	0.0390	6.65	0.0415
	5	-29.5325	0.0072	-3.32	0.0662	6.11	0.0623
	10	186.7846	0.9999	-4.83	0.0006	11.94	0.0010
	20	-35.0872	0.0018	-2.29	0.4391	3.00	0.5776

Stationarity analysis on first difference of CPI_NOK, Δ CPI_NOK

PROC ARIMA: Variable =dCPI_NOK

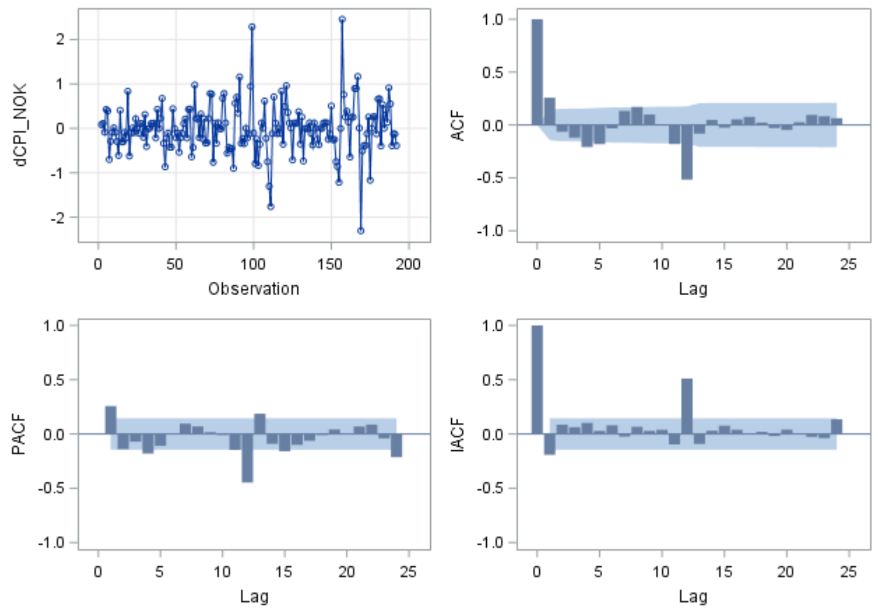
The ARIMA Procedure

Name of Variable = dCPI_NOK	
Mean of Working Series	-0.00129
Standard Deviation	0.551143
Number of Observations	191

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	31.78	6	<.0001	0.257	-0.064	-0.120	-0.209	-0.181	-0.032
12	104.62	12	<.0001	0.132	0.170	0.098	0.006	-0.180	-0.516
18	108.56	18	<.0001	-0.082	0.048	-0.025	0.053	0.077	0.022
24	113.73	24	<.0001	-0.029	-0.047	0.026	0.095	0.082	0.064

Trend and Correlation Analysis for dCPI_NOK

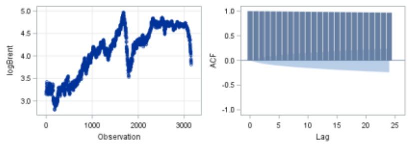
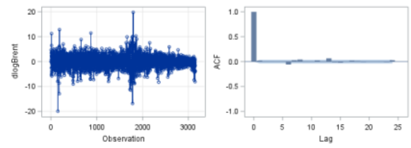
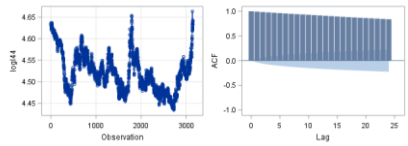
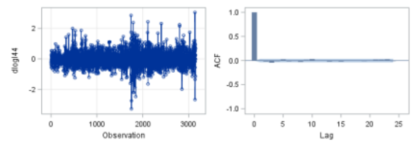
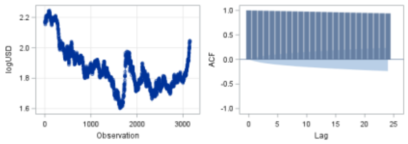
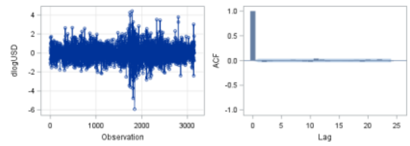
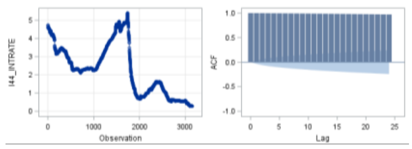
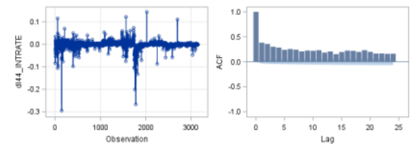
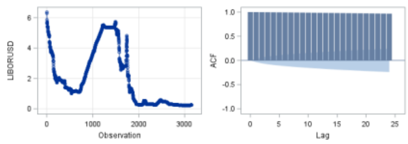
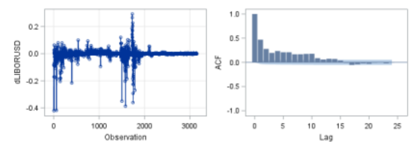
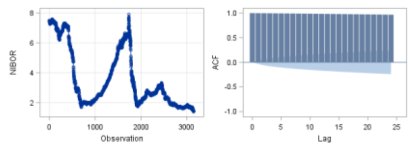
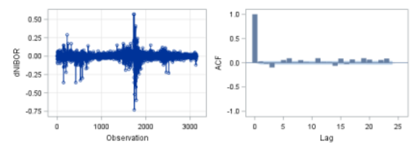


Augmented Dickey-Fuller Unit Root Tests

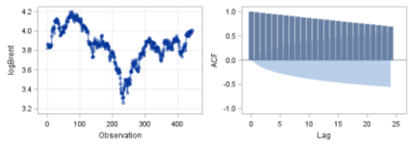
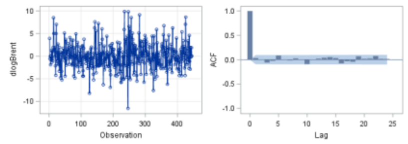
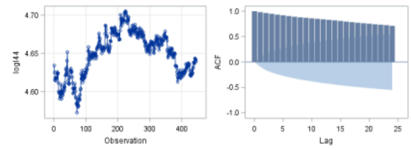
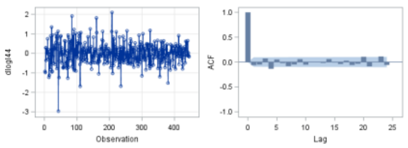
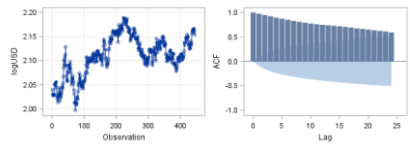
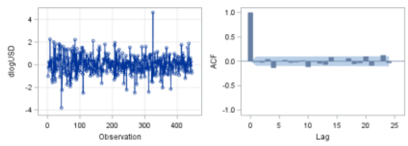
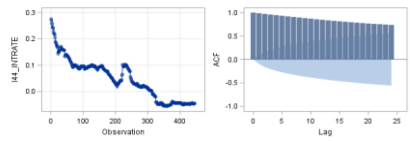
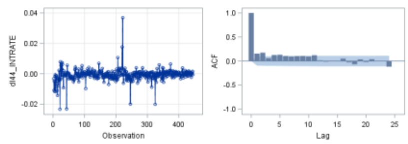
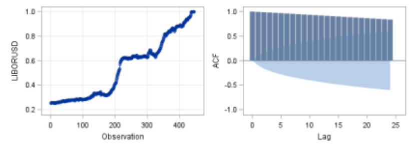
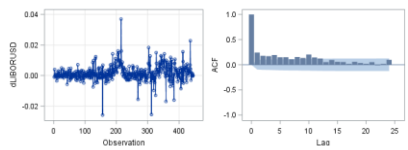
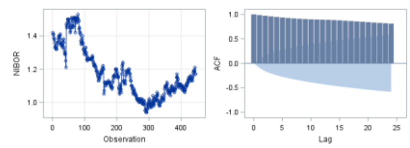
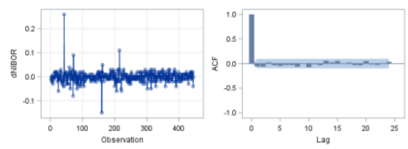
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-185.975	0.0001	-9.58	<.0001		
	2	-230.491	0.0001	-8.37	<.0001		
	3	-728.035	0.0001	-8.52	<.0001		
	4	1912.940	0.9999	-8.04	<.0001		
	5	1998.689	0.9999	-6.84	<.0001		
	10	471.6449	0.9999	-4.52	<.0001		
	20	38.7804	0.9999	-3.75	0.0002		
Single Mean	1	-185.970	0.0001	-9.55	<.0001	45.62	0.0010
	2	-230.481	0.0001	-8.34	<.0001	34.82	0.0010
	3	-727.589	0.0001	-8.49	<.0001	36.09	0.0010
	4	1916.045	0.9999	-8.02	<.0001	32.14	0.0010
	5	1997.735	0.9999	-6.82	<.0001	23.28	0.0010
	10	474.0384	0.9999	-4.50	0.0003	10.14	0.0010
	20	38.7623	0.9999	-3.73	0.0045	7.00	0.0010
Trend	1	-187.105	0.0001	-9.55	<.0001	45.61	0.0010
	2	-233.714	0.0001	-8.35	<.0001	34.88	0.0010
	3	-788.855	0.0001	-8.54	<.0001	36.43	0.0010
	4	1449.036	0.9999	-8.09	<.0001	32.71	0.0010
	5	1369.100	0.9999	-6.88	<.0001	23.65	0.0010
	10	368.9417	0.9999	-4.55	0.0017	10.35	0.0010
	20	36.9804	0.9999	-3.81	0.0184	7.26	0.0249

7. Summary of line and ACF plots

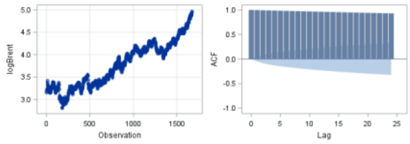
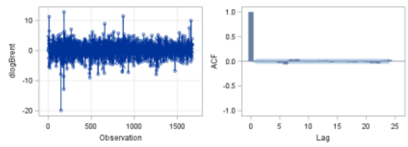
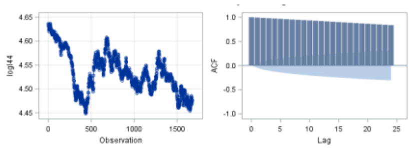
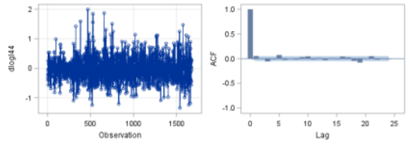
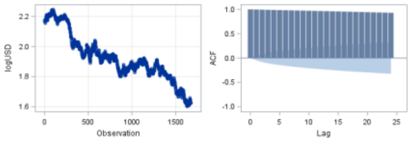
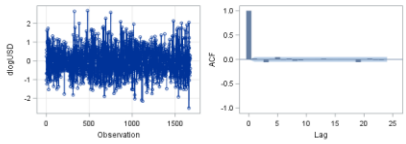
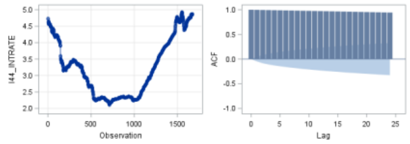
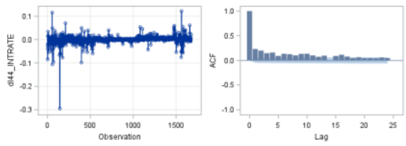
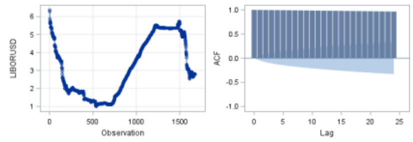
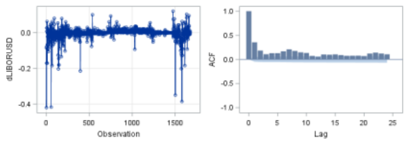
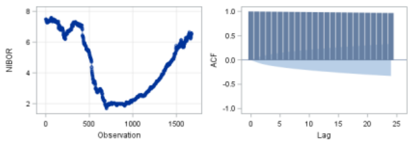
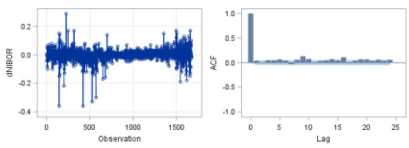
7.1 Sample 2.1

Overview of line and ACF plots Sample 2.1		
Variable	Undifferenced variable	First difference of variable
logBrent		
log I44		
log USD		
I44_INTRATE		
LIBORUSD		
NIBOR		

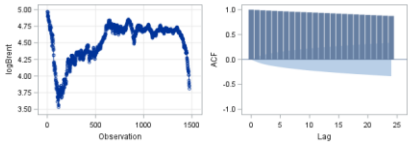
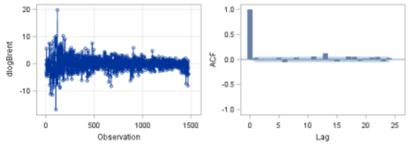
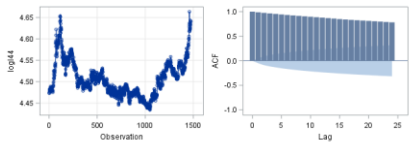
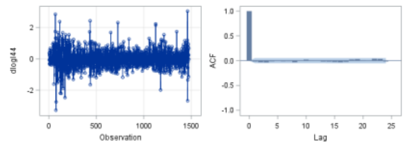
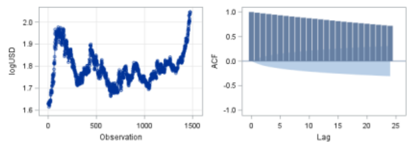
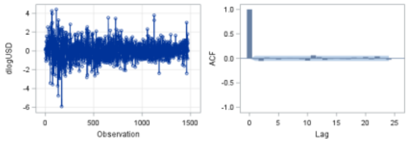
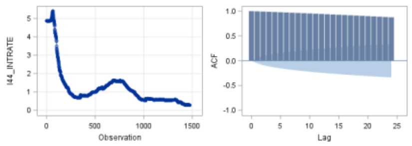
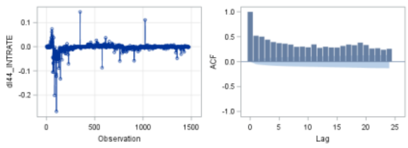
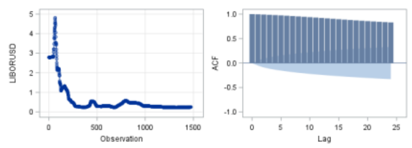
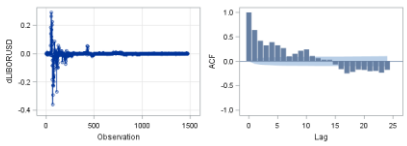
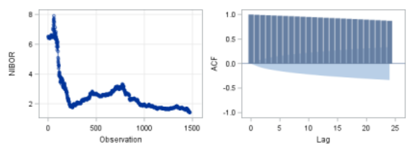
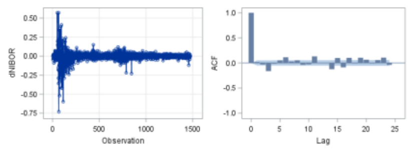
7.2 Sample 2.2

Overview of line and ACF plots Sample 2.2		
Variable	Undifferenced variable	First difference of variable
logBrent		
log I44		
log USD		
I44_INTRATE		
LIBORUSD		
NIBOR		

7.3 Sample 3.1

Overview of line and ACF plots Sample 3.1		
Variable	Undifferenced variable	First difference of variable
logBrent		
log I44		
log USD		
I44_INTRATE		
LIBORUSD		
NIBOR		

7.4 Sample 3.2

Overview of line and ACF plots Sample 3.2		
Variable	Undifferenced variable	First difference of variable
logBrent		
log I44		
log USD		
I44_INTRATE		
LIBORUSD		
NIBOR		

8. Cointegration models

8.1 Sample 2.2 Model 1

8.1.1 Model 1: Cointegration model

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.12849893	DFE	443
MSE	0.0002901	Root MSE	0.01703
SBC	-2351.658	AIC	-2359.8542
MAE	0.01438041	AICC	-2359.827
MAPE	0.30957566	HQC	-2356.6223
Durbin-Watson	0.1081	Total R-Square	0.6451

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	397.3735	<.0001
AR(2)	398.1114	<.0001
AR(3)	398.1199	<.0001
AR(4)	398.2167	<.0001
AR(5)	398.4103	<.0001

Shin Cointegration Test			
Type	Lags	Eta	Pr > Eta
Single Mean	17	0.2913	0.0604
Trend	17	0.2992	0.0005

KERNEL=NW, SCHW=12

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	5.1247	0.0168	304.85	<.0001
logBrent	1	-0.1237	0.004360	-28.38	<.0001

8.1.2 Model 1: Autocorrelation analysis to determine the number of lags in the ADF test

Columns market by stars in correspondence with lag 1-15 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Rows market with green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autcorrelation analysis Sample 2.2															
Number of lags included of the error term to obtain no significant autocorrelation (***, **, * and "insig" represents the statistical significance level of the autocorrelation coefficient)															
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag
Model 1															
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Conclusion: 1 lag

8.1.3 Model 1: ADF test on regression residuals

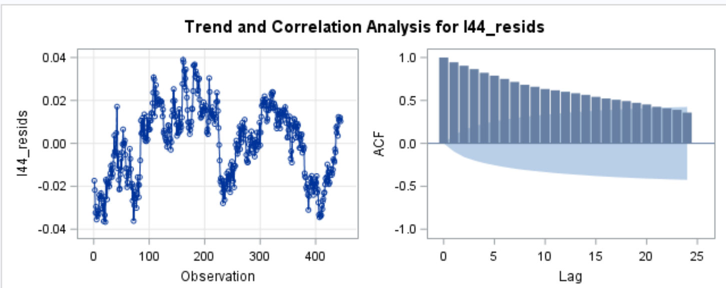
ADF-test on I44 residuals

The ARIMA Procedure

Name of Variable = I44_resids	
Mean of Working Series	2.36E-15
Standard Deviation	0.016993
Number of Observations	445

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1945.31	6	<.0001	0.944	0.904	0.865	0.822	0.789	0.75
12	3112.71	12	<.0001	0.716	0.683	0.659	0.633	0.618	0.60
18	3912.71	18	<.0001	0.584	0.565	0.542	0.523	0.508	0.49
24	4408.95	24	<.0001	0.472	0.453	0.426	0.408	0.390	0.35

Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-19.1561	0.0020	-3.14	0.0018		
	2	-18.9288	0.0022	-3.17	0.0016		
	3	-20.9058	0.0012	-3.28	0.0011		
	4	-18.6030	0.0024	-3.13	0.0018		
	5	-20.3428	0.0014	-3.21	0.0014		
Single Mean	1	-19.1512	0.0137	-3.14	0.0252	4.97	0.0388
	2	-18.9185	0.0145	-3.17	0.0232	5.10	0.0346
	3	-20.8895	0.0089	-3.27	0.0171	5.44	0.0242
	4	-18.5834	0.0157	-3.13	0.0258	5.01	0.0374
	5	-20.3174	0.0103	-3.21	0.0206	5.26	0.0297
Trend	1	-19.1346	0.0801	-3.13	0.1012	4.91	0.1906
	2	-18.8627	0.0847	-3.15	0.0959	5.03	0.1656
	3	-20.8327	0.0563	-3.26	0.0743	5.38	0.0990
	4	-18.5126	0.0909	-3.12	0.1041	4.95	0.1817
	5	-20.2443	0.0637	-3.20	0.0863	5.20	0.1317



8.2 Sample 2.2 - Model 2

8.2.1 Model 2: Cointegration model

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.09038279	DFE	441
MSE	0.0002049	Root MSE	0.01432
SBC	-2496.0426	AIC	-2512.4349
MAE	0.01150908	AICC	-2512.344
MAPE	0.24775141	HQC	-2505.9711
Durbin-Watson	0.1120	Total R-Square	0.7504

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	395.0540	<.0001
AR(2)	395.4775	<.0001
AR(3)	395.5997	<.0001
AR(4)	395.9847	<.0001
AR(5)	396.1015	<.0001

Shin Cointegration Test			
Type	Lags	Eta	Pr > Eta
Single Mean	17	0.2317	0.0175
Trend	17	0.0724	0.0859

KERNEL=NW, SCHW=12

Parameter Estimates						
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|	Variable Label
Intercept	1	5.1189	0.0161	317.51	<.0001	
logBrent	1	-0.0885	0.005020	-17.64	<.0001	
INTDIFF_I44	1	-0.1083	0.008246	-13.13	<.0001	INTDIFF I44
LIBORUSD	1	-0.0142	0.003061	-4.63	<.0001	LIBORUSD

8.2.2 Model 2: Autocorrelation analysis to determine the number of lags in the ADF test

Columns market by stars in correspondence with lag 1-15 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Rows market with green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis Sample 2.2															
Number of lags included of the error term to obtain no significant autocorrelation (***, **, * and "insig" represents the statistical significance level of the autocorrelation coefficient)															
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag
Model 2															
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8.2.3 Model 2: ADF test on regression residuals

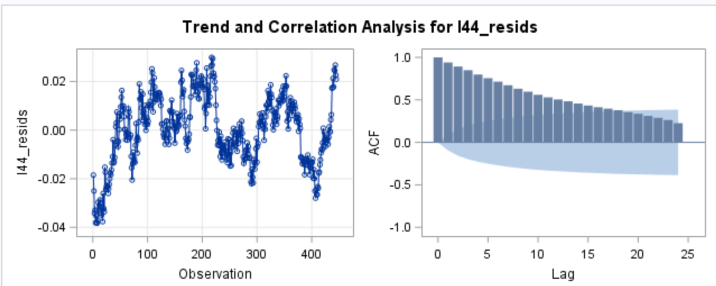
ADF-test on logI44 residuals:

The ARIMA Procedure

Name of Variable = I44_resids	
Mean of Working Series	1.5E-15
Standard Deviation	0.014252
Number of Observations	445

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1853.74	6	<.0001	0.940	0.892	0.849	0.798	0.755	0.714
12	2791.08	12	<.0001	0.672	0.631	0.596	0.560	0.529	0.505
18	3300.96	18	<.0001	0.483	0.457	0.433	0.414	0.396	0.378
24	3554.46	24	<.0001	0.356	0.337	0.312	0.288	0.263	0.226

Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-20.6599	0.0013	-3.24	0.0013		
	2	-18.9044	0.0022	-3.16	0.0016		
	3	-22.9780	0.0006	-3.44	0.0006		
	4	-21.0859	0.0011	-3.34	0.0009		
	5	-21.8821	0.0009	-3.33	0.0009		
Single Mean	1	-20.6388	0.0095	-3.23	0.0193	5.36	0.0267
	2	-18.8629	0.0147	-3.16	0.0237	5.22	0.0310
	3	-22.9046	0.0055	-3.44	0.0106	6.12	0.0090
	4	-20.9916	0.0087	-3.34	0.0141	5.86	0.0148
	5	-21.7673	0.0072	-3.33	0.0146	5.81	0.0160
Trend	1	-20.8744	0.0558	-3.24	0.0777	5.26	0.1202
	2	-18.9445	0.0833	-3.15	0.0966	4.98	0.1756
	3	-22.9835	0.0356	-3.42	0.0496	5.90	0.0714
	4	-20.9794	0.0546	-3.32	0.0649	5.56	0.0892
	5	-21.7646	0.0462	-3.31	0.0659	5.53	0.0910



8.3 Sample 2.2 - Model 3

8.3.1 Model 3: Cointegration model

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.3329937	DFE	443
MSE	0.0007517	Root MSE	0.02742
SBC	-1927.9277	AIC	-1936.1239
MAE	0.02091997	AICC	-1936.0967
MAPE	0.99489043	HQC	-1932.892
Durbin-Watson	0.0976	Total R-Square	0.5621

Godfrey's Serial Correlation Test

Alternative	LM	Pr > LM
AR(1)	395.5415	<.0001
AR(2)	395.6140	<.0001
AR(3)	395.7044	<.0001
AR(4)	395.7971	<.0001
AR(5)	395.9423	<.0001

Shin Cointegration Test

Type	Lags	Eta	Pr > Eta
Single Mean	17	0.6805	0.0036
Trend	17	0.2052	0.0053

KERNEL=NW, SCHW=12

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	2.7542	0.0271	101.77	<.0001
logBrent	1	-0.1674	0.007018	-23.85	<.0001

8.3.2 Model 3: Autocorrelation analysis to determine the number of lags in the ADF test

Columns market by stars in correspondence with lag 1-15 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Rows market with green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autcorrelation analysis Sample 2.2															
Number of lags included of the error term to obtain no significant autocorrelation (***, **, * and "insig" represents the statistical significance level of the autocorrelation coefficient)															
	1 lag	**2 lag**	**3 lag**	**4 lag**	**5 lag**	**6 lag**	**7 lag**	**8 lag**	**9 lag**	**10 lag**	**11 lag**	**12 lag**	**13 lag**	**14 lag**	**15 lag**
Model 3															
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8.3.3 Model 3: ADF test on regression residuals

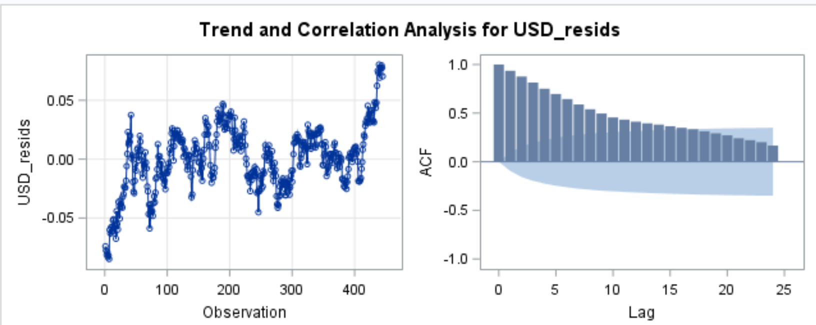
ADF-test on logUSD residuals:

The ARIMA Procedure

Name of Variable = l44_resids	
Mean of Working Series	5.59E-17
Standard Deviation	0.027355
Number of Observations	445

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1697.69	6	<.0001	0.936	0.877	0.814	0.751	0.697	0.645
12	2359.03	12	<.0001	0.589	0.540	0.496	0.456	0.433	0.412
18	2714.46	18	<.0001	0.395	0.382	0.365	0.349	0.335	0.314
24	2871.47	24	<.0001	0.292	0.272	0.241	0.222	0.201	0.166

Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-20.6527	0.0013	-3.26	0.0012		
	2	-23.1254	0.0006	-3.44	0.0006		
	3	-25.9874	0.0002	-3.56	0.0004		
	4	-23.0835	0.0006	-3.37	0.0008		
	5	-23.8456	0.0004	-3.37	0.0008		
	7	-25.7979	0.0002	-3.21	0.0014		
Single Mean	1	-20.5849	0.0096	-3.25	0.0181	5.70	0.0184
	2	-22.9995	0.0054	-3.43	0.0108	6.30	0.0049
	3	-25.7948	0.0028	-3.56	0.0073	6.71	0.0010
	4	-22.8512	0.0055	-3.36	0.0133	6.14	0.0085
	5	-23.5485	0.0047	-3.36	0.0132	6.16	0.0080
	7	-25.3775	0.0031	-3.20	0.0211	5.50	0.0230
Trend	1	-25.5633	0.0203	-3.60	0.0306	6.50	0.0444
	2	-28.5732	0.0103	-3.78	0.0186	7.15	0.0265
	3	-32.3834	0.0043	-3.93	0.0118	7.72	0.0141
	4	-28.6040	0.0103	-3.69	0.0244	6.80	0.0360
	5	-29.6666	0.0081	-3.69	0.0241	6.82	0.0356
	7	-33.5228	0.0033	-3.61	0.0304	6.51	0.0442



8.4 Sample 2.2 - Model 4

8.4.1 Model 4: Cointegration model

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.26837189	DFE	441
MSE	0.0006086	Root MSE	0.02467
SBC	-2011.7403	AIC	-2028.1326
MAE	0.01981508	AICC	-2028.0417
MAPE	0.94120465	HQC	-2021.6688
Durbin-Watson	0.1034	Total R-Square	0.6471

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	396.5596	<.0001
AR(2)	396.6038	<.0001
AR(3)	396.6095	<.0001
AR(4)	396.7218	<.0001
AR(5)	396.9588	<.0001

Shin Cointegration Test			
Type	Lags	Eta	Pr > Eta
Single Mean	17	0.1761	0.0386
Trend	17	0.0943	0.0342

KERNEL=NW, SCHW=12

Parameter Estimates						
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|	Variable Label
Intercept	1	2.6489	0.0275	96.43	<.0001	
logBrent	1	-0.1240	0.007846	-15.80	<.0001	
INTDIFF_LIBORUSD	1	-0.0645	0.0120	-5.37	<.0001	INTDIFF LIBORUSD
LIBORUSD	1	-0.0386	0.0167	-2.32	0.0209	LIBORUSD

8.4.2 Model 4: Autocorrelation analysis to determine the number of lags in the ADF test

Columns market by stars in correspondence with lag 1-15 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Rows market with green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis
Sample 2.2

Number of lags included of the error term to obtain no significant autocorrelation
(***, **, * and "insig" represents the statistical significance level of the autocorrelation coefficient)

	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag
Model 4															
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8.4.3 Model 4: ADF test on regression residuals

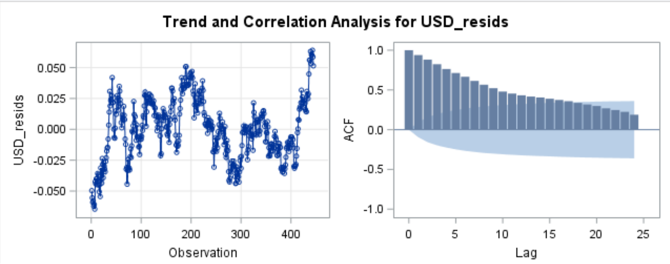
ADF-test on logUSD residuals:

The ARIMA Procedure

Name of Variable = l44_resids	
Mean of Working Series	-62E-17
Standard Deviation	0.024558
Number of Observations	445

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	1742.57	6	<.0001	0.939	0.882	0.824	0.763	0.713	0.666
12	2468.83	12	<.0001	0.614	0.565	0.522	0.479	0.454	0.432
18	2872.11	18	<.0001	0.417	0.405	0.389	0.374	0.358	0.337
24	3063.53	24	<.0001	0.317	0.298	0.268	0.247	0.224	0.188

Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-22.0061	0.0008	-3.33	0.0009		
	2	-23.1348	0.0006	-3.40	0.0007		
	3	-26.4765	0.0002	-3.56	0.0004		
	4	-23.0291	0.0006	-3.32	0.0010		
	5	-23.2493	0.0005	-3.29	0.0011		
	8	-25.5305	0.0002	-3.16	0.0017		
Single Mean	1	-21.9605	0.0069	-3.33	0.0147	5.77	0.0168
	2	-23.0510	0.0053	-3.39	0.0122	6.01	0.0114
	3	-26.3443	0.0024	-3.56	0.0072	6.57	0.0010
	4	-22.8699	0.0055	-3.31	0.0152	5.82	0.0158
	5	-23.0498	0.0053	-3.28	0.0167	5.72	0.0180
	8	-25.1963	0.0032	-3.15	0.0242	5.22	0.0308
Trend	1	-22.0371	0.0437	-3.33	0.0633	5.54	0.0906
	2	-23.0942	0.0348	-3.39	0.0546	5.74	0.0799
	3	-26.3771	0.0169	-3.55	0.0352	6.32	0.0495
	4	-22.8738	0.0365	-3.31	0.0663	5.48	0.0935
	5	-23.0470	0.0351	-3.28	0.0717	5.37	0.0992
	8	-25.1941	0.0220	-3.15	0.0968	4.96	0.1812



8.5 Robustness sample – Model 6

8.5.1 Model 6: Cointegration model

Regression logI44 on logBrent: Saving resids

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.61171015	DFE	185
MSE	0.00331	Root MSE	0.05750
SBC	-522.13162	AIC	-544.93409
MAE	0.04533458	AICC	-544.32539
MAPE	2.37382655	HQC	-535.69892
Durbin-Watson	0.4180	Total R-Square	0.8684

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	119.5488	<.0001
AR(2)	119.6266	<.0001
AR(3)	120.2188	<.0001
AR(4)	122.8886	<.0001
AR(5)	122.9532	<.0001

Shin Cointegration Test			
Type	Lags	Eta	Pr > Eta
Single Mean	14	0.1379	0.0064
Trend	14	0.1285	0.0008

KERNEL=NW, SCHW=12

Parameter Estimates						
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|	Variable Label
Intercept	1	4.4161	0.9328	4.73	<.0001	
logBrent	1	-0.3309	0.0125	-26.44	<.0001	
INTDIFF_LIBORUSD	1	0.003819	0.002874	1.33	0.1856	INTDIFF LIBORUSD
LIBORUSD	1	0.0103	0.004135	2.50	0.0134	LIBORUSD
logINDPRO_USD	1	0.5357	0.1165	4.60	<.0001	
logINDPRO_NOK	1	-0.7913	0.1144	-6.92	<.0001	
CPIDIFF_USD	1	0.0145	0.003035	4.79	<.0001	CPIDIFF USD

8.5.2 Model 6: Autocorrelation analysis to determine the number of lags in the ADF test

Columns market by stars in correspondence with lag 1-15 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Rows market with green represent the acceptable model, where no significant autocorrelation is present.

The BG-test indicates the number of lags included in the ADF-test.

Autocorrelation analysis Robustness sample															
Number of lags included of the error term to obtain no significant autocorrelation (***, **, * and "insig" represents the statistical significance level of the autocorrelation coefficient)															
0 lag	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag
Model 6															
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8.5.3 Model 6: ADF test on regression residuals

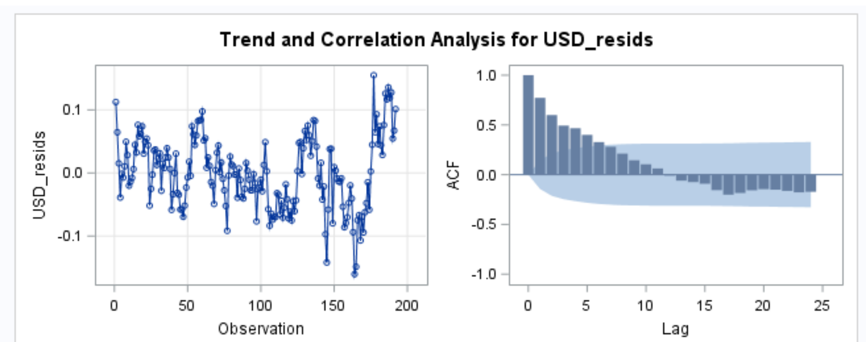
ADF-test on USD residuals:

The ARIMA Procedure

Name of Variable = I44_resids	
Mean of Working Series	-156E-17
Standard Deviation	0.056445
Number of Observations	192

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	331.08	6	<.0001	0.772	0.599	0.493	0.467	0.400	0.327
12	363.31	12	<.0001	0.281	0.212	0.145	0.104	0.063	-0.010
18	387.98	18	<.0001	-0.060	-0.075	-0.091	-0.155	-0.201	-0.184
24	422.22	24	<.0001	-0.157	-0.145	-0.151	-0.163	-0.178	-0.172

Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-40.9846	<.0001	-4.80	<.0001		
	1	-40.3473	<.0001	-4.42	<.0001		
	2	-33.6320	<.0001	-3.80	0.0002		
	3	-20.0108	0.0014	-2.80	0.0052		
	4	-23.6375	0.0004	-2.93	0.0036		
	5	-23.4097	0.0004	-2.79	0.0054		
Single Mean	0	-40.9901	0.0013	-4.79	0.0001	11.48	0.0010
	1	-40.3503	0.0013	-4.40	0.0005	9.70	0.0010
	2	-33.6162	0.0013	-3.78	0.0037	7.17	0.0010
	3	-19.9422	0.0102	-2.79	0.0624	3.94	0.0923
	4	-23.5469	0.0041	-2.91	0.0469	4.27	0.0719
	5	-23.2569	0.0044	-2.77	0.0650	3.90	0.0945
Trend	0	-40.7480	0.0006	-4.72	0.0009	11.46	0.0010
	1	-40.1245	0.0006	-4.35	0.0033	9.67	0.0010
	2	-33.4235	0.0028	-3.73	0.0226	7.13	0.0283
	3	-19.6584	0.0672	-2.73	0.2277	3.89	0.4001
	4	-23.2174	0.0309	-2.84	0.1855	4.22	0.3345
	5	-22.9662	0.0326	-2.70	0.2383	3.82	0.4135



9. Error correction models

9.1 Sample 2.2 - Model 1.1

The AUTOREG Procedure

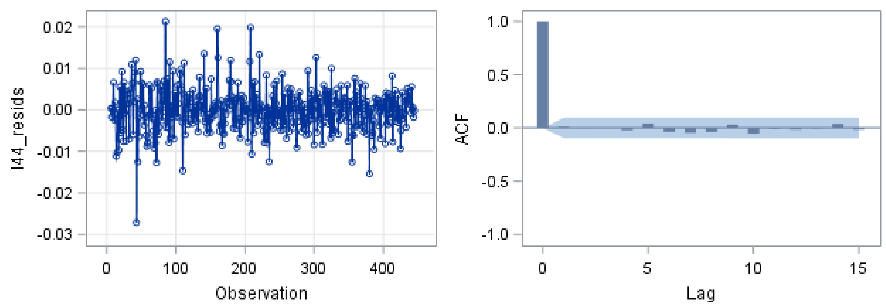
Ordinary Least Squares Estimates			
SSE	0.01186029	DFE	430
MSE	0.0000276	Root MSE	0.00525
SBC	-3319.8535	AIC	-3360.7212
MAE	0.00381704	AICC	-3360.2084
MAPE	136.026684	HQC	-3344.5989
Durbin-Watson	1.9809	Total R-Square	0.0818

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	2.1025	0.1471
AR(2)	2.2728	0.3210
AR(3)	2.4676	0.4812
AR(4)	4.7087	0.3185
AR(5)	4.9078	0.4272
AR(6)	7.3443	0.2902
AR(7)	8.0439	0.3287
AR(8)	8.1209	0.4217
AR(9)	8.2302	0.5111
AR(10)	9.6501	0.4717

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.0000757	0.000251	0.30	0.7625
dlogl44_1	1	-0.1103	0.0505	-2.19	0.0294
dlogl44_2	1	-0.0375	0.0507	-0.74	0.4604
dlogl44_3	1	0.0863	0.0504	1.71	0.0877
dlogl44_4	1	-0.1103	0.0492	-2.24	0.0255
dlogBrent_1	1	-0.0411	0.009053	-4.54	<.0001
dlogBrent_2	1	0.001113	0.009246	0.12	0.9042
dlogBrent_3	1	0.008977	0.009241	0.97	0.3319
dlogBrent_4	1	0.008446	0.009263	0.91	0.3624
l44_resids_1	1	-0.0189	0.0158	-1.20	0.2298

Test 1				
Source	DF	Mean Square	F Value	Pr > F
Numerator	5	0.000137	4.97	0.0002
Denominator	430	0.000027582		

Trend and Correlation Analysis for l44_resids



9.2 Sample 2.2 - Model 1.1R

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.36000776	DFE	439
MSE	0.0008201	Root MSE	0.02864
SBC	-1870.4795	AIC	-1886.8538
MAE	0.02137731	AICC	-1886.7625
MAPE	153.687024	HQC	-1880.3959
Durbin-Watson	2.0012	Total R-Square	0.0221

Godfrey's Serial Correlation Test

Alternative	LM	Pr > LM
AR(1)	0.0374	0.8466
AR(2)	0.0374	0.9815
AR(3)	2.0455	0.5630
AR(4)	2.6462	0.6187
AR(5)	5.0229	0.4131
AR(6)	5.2089	0.5173
AR(7)	5.6283	0.5838
AR(8)	5.9237	0.6558
AR(9)	5.9753	0.7424
AR(10)	11.5800	0.3141

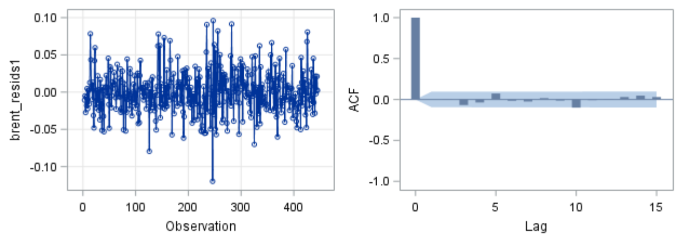
Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.000302	0.001361	0.22	0.8246
dlogBrent_1	1	0.0469	0.0491	0.95	0.3404
dlogI44_1	1	0.2941	0.2651	1.11	0.2680
I44_resids_1	1	-0.2451	0.0814	-3.01	0.0028

Test 1

Source	DF	Mean Square	F Value	Pr > F
Numerator	2	0.003851	4.70	0.0096
Denominator	439	0.000820		

Trend and Correlation Analysis for brent_resids1



9.3 Sample 2.2 - Model 2.1

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.01135722	DFE	422
MSE	0.0000269	Root MSE	0.00519
SBC	-3290.2297	AIC	-3363.7917
MAE	0.00373744	AICC	-3362.167
MAPE	145.80333	HQC	-3334.7714
Durbin-Watson	1.9778	Total R-Square	0.1207

Godfrey's Serial Correlation Test

Alternative	LM	Pr > LM
AR(1)	3.1058	0.0780
AR(2)	3.4053	0.1822
AR(3)	3.4063	0.3331
AR(4)	3.4077	0.4920
AR(5)	3.4129	0.6366
AR(6)	6.5898	0.3605
AR(7)	7.6742	0.3622
AR(8)	7.8664	0.4466
AR(9)	7.9415	0.5401
AR(10)	9.5717	0.4788

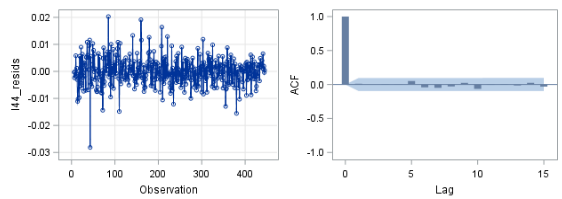
Test 1

Source	DF	Mean Square	F Value	Pr > F
Numerator	5	0.000144	5.37	<.0001
Denominator	422	0.000026913		

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	-0.000104	0.000281	-0.37	0.7108
dlogl44_1	1	-0.1549	0.0572	-2.71	0.0071
dlogl44_2	1	-0.1198	0.0577	-2.07	0.0386
dlogl44_3	1	0.1076	0.0567	1.90	0.0584
dlogl44_4	1	-0.0959	0.0553	-1.73	0.0840
dlogBrent_1	1	-0.0406	0.009172	-4.43	<.0001
dlogBrent_2	1	-0.007484	0.009411	-0.80	0.4269
dlogBrent_3	1	0.007561	0.009399	0.80	0.4216
dlogBrent_4	1	0.0105	0.009353	1.12	0.2619
dintdiff_l44_1	1	-0.0135	0.0117	-1.16	0.2467
dintdiff_l44_2	1	-0.0360	0.0117	-3.07	0.0023
dintdiff_l44_3	1	0.002267	0.0118	0.19	0.8479
dintdiff_l44_4	1	-0.004049	0.0118	-0.34	0.7315
dLIBORUSD_1	1	0.1125	0.0505	2.23	0.0265
dLIBORUSD_2	1	0.0412	0.0518	0.80	0.4269
dLIBORUSD_3	1	-0.0264	0.0516	-0.51	0.6085
dLIBORUSD_4	1	-0.006287	0.0509	-0.12	0.9018
l44_resids_1	1	-0.0372	0.0198	-1.88	0.0603

Trend and Correlation Analysis for l44_resids



9.4 Sample 2.2 - Model 2.1R

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.35627819	DFE	437
MSE	0.0008153	Root MSE	0.02855
SBC	-1862.9057	AIC	-1887.4671
MAE	0.02108754	AICC	-1887.2744
MAPE	150.04858	HQC	-1877.7803
Durbin-Watson	2.0129	Total R-Square	0.0322

Godfrey's Serial Correlation Test

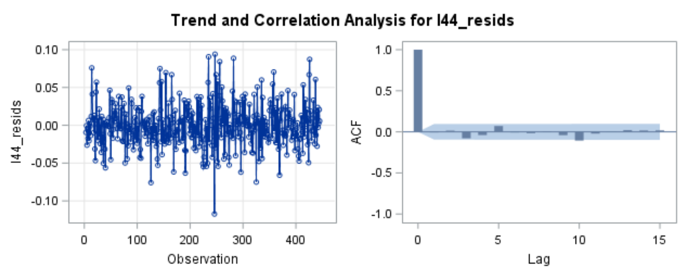
Alternative	LM	Pr > LM
AR(1)	0.7844	0.3758
AR(2)	0.8158	0.6651
AR(3)	3.1924	0.3629
AR(4)	3.9464	0.4133
AR(5)	6.4182	0.2676
AR(6)	6.4760	0.3720
AR(7)	6.7143	0.4592
AR(8)	6.8514	0.5527
AR(9)	7.3949	0.5961
AR(10)	13.8202	0.1814

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.001484	0.001429	1.04	0.2994
dlogBrent_1	1	0.0530	0.0495	1.07	0.2850
dlogl44_1	1	0.4656	0.2964	1.57	0.1170
dintdiff_I44_1	1	0.0893	0.0630	1.42	0.1569
dLIBORUSD_1	1	-0.7183	0.2665	-2.70	0.0073
I44_resids_1	1	-0.1687	0.0988	-1.71	0.0886

Test 1

Source	DF	Mean Square	F Value	Pr > F
Numerator	2	0.001888	2.32	0.0999
Denominator	437	0.000815		



9.5 Sample 2.2 - Model 3.1

The AUTOREG Procedure

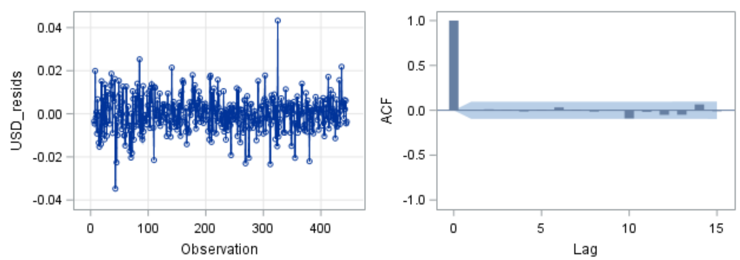
Ordinary Least Squares Estimates			
SSE	0.03003605	DFE	430
MSE	0.0000699	Root MSE	0.00836
SBC	-2911.0043	AIC	-2951.8721
MAE	0.00621724	AICC	-2951.3592
MAPE	289.519869	HQC	-2935.7497
Durbin-Watson	1.9970	Total R-Square	0.0607

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	0.0289	0.8651
AR(2)	2.0182	0.3646
AR(3)	3.0005	0.3916
AR(4)	3.4242	0.4895
AR(5)	3.7920	0.5797
AR(6)	3.8769	0.6933
AR(7)	5.6075	0.5862
AR(8)	5.7133	0.6793
AR(9)	6.4003	0.6993
AR(10)	12.2712	0.2673

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.000324	0.000400	0.81	0.4186
dlogUSD_1	1	-0.0348	0.0501	-0.69	0.4878
dlogUSD_2	1	0.007551	0.0501	0.15	0.8802
dlogUSD_3	1	0.0865	0.0501	1.73	0.0847
dlogUSD_4	1	-0.1240	0.0498	-2.49	0.0131
dlogBrent_1	1	-0.0466	0.0144	-3.24	0.0013
dlogBrent_2	1	0.0103	0.0145	0.71	0.4789
dlogBrent_3	1	0.0246	0.0145	1.70	0.0908
dlogBrent_4	1	0.004880	0.0145	0.34	0.7372
USD_resids_1	1	-0.0314	0.0162	-1.94	0.0525

Test 1				
Source	DF	Mean Square	F Value	Pr > F
Numerator	5	0.000252	3.61	0.0033
Denominator	430	0.000069851		

Trend and Correlation Analysis for USD_resids



9.6 Sample 2.2 - Model 3.1R

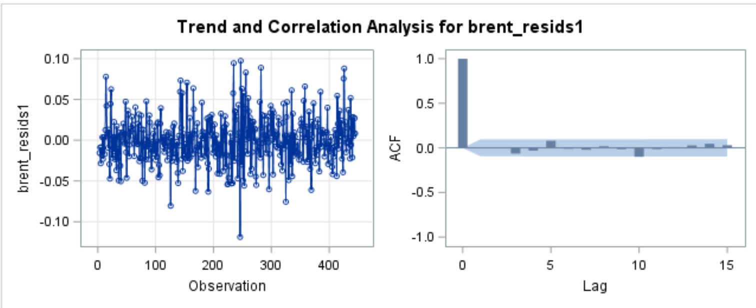
The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.36373486	DFE	439
MSE	0.0008286	Root MSE	0.02878
SBC	-1865.9168	AIC	-1882.2911
MAE	0.0214123	AICC	-1882.1998
MAPE	142.781755	HQC	-1875.8332
Durbin-Watson	1.9998	Total R-Square	0.0120

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	0.0119	0.9130
AR(2)	0.0139	0.9931
AR(3)	1.7861	0.6180
AR(4)	2.2287	0.6938
AR(5)	5.0733	0.4070
AR(6)	5.1571	0.5238
AR(7)	5.4486	0.6054
AR(8)	5.7874	0.6710
AR(9)	5.8435	0.7555
AR(10)	11.4041	0.3269

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.000280	0.001369	0.20	0.8379
dlogBrent_1	1	0.0399	0.0493	0.81	0.4183
dlogUSD_1	1	0.0955	0.1698	0.56	0.5741
USD_resids_1	1	-0.1123	0.0515	-2.18	0.0296

Test 1				
Source	DF	Mean Square	F Value	Pr > F
Numerator	2	0.001987	2.40	0.0920
Denominator	439	0.000829		



9.7 Sample 2.2 - Model 4.1

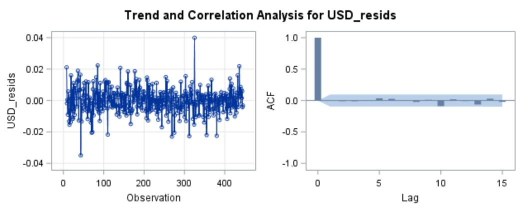
The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.02793392	DFE	412
MSE	0.0000678	Root MSE	0.00823
SBC	-2830.0102	AIC	-2936.1479
MAE	0.00597884	AICC	-2932.7319
MAPE	322.727529	HQC	-2894.2687
Durbin-Watson	1.9908	Total R-Square	0.1263

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	0.2019	0.6532
AR(2)	1.1726	0.5564
AR(3)	1.7724	0.6210
AR(4)	2.0648	0.7238
AR(5)	7.9311	0.1601
AR(6)	9.1836	0.1635
AR(7)	9.4855	0.2197
AR(8)	9.5306	0.2995
AR(9)	9.8928	0.3592
AR(10)	15.8182	0.1050

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.000192	0.000464	0.41	0.6801
dlogUSD_1	1	-0.0650	0.0557	-1.17	0.2435
dlogUSD_2	1	-0.0185	0.0555	-0.33	0.7383
dlogUSD_3	1	0.1325	0.0547	2.42	0.0159
dlogUSD_4	1	-0.1043	0.0548	-1.90	0.0578
dlogUSD_5	1	0.0102	0.0543	0.19	0.8518
dlogUSD_6	1	0.0880	0.0542	1.62	0.1053
dlogBrent_1	1	-0.0536	0.0146	-3.66	0.0003
dlogBrent_2	1	-0.004926	0.0148	-0.33	0.7399
dlogBrent_3	1	0.0248	0.0148	1.68	0.0940
dlogBrent_4	1	0.006050	0.0148	0.41	0.6823
dlogBrent_5	1	-0.0220	0.0147	-1.49	0.1361
dlogBrent_6	1	-0.0106	0.0147	-0.72	0.4711
dLIBORUSD_1	1	0.1320	0.0837	1.58	0.1156
dLIBORUSD_2	1	-0.0132	0.0851	-0.16	0.8766
dLIBORUSD_3	1	-0.0842	0.0845	-1.00	0.3198
dLIBORUSD_4	1	0.1074	0.0847	1.27	0.2057
dLIBORUSD_5	1	-0.0306	0.0853	-0.36	0.7201
dLIBORUSD_6	1	0.0287	0.0846	0.34	0.7346
dintdiff_LIBORUSD_1	1	-0.008103	0.0185	-0.44	0.6611
dintdiff_LIBORUSD_2	1	-0.0465	0.0183	-2.54	0.0116
dintdiff_LIBORUSD_3	1	0.000562	0.0185	0.03	0.9757
dintdiff_LIBORUSD_4	1	0.005787	0.0185	0.31	0.7545
dintdiff_LIBORUSD_5	1	0.0293	0.0184	1.59	0.1116
dintdiff_LIBORUSD_6	1	0.0570	0.0185	3.09	0.0022
USD_resids_1	1	-0.0569	0.0197	-2.89	0.0041

Test 1				
Source	DF	Mean Square	F Value	Pr > F
Numerator	7	0.000270	3.98	0.0003
Denominator	412	0.000067801		



9.8 Sample 2.2 - Model 4.1R

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.35811261	DFE	437
MSE	0.0008195	Root MSE	0.02863
SBC	-1860.6306	AIC	-1885.192
MAE	0.02114948	AICC	-1884.9994
MAPE	142.33937	HQC	-1875.5052
Durbin-Watson	2.0103	Total R-Square	0.0272

Godfrey's Serial Correlation Test

Alternative	LM	Pr > LM
AR(1)	0.6241	0.4295
AR(2)	0.6394	0.7264
AR(3)	2.7387	0.4337
AR(4)	3.3018	0.5087
AR(5)	6.0639	0.3000
AR(6)	6.1016	0.4119
AR(7)	6.3481	0.4997
AR(8)	6.5101	0.5903
AR(9)	6.8794	0.6497
AR(10)	12.6526	0.2438

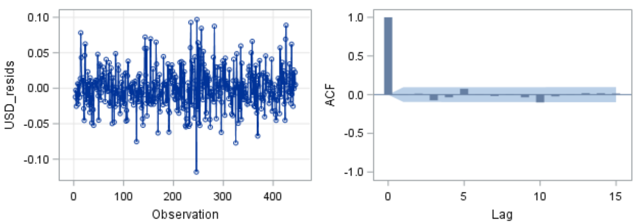
Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.001523	0.001434	1.06	0.2886
dlogBrent_1	1	0.0422	0.0492	0.86	0.3920
dlogUSD_1	1	0.1927	0.1813	1.06	0.2883
dLIBORUSD_1	1	-0.7105	0.2732	-2.60	0.0096
dintdiff_LIBORUSD_1	1	0.0350	0.0619	0.56	0.5725
USD_resids_1	1	-0.0857	0.0579	-1.48	0.1398

Test 1

Source	DF	Mean Square	F Value	Pr > F
Numerator	2	0.001195	1.46	0.2339
Denominator	437	0.000819		

Trend and Correlation Analysis for USD_resids



9.9 Robustness sample – Model 6.1

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	0.10806653	DFE	181
MSE	0.0005971	Root MSE	0.02443
SBC	-833.26627	AIC	-862.48949
MAE	0.01857289	AICC	-861.48949
MAPE	314.929312	HQC	-850.65159
Durbin-Watson	2.0384	Total R-Square	0.2060

Godfrey's Serial Correlation Test

Alternative	LM	Pr > LM
AR(1)	0.5271	0.4678
AR(2)	4.9035	0.0861
AR(3)	6.7592	0.0800
AR(4)	6.7770	0.1482
AR(5)	7.3486	0.1960
AR(6)	8.5484	0.2006
AR(7)	9.2052	0.2383
AR(8)	9.4512	0.3057
AR(9)	12.3785	0.1928
AR(10)	12.7102	0.2403

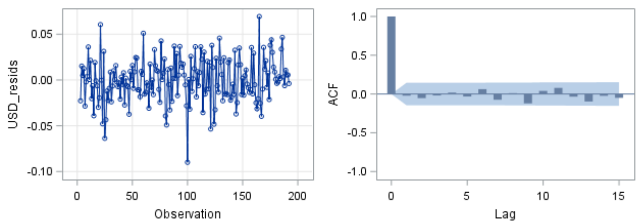
Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.000535	0.001799	0.30	0.7663
dlogUSD_1	1	0.3513	0.0799	4.40	<.0001
dlogBrent_1	1	0.005453	0.0215	0.25	0.8003
dLIBORUSD_1	1	-0.0209	0.008589	-2.43	0.0162
dintdiff_LIBORUSD_1	1	-0.0110	0.008044	-1.37	0.1724
dlogINDPRO_NOK_1	1	-0.004635	0.0585	-0.08	0.9370
dlogINDPRO_USD_1	1	-0.2829	0.2640	-1.07	0.2854
dCPIDIFF_USD_1	1	0.003327	0.003010	1.11	0.2705
USD_resids_1	1	-0.0758	0.0342	-2.21	0.0281

Test 1

Source	DF	Mean Square	F Value	Pr > F
Numerator	2	0.001515	2.54	0.0819
Denominator	181	0.000597		

Trend and Correlation Analysis for USD_resids



9.10 Robustness sample – Model 6.1R

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	1.6122782	DFE	181
MSE	0.00891	Root MSE	0.09438
SBC	-319.76155	AIC	-348.98477
MAE	0.07169053	AICC	-347.98477
MAPE	139.138298	HQC	-337.14687
Durbin-Watson	2.0111	Total R-Square	0.1705

Godfrey's Serial Correlation Test

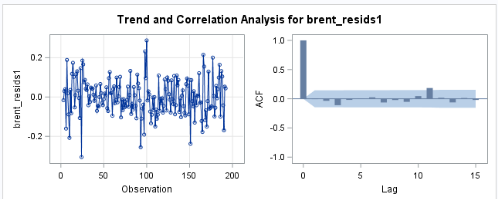
Alternative	LM	Pr > LM
AR(1)	0.0515	0.8204
AR(2)	0.4723	0.7897
AR(3)	3.4931	0.3217
AR(4)	3.8420	0.4278
AR(5)	4.0882	0.5368
AR(6)	4.1086	0.6620
AR(7)	5.5591	0.5921
AR(8)	5.6857	0.6824
AR(9)	6.2457	0.7151
AR(10)	6.3781	0.7826

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	-0.004155	0.006947	-0.60	0.5505
dlogBrent_1	1	0.0656	0.0831	0.79	0.4312
dlogUSD_1	1	-0.9227	0.3086	-2.99	0.0032
dLIBORUSD_1	1	0.0653	0.0332	1.97	0.0505
dintdiff_LIBORUSD_1	1	0.006610	0.0311	0.21	0.8317
dlogINDPRO_NOK_1	1	0.4502	0.2261	1.99	0.0480
dlogINDPRO_USD_1	1	1.4126	1.0198	1.39	0.1677
dCPIDIFF_USD_1	1	-0.0158	0.0116	-1.36	0.1767
USD_resids_1	1	-0.2098	0.1322	-1.59	0.1143

Test 1

Source	DF	Mean Square	F Value	Pr > F
Numerator	2	0.058760	6.60	0.0017
Denominator	181	0.008908		



10. Granger causality, autocorrelation analysis in error correction models

Columns market by stars in correspondence with lag 1-15 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Rows market with green represent the acceptable model, where no significant autocorrelation is present.

10.1 Sample 2.2

Granger causality within the error correction model, autocorrelation analysis
Sample 2.2

Number of lags included of the variables to obtain no autocorrelation

	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)	ECM term
Does the oil price Granger cause the exchange rates?																	
Model 1.1	Y = ΔlogI44. X = ΔlogBrent															F (Pr>F)	Coefficient
															**	***2.11	-0.0161
														***		***2.17	-0.0164
													**			***2.45	-0.0122
												insign				***2.69	-0.0094
											insign					***2.91	-0.0094
										insign						***3.04	-0.0101
									*							***3.12	-0.0140
								***								***3.07	-0.0122
							*									***3.39	-0.0172
						insign										***3.99	-0.0200
					insign											***4.61	-0.0212
				insign												*****4.97**	**-0.0189**
			**													***6.16	-0.0256
		**														***7.70	-0.0210
	**															***12.01	-0.0221
Model 2.1	Y = ΔlogI44. X = ΔlogBrent. Control variables = Δintdiff_I44 and ΔLIBORUSD															F (Pr>F)	Coefficient
															insign	**2.11	-0.0403
														*		**2.06	-0.0406
													insign			***2.28	-0.0336
												insign				***2.51	-0.0299
											insign					***2.67	-0.0289
										insign						***3.27	-0.0357
									insign							***3.50	-0.0377
								***								***3.51	*-0.0410
							*									***3.98	**-0.0436
						insign										***4.61	**-0.0470
					insign											***4.98	**-0.0414
				*****												*****5.37**	***-0.0372**
			*													***6.96	**-0.0451
		**														***8.64	**-0.0397
	***															***14.33	**-0.0427
Model 3.1	Y = ΔlogUSD. X = ΔlogBrent															F (Pr>F)	Coefficient
															insign	**1.84	-0.0288
														*		**1.97	-0.0275
													insign			**2.05	-0.0174
												insign				***2.21	-0.0170
											insign					***2.43	-0.0196
										insign						***2.54	-0.0239
									**							***2.45	-0.0282
								insign								***2.69	-0.0280
							insign									**2.59	*-0.0297
						*										***3.11	**-0.0357
					insign											***3.37	*-0.0324
				insign												*****3.61**	***-0.0314**
			*													***4.68	**-0.038
		**														***4.85	**-0.0332
	**															***7.22	**-0.0330
Model 4.1	Y = ΔlogUSD. X = ΔlogBrent. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F (Pr>F)	Coefficient
															insign	**1.91	-0.0410
														insign		**2.00	-0.0399
													insign			***2.21	-0.0339
												insign				***2.34	-0.0338
											insign					***2.45	*-0.0411
										*						***2.86	**-0.0476
									**							***3.12	**-0.0536
								insign								***3.41	**-0.0541
							insign									***3.29	**-0.0518
						insign										*****3.98**	*****-0.0569**
					***											***3.92	**-0.047
				*												***4.10	**-0.0446
			insign													***5.33	***-0.0514
		*														***5.72	***-0.0474
	**															***9.35	***-0.0491

***, **, * and "insig" represents the statistical significance level of respective tests

Granger causality within the error correction model, autocorrelation analysis
Sample 2.2

Number of lags included of the variables to obtain no autocorrelation

	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)	ECM term
Does the exchange rate Granger cause the oil price?																	
Model 1.1R	Y = ΔlogBrent. X = ΔlogI44															F (Pr>F)	Coefficient
															**	1.45	**-0.2621
														insign		*1.58	**-0.2592
													insign			**1.72	***-0.2778
												insign				**1.94	***-0.2871
											insign					**2.13	***-0.2965
										insign						***2.28	***-0.2980
									insign							***2.19	***-0.2927
								**								**1.94	***-0.3240
							insign									**2.18	***-0.3267
						insign										**2.14	***-0.3013
					insign											**2.14	***-0.2757
				insign												**2.31	***-0.2620
			insign													***2.67	***-0.2528
		insign														**3.31	***-0.2569
	insign															*****4.70**	*****-0.2451**
Model 2.1R	Y = ΔlogBrent. X = ΔlogI44. Control variables = Δintdiff_I44 and ΔLIBORUSD															F (Pr>F)	Coefficient
															insign	0.91	-0.2122
														insign		1.09	-0.2308
													insign			1.15	**-0.2764
												insign				1.37	**-0.2967
											insign					1.50	**-0.3146
										insign						*1.63	**-0.3228
									insign							*1.69	**-0.2827
								***								*1.73	**-0.2967
							insign									*1.78	**-0.3008
						insign										*1.84	**-0.2669
					insign											*1.83	**-0.2281
				*												1.47	*-0.2042
			*													1.65	*-0.1851
		insign														1.77	*-0.1763
	insign															***2.32**	***-0.1687**
Model 3.1R	Y = ΔlogBrent. X = ΔlogUSD															F (Pr>F)	Coefficient
															**	0.91	*-0.1310
														*		1.00	*-0.1382
													insign			1.02	**-0.1662
												**				1.31	***-0.1897
											insign					1.43	***-0.1883
										insign						1.47	***-0.1863
									insign							1.51	***-0.1811
								insign								1.62	***-0.1855
							insign									*1.76	***-0.1763
						insign										*1.79	***-0.1607
					insign											*1.85	**-0.1428
				insign												*1.99	**-0.1339
			insign													*2.17	**-0.1195
		insign														*2.27	**-0.1285
	insign															***2.40**	****-0.1123**
Model 4.1R	Y = ΔlogBrent. X = ΔlogUSD. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F (Pr>F)	Coefficient
															insign	0.83	-0.1052
														insign		0.96	-0.1275
													insign			0.91	*-0.1663
												insign				1.12	**-0.1828
											insign					1.24	**-0.1789
										insign						1.22	**-0.1911
									**							1.39	**-0.1713
								**								1.53	**-0.1644
							insign									1.64	**-0.1597
						insign										1.64	**-0.1401
					insign											*1.80	**-0.1229
				insign												1.81	*-0.1141
			insign													1.77	-0.0964
		insign														1.72	-0.0985
	insign															**1.46**	**-0.0857**

***, **, * and "insig" represents the statistical significance level of respective tests

10.2 Robustness sample

Granger causality within the error correction model, autocorrelation analysis Full sample, robustness																	
Number of lags included of the variables to obtain no autocorrelation																	
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)	ECM term
Does the oil price Granger cause the exchange rates?																	
Model 6.1	Y = ΔlogUSD. X = ΔlogBrent. Control variables = Δintdiff_I44, ΔLIBORUSD, ΔINDPRO_NOK, ΔINDPRO_I44 and ΔCPIdiff_I44															F-value	Coefficient
															***	1.06	**-0.2388
														insig		0.80	**-0.1714
													*			0.73	**-0.1996
												insig				0.87	**-0.2050
											**					0.65	**-0.1581
										insig						0.69	**-0.1439
									insig							1.10	***-0.1642
								**								1.05	**-0.1309
							***									0.91	**-0.1109
						***										1.23	**-0.1077
					insig											1.66	**-0.1129
				insig												1.81	**-0.0997
			insig													*2,09	**-0.0862
		insig														**2.66	**0.0840
	insig															***2.54**	****-0.0758**

***, **, * and "insig" represents the statistical significance level of respective tests

Granger causality within the error correction model, autocorrelation analysis Full sample, robustness																	
Number of lags included of the variables to obtain no autocorrelation																	
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)	ECM term
Do the exchange rates Granger cause the oil price																	
Model 6.1R	X = ΔlogUSD. Control variables = ΔLIBORUSD, Δintdiff_LIBORUSD, ΔINDPRO_USD, ΔINDPRO_NOK and ΔCPIdiff_USDY = ΔlogBrent.															F-value	Coefficient
															***	1.28	-0.1475
														***		1.48	-0.2896
													***			1.57	-0.1748
												***				1.40	0.0195
											***					1.55	0.1952
										***						*1.72	0.1366
									*							*1.80	0.0693
								insign								*1.90	-0.0514
							insign									**2.25	-0.0196
						insign										**2.19	0.1037
					insign											***2.94	0.1285
				insign												***3.24	0.0044
			insign													***3.83	-0.0130
		insig														**3.50	-0.1270
	insig															***6.60	-0.2098

***, **, * and "insig" represents the statistical significance level of respective tests

11. Granger causality, autocorrelation analysis

Columns market by stars in correspondence with lag 1-15 represent at which level the Breusch-Godfrey test for no autocorrelation is rejected. Cells market green represent tests where no autocorrelation by the BG test was rejected, but where the ACF plot show no spikes outside the confidence bans. Therefore, the conclusion for these are that the no autocorrelation condition is satisfied.

Rows market with green represent the acceptable model, where no significant autocorrelation is present.

11.1 Full sample

Granger causality, autocorrelation analysis Full sample																
Number of lags included of the variables to obtain no autocorrelation																
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Does the oil price Granger cause the exchange rates?																
Model 1.1	Y = ΔlogI44. X = ΔlogBrent															F-value
															insign	***5.78
														*		***6.08
													insign			***6.51
												insign				***7.01
											insign					***7.43
										insign						***8.01
									insign							***8.57
								**								***9.18
							***									***10.00
						**										***11.65
					**											***13.70
				**												*****17.05**
			**													***21.60
		**														***32.48
	***															***63.55
Model 2.1	Y = ΔlogI44. X = ΔlogBrent. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															insign	*****5.60**
														***		***5.89
													**			***6.32
												**				***6.93
											*					***7.31
										**						***7.81
									insign							***8.38
								***								***9.14
							***									***10.04
						***										***11.63
					***											***13.71
				***												***17.66
			***													***28.86
		**														***32.83
	***															***62.39

Model 3.1	Y = ΔlogUSD. X = ΔlogBrent															F-value
															insign	***4.43
														insign		***4.74
													insign			***5.09
												insign				***5.40
											insign					***5.63
										*						***6.25
									**							***6.64
								*								***7.36
							insign									***8.01
						insign										***9.39
					insign											***11.25
				insign												***14.04
			insign													***18.05
		insign														***27.06
	*															*****54.49**
Model 4.1	Y = ΔlogUSD. X = ΔlogBrent. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															**	***4.21
														***		***4.58
													**			***4.93
												**				***5.18
											*					***5.35
										**						***5.97
									**							***6.42
								**								***7.22
							***									***7.97
						**										***9.23
					insign											***11.13
				*												***14.59
			***													***18.38
		***														***26.68
	insign															*****51.27**

***, **, * and "insig" represents the statistical significance level of respective tests

Granger causality, autocorrelation analysis Full sample																
Number of lags included of the variables to obtain no autocorrelation																
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Do the exchange rates Granger cause the oil price?																
Model 1.1R	Y = ΔlogBrent. X = ΔlogI44															F-value
															insign	***1.64**
														*		1.50
													insign			1.45
												***				1.43
											***					*1.58
										***						1.30
									***							1.04
								***								1.15
							***									1.16
						***										1.40
					***											0.59
				**												0.54
			**													0.68
		**														0.58
	**															1.08
Model 2.1R	Y = ΔlogI44. X = ΔlogI44. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															**	**1.80
														**		*1.65
													insign			*1.53
												insign				*1.60
											insign					***1.67**
										***						1.23
									***							1.07
								***								1.22
							***									1.28
						***										1.61
					***											0.53
				***												0.53
			***													0.71
		***														0.63
	**															1.17
Model 3.1R	Y = ΔlogBrent. X = ΔlogUSD															F-value
															**	***2.37
														insign		***2.47
													insign			****2.11**
												***				**2.10
											**					**2.30
										***						*1.75
									***							1.62
								***								*1.75
							***									*1.87
						***										**2.27
					***											*2.14
				**												**2.48
			**													**3.13
		**														1.44
	**															*2.79
Model 4.1R	Y = ΔlogBrent. X = ΔlogUSD. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															***	***2.29
														*		***2.36
													insign			**2.00
												insign				**2.02
											insign					****2.23**
										***						*1.64
									***							*1.71
								***								*1.90
							***									**2.12
						**										**2.64
					***											**2.27
				***												**2.72
			***													**3.43
		***														1.40
	**															*2.77

***, **, * and "insig" represents the statistical significance level of respective tests

11.2 Sample 2.1

Granger causality, autocorrelation analysis Sample 2.1																
Number of lags included of the variables to obtain no autocorrelation																
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Does the oil price Granger cause the exchange rates?																
Model 1.1	Y = ΔlogI44. X = ΔlogBrent															F-value
															insign	***4.16
														insign		***4.40
													insign			***4.71
												insign				***5.07
											insign					***5.26
										insign						***5.71
									insign							***6.02
								insign								***6.69
							*									***7.31
						insign										***8.52
					*											***10.05
				*												***12.40
			*													***14.74
		*														*****22.38**
	**															***43.78
Model 2.1	Y = ΔlogI44. X = ΔlogBrent. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															insign	*****4.14**
														***		***4.40
													**			***4.71
												insign				***5.21
											insign					***5.34
										insign						***5.77
									insign							***6.14
								***								***6.87
							***									***7.58
						***										***8.61
					***											***10.16
				***												***12.89
			***													***14.84
		**														***22.36
	**															***42.11

Model 3.1	Y = ΔlogUSD. X = ΔlogBrent															F-value
															insign	***3.61
														insign		***3.86
													insign			***4.16
												insign				***4.40
											insign					***4.58
										insign						***5.16
									insign							***5.58
								insign								***6.21
							insign									***6.99
						*										***8.15
					insign											***9.74
				insign												***12.15
			insign													***15.44
		insign														***22.13
	insign															*****43.01**
Model 4.1	Y = ΔlogUSD. X = ΔlogBrent. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															insign	***3.52
														***		***3.82
													insign			***4.13
												insign				***4.32
											insign					***4.43
										insign						***5.02
									insign							***5.53
								insign								***6.20
							***									***7.15
						insign										***8.15
					insign											***9.73
				insign												***12.76
			***													***15.79
		***														***21.55
	insign															*****41.52**

***, **, * and "insig" represents the statistical significance level of respective tests

Granger causality, autocorrelation analysis Sample 2.1																
Number of lags included of the variables to obtain no autocorrelation																
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Do the exchange rates Granger cause the oil price?																
Model 1.1R	Y = ΔlogBrent. X = ΔlogI44															F-value
															*	**1.75
														insign		*1.56
													insign			***1.66**
												***				*1.64
											***					**1.81
										***						*1.66
									***							1.36
								***								1.36
							***									1.48
						***										1.74
					***											0.16
				**												0.20
			**													0.24
		**														0.34
	**															0.59
Model 2.1R	Y = ΔlogBrent. X = ΔlogI44. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															**	**1.84
														insign		*1.65
													insign			**1.74
												insign				**1.84
											*					****1.91**
										***						1.60
									***							1.41
								***								1.57
							***									*1.78
						***										*2.04
					***											0.22
				***												0.25
			***													0.29
		***														0.39
	**															0.69

Model 3.1R	Y = ΔlogBrent. X = ΔlogUSD															F-value
															**	*****2.21**
														insign		***2.28
													insign			***2.15
												***				***2.32
											***					**1.93
										***						**1.93
									***							*1.79
								***								*1.73
							***									*1.88
						***										**2.22
					***											1.66
				***												*1.98
			**													*2.52
		**														1.75
	***															*3.72
Model 4.1R	Y = ΔlogBrent. X = ΔlogUSD. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															***	***2.12
														insign		***2.17
													insign			**2.07
												*				**2.07
											insign					**2.25
										***						*1.83
									***							**1.91
								***								**1.98
							***									****2.30**
						***										**2.69
					***											1.76
				***												*2.19
			***													**2.76
		***														1.60
	***															*3.80

***, **, * and "insig" represents the statistical significance level of respective tests

11.3 Sample 3.1

Granger causality, autocorrelation analysis Sample 3.1																
Number of lags included of the variables to obtain no autocorrelation																
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Does the oil price Granger cause the exchange rates?																
Model 1.1	Y = ΔlogI44. X = ΔlogBrent															F-value
															**	**2.05
														insign		***2.19
													insign			***2.35
												insign				***2.37
											insign					***2.47
										insign						***2.70
									insign							***2.88
								insign								***3.09
							insign									***3.22
						insign										***3.67
					insign											*****4.09**
				**												***4.99
			***													***5.08
		**														***7.06
	***															***13.08
Model 2.1	Y = ΔlogI44. X = ΔlogBrent. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															*	***2.10
														*		***2.21
													*			***2.37
												**				***2.47
											**					***2.60
										insign						***2.73
									insign							***2.89
								insign								***3.07
							insign									***3.28
						insign										***3.79
					insign											*****4.24**
				**												***5.35
			***													***5.10
		***														***6.69
	***															***12.72
Model 3.1	Y = ΔlogUSD. X = ΔlogBrent															F-value
															insign	***2.22
														insign		***2.37
													insign			***2.43
												insign				***2.60
											*					***2.65
										insign						***2.93
									insign							***3.15
								insign								***3.39
							***									***3.70
						insign										***4.47
					insign											***5.33
				insign												*****6.48**
			**													***6.86
		***														***9.91
	**															***17.80
Model 4.1	Y = ΔlogUSD. X = ΔlogBrent. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															insign	***2.25
														insign		***2.40
													insign			***2.48
												insign				***2.70
											insign					***2.78
										insign						***2.99
									**							***3.16
								**								***3.36
							**									***3.59
						insign										***4.48
					insign											***5.39
				insign												*****6.67**
			***													***6.74
		**														***9.48
	**															***17.59

***, **, * and "insig" represents the statistical significance level of respective tests

Granger causality, autocorrelation analysis
Sample 3.1

Number of lags included of the variables to obtain no autocorrelation

	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Do the exchange rates Granger cause the oil price?																
Model 1.1R	Y = ΔlogBrent. X = ΔlogI44															F-value
															**	0.93
														**		0.83
													*			0.90
												**				0.86
											**					0.96
										***						0.87
									***							0.81
								***								0.89
							***									0.97
						**										1.12
					***											**0.40**
				**												0.07
			**													0.08
		*														0.11
	*															0.06
Model 2.1R	Y = ΔlogBrent. X = ΔlogI44. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															insign	0.91
														insign		0.88
													*			0.95
												*				0.93
											insign					0.99
										***						0.79
									***							0.69
								***								0.79
							***									0.94
						**										1.08
					**											**0.39**
				**												0.04
			**													0.06
		**														0.11
	*															0.05

	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Model 3.1R	Y = ΔlogBrent. X = ΔlogUSD															F-value
															***	0.89
														***		0.90
													**			0.93
												*				0.93
											***					1.06
										***						1.00
									***							1.03
								***								1.13
							***									1.21
						*										**1.59**
					***											0.82
				***												0.79
			insign													0.82
		insign														1.20
	**															0.65
Model 4.1R	Y = ΔlogBrent. X = ΔlogUSD. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															**	0.84
														**		0.85
													**			0.88
												**				0.90
											**					0.99
										***						0.89
									***							0.92
								***								1.00
							***									1.15
						**										**1.59**
					***											0.74
				insign												0.67
			**													0.61
		**														0.81
	*															0.52

***, **, * and "insig" represents the statistical significance level of respective tests

11.4 Sample 3.4

Granger causality, autocorrelation analysis
Sample 3.2

Number of lags included of the variables to obtain no autocorrelation

	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Does the oil price Granger cause the exchange rates?																
Model 1.1	Y = ΔlogI44. X = ΔlogBrent															F-value
															insign	***4.27
														*		***4.41
													insign			***4.68
												insign				***5.00
											insign					***5.35
										insign						***5.69
									**							***5.17
								*								***5.82
							**									***5.36
						**										***6.10
					**											***7.29
				insign												***9.13
			insign													***11.54
		insign														***17.12
	insign															*****33.29**
Model 2.1	Y = ΔlogI44. X = ΔlogBrent. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															***	***3.76
														insign		***3.76
													***			***4.10
												***				***4.56
											**					***4.94
										**						***5.20
									**							***4.88
								***								***5.63
							**									***5.77
						***										***6.37
					***											***7.14
				***												***9.24
			***													***12.25
		insign														***18.36
	insign															*****32.73**
Model 3.1	Y = ΔlogUSD. X = ΔlogBrent															F-value
															insign	***3.12
														insign		***3.19
													insign			***3.41
												*				***3.37
											insign					***3.69
										**						***4.18
									***							***4.10
								**								***4.45
							insign									***4.71
						insign										***5.30
					insign											***5.95
				insign												***7.43
			insign													***9.77
		insign														*****14.51**
	**															***27.27
Model 4.1	Y = ΔlogUSD. X = ΔlogBrent. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															*	***3.08
														insign		***3.05
													insign			*****3.15**
												**				***3.00
											***					***3.26
										*						***3.69
									**							***4.03
								insign								***4.58
							*									***5.26
						***										***5.76
					***											***5.87
				**												***7.69
			***													***10.55
		**														***14.45
	*															***26.62

***, **, * and "insig" represents the statistical significance level of respective tests

Granger causality, autocorrelation analysis
Sample 3.2

Number of lags included of the variables to obtain no autocorrelation

	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Do the exchange rates Granger cause the oil price?																
Model 1.1R	Y = ΔlogBrent. X = ΔlogI44															F-value
															***	***2.09
														insign		**2.06
													insign			***2.19
												***				***2.21
											**					***2.30
										*						***2.73
									***							***2.43
								***								**2.30
							*									**2.59
						insign										***3.03
					insign											0.59
				*												0.37
			**													0.46
		*														0.30
	insign															0.52
Model 2.1R	Y = ΔlogBrent. X = ΔlogI44. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															***	*1.75
														**		*1.73
													insign			*1.71
												insign				**1.87
											insign					**1.84
										insign						**2.09
									**							**1.96
								***								**2.25
							***									***2.75
						insign										***3.61
					***											0.72
				**												0.75
			***													0.77
		**														0.56
	***															0.62
Model 3.1R	Y = ΔlogBrent. X = ΔlogUSD															F-value
															insign	***2.25
														insign		***2.30
													insign			***2.24
												**				**1.99
											**					**2.13
										***						**2.16
									***							**2.16
								***								*1.79
							**									*1.89
						insign										*1.99
					insign											**2.32
				**												**2.86
			insign													***3.87
		insign														2.05
	*															2.69
Model 4.1R	Y = ΔlogBrent. X = ΔlogUSD. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															***	**1.77
														**		**1.85
													insign			*1.68
												*				1.36
											insign					1.44
										insign						1.44
									***							*1.74
								***								*1.68
							**									*1.84
						**										*2.08
					***											**2.31
				insign												**3.03
			insign													***4.34
		insign														1.84
	insign															*2.94

***, **, * and "insig" represents the statistical significance level of respective tests

11.5 Robustness Sample

Granger causality, autocorrelation analysis Full sample, robustness																
Number of lags included of the variables to obtain no autocorrelation																
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Model 1.1	Y = ΔlogI44. X = ΔlogBrent															F-value
															*	1.20
														insign		1.25
													**			1.14
												**				1.15
											**					1.15
										insign						1.35
									*							1.42
								**								*1.80
							insign									*1.83
						insign										1.56
					insign											1.60
				*												*2.09
			**													2.06
		**														**3.79
	***															1.82
Model 2.1	Y = ΔlogI44. X = ΔlogBrent. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															*	1.35
														*		1.21
													insign			1.18
												**				1.46
											**					1.24
										insign						1.51
									*							1.50
								insign								**2.10
							insign									*1.86
						*										*1.85
					insign											**2.27
				insign												**3.33
			**													**3.54
		**														***5.56
	**															1.23
Model 5.1	Y = ΔlogI44. X = ΔlogBrent. Control variables = Δintdiff_I44, ΔLIBORUSD, ΔlogINDPRO_USD, ΔlogINDPRO_NOK, ΔlogINDPRO_I44 and ΔCPIdiff_I44															F-value
															*	1.03
														***		0.95
													insign			1.06
												***				0.93
											insign					1.01
										insign						1.44
									insign							1.60
								insign								**2.35
							insign									*2.07
						*										**2.30
					insign											**2.50
				insign												**2.78
			**													**2.85
		*														***6.08
	***															1.57

Model 3.1	Y = ΔlogUSD. X = ΔlogBrent															F-value
															insign	0.57
														insign		0.53
													insign			0.53
												insign				0.54
											insign					0.55
										insign						0.66
									insign							0.49
								insign								0.57
							insign									0.60
						insign										0.77
					insign											0.88
				insign												0.97
			insign													1.31
		insign														2.21
	insign															**0.54**
Model 4.1	Y = ΔlogUSD. X = ΔlogBrent. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															insign	0.91
														insign		0.76
													insign			0.63
												**				0.63
											*					0.44
										**						0.51
									insign							0.38
								*								0.46
							*									0.41
						*										0.37
					insign											0.46
				insign												0.55
			insign													1.02
		insign														1.56
	insign															**0.14**

***, **, * and "insig" represents the statistical significance level of respective tests

Granger causality, autocorrelation analysis Full sample, robustness																
Number of lags included of the variables to obtain no autocorrelation (***, **, * and "insig" represents the statistical significance level of the autocorrelation coefficient)																
	1 lag	2 lag	3 lag	4 lag	5 lag	6 lag	7 lag	8 lag	9 lag	10 lag	11 lag	12 lag	13 lag	14 lag	15 lag	F-test (on all lags of X)
Model 1.1R	Y = ΔlogBrent. X = ΔlogI44															F-value
															insign	***2.19
														insign		***2.36
													insign			***2.44
												*				***2.38
											insign					*****2.41**
										***						**2.11
									**							**2.17
								**								**2.50
							insign									***2.80
						insign										***3.30
					**											1.36
				insign												1.40
			insign													1.92
		**														0.97
	insign															1.69
Model 2.1R	Y = ΔlogBrent. X = ΔlogI44. Control variables = Δintdiff_I44 and ΔLIBORUSD															F-value
															insign	1.53
														insign		*1.66
													insign			**1.96
												**				**1.89
											insign					**2.16
										******						****1.94**
									**							*1.70
								**								**2.13
							insign									**2.37
						insign										**2.69
					*											0.86
				insign												0.86
			insign													0.92
		insign														0.85
	insign															0.75
Model 5.1R	Y = ΔlogBrent. X = ΔlogI44. Control variables = Δintdiff_I44, ΔLIBORUSD, ΔINDPRO_USD, ΔINDPRO_NOK and ΔCPIdiff_I44															F-value
															***	1.34
														*******		**1.42**
													***			1.36
												**				1.30
											*					1.39
										**						1.14
									**							1.34
								***								1.33
							**									1.70
						insign										1.48
					insign											1.16
				***												0.85
			insign													1.16
		insign														0.76
	insign															0.92

Model 3.1R	Y = ΔlogBrent. X = ΔlogUSD															F-value
															*	***3.30
														insign		***3.52
													insign			***3.64
												***				***3.74
											*****					*****4.04**
										**						***4.01
									**							***4.27
								***								***4.18
							insign									***4.79
						insign										***5.12
					insign											***6.00
				**												***6.64
			insign													***8.39
		***														***7.65
	insign															***14.29
Model 4.1R	Y = ΔlogBrent. X = ΔlogBrent. Control variables = ΔLIBORUSD and Δintdiff_LIBORUSD															F-value
															**	***2.32
														**		***2.59
													**			***2.83
												***				***2.90
											******					*****3.09**
										**						***3.39
									*							***3.65
								***								***3.52
							insign									***4.11
						insign										***4.64
					insign											***5.37
				insign												***6.05
			insign													***7.69
		**														***7.12
	**															***15.32

***, **, * and "insig" represents the statistical significance level of respective tests