Has the Russian ruble's exchange rate decoupled itself from oil prices ?

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Abstract

This paper studies the evolution of the relationship between the exchange rate of the ruble and oil prices over the period from January 2012 to September 2019. Its main purpose is to verify that the ruble's exchange rate to US dollar has decoupled itself from oil prices after the Russian ruble crisis. This dissociation is explained with the support of the theoretical basis of the Dutch disease and additional commercial, financial and monetary variables. The analysis is based on 93 observations using time series for monthly data. The period subjected to the analysis was divided into three sub-periods: January 2012 - July 2014, July 2014 - March 2016 and March 2016 - September 2019 to indicate any difference in the relationships between our variables relatively to particular ruble's exchange trends. The analysis uses Ordinary Least Squares (OLS) method and proves that oil prices did not explain ruble's exchange rate variability during the third sub-period, whereas previous sub-period were characterized by strong relationships between these two variables. The switch in the exchange rate regime of November 2014 as a consequence of the Russain ruble crisis led to the emergence of a financial variable to explain ruble's exhange rate variability.

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1 Introduction

In the wake of oil prices fall, the exchange rate of the ruble (RUB) against the dollar (USD) has fallen in substantial proportion and in the same direction. In the beginning of September 2014, (BRENT) oil barrel price was 100USD, whereas ruble exchange rate was 35RUB for 1USD. In January 2015 just 4 months later, the oil barrel price lost 50 percent of its value, and 60RUB was equivalent to 1USD, reflecting a 70 percent value loss for the ruble. These large exchange rate's variations have occurred in the context of the Russian ruble crisis and can be explained by the important role of oil on the Russian economy.

Currently standing as one of the top oil producer in the world[1], Russia has an economy highly hooked up on this resource. Oil exploitation is determinant on commercial, fiscal and production channels that explain the economic development of the country. More than oil volume, it is the market price that settles this role, since it conditions the amount of earnings linked to this resource, and because it is an important reference for the government when determining fiscal and monetary policy, making the Russian economy inherently dependant on it. This dependence has been recalled and illustrated by the strong variations during the past decade, which have been mainly characterized by halving prices in short time periods constituting shocks for the Russian economy. Downward oil prices are dangerous

[1] Second in 2014, Market Realist

for the latter, as they make it vulnerable to fluctuations when a crisis starts on the market, but maybe less on the long term than high oil prices, that are seen as "godsends" windfalls, creating prosperity and conditioning in part the economic growth.

Large oil exports earnings[2] coming from high oil levels may create a certain prosperity, but interweaves the economy towards more dependence on the oil price. These earnings result from the difference between market price and cost of production and can also be called rents, as the country has a comparative advantage in the international trade[3]. These rents (or earnings) give rise to a destructive economic phenomenon known as the Dutch disease, which demonstrates that oil exports cannot be the base of a good economic development in the long term (even if prices are high) since it impacts the monetary channel and more specifically the country's exchange rate. Multiple studies have analyzed the role of oil prices on the exchange rate of the ruble, either by focusing exclusively on their relationship or by including additional variables, for a specific period. Some covered extended time analysis without taking into account major upheavals that may have distorted their results, when others concentrated on brief time periods that may be too limited to have relevant and meaningful ones. These studies are numerous but they never tried to determine how the relationship between variables had evolved through time, particularly after the major Russian ruble crisis of 2014-2016. The absence of the notion of change that implies a crisis and interpretation with a theoretical basis such as the Dutch disease is the major drawback of these studies, that this paper tries to overcome.

The purpose of this paper is to study the nature and evolution of the relationship between the exchange rate of the ruble and oil prices during the past decade. More specifically examine its strength, how it has changed and what it implies in terms of Dutch disease considerations. The study covers the period from January 2012 to September 2019, that can be divided in three sub-periods relative to specific ruble's exchange rate trends. Our hypothesis is that the strength of the relationship has grown weaker after the Russian ruble crisis, as the collapse of the ruble's value could have been beneficial to other sectors of the economy becoming more competitive. To support our analysis we chose to include additional variables that may explain at some extent ruble's exchange rate variability and clarify its relationship with oil prices. Hence the ultimate question raised is: Has the ruble's exchange rate decoupled itself from oil prices ?

This paper is organized as follows. In Section 2 with the support of an abundant academic literature a theoretical framework is provided. In Section 3 and 4, the data and methodology used to answer the research question are put forward. In Section 5, the results of the analysis are represented and discussed. In Section 6 a conclusion is drawn.

2 Theoretical Framework

2.1 Dutch disease in Russia

There is no simple definition that could describe in two sentences all the effects and consequences implied by the Dutch disease, that is why we propose an extended one: The Dutch disease affects countries that export abundant and cheap natural resources, in the same vein as Russia with its oil. By exporting these commodities, the demand on the nation's currency increases, making it more valuable and creating an overvaluation of the country's exchange rate. This overvaluation impact non-oil manufactured goods and services sectors, which are becoming less competitive on the international market as they are relatively higher-priced, preventing them to develop further towards high

[2] We will focus on exports as 70 percent of oil production is exported

[3] As defined by David Ricardo in *Principles of Political Economy and Taxation, 1817*

value-added industries[4]. In the end exported commodities become the sole source of income to support the nation's economic growth, reflecting a strong dependency. That being said the first question is: Does Russia suffers from the Dutch disease ?

Many studies have analyzed the presence of the Dutch disease in Russia, but their appreciation differs concerning the form this one might take. The article of Pavlova et al (2017) describes the two points of view of experts on this matter. The first and prevalent standpoint is that "Russia does not suffer from the Dutch disease, but features its certain patterns", when the second one demonstrates the existence of symptoms by highlighting the importance of oil prices on economic growth "postponing the development of other sources of income".

The study of Bilan et al (2018) holds the second standpoint emphasizing on the existence of a "strong and positive correlation of oil prices and GDP". This is confirmed by Blokhina et al (2016) claiming that oil prices created prosperity and conditioned in part the Russian economic growth of the 2000s[5], but also by Vartapetov et al (2019) for a more recent period. Jacques Sapir, a well known French economist does not reject this existence, however he reminds that it is due to the effects of oil prices "on budgetary and financial mechanisms" more than on the level of production as "oil and gas activities together only account for 10 percent of the GDP"[6]. In 2014, half of the federal budget[7], nearly 70 percent of export revenues[8] and 80 percent of foreign investments[9] were linked to oil industries, suggesting a link between oil prices and a balanced budget, but also with the exchange rate of the ruble. The impact on the growth rate is only the final stage of the economy's dependence on oil prices. What is interesting is the links that create this correlation and particularly the one between oil prices and the ruble's exchange rate.

Bilan et al (2018) estimated the existence of this link for the period from 2009 to 2014. By conducting long term regressions it concluded that oil prices explained a large part of the ruble's exchange rate variability. Other studies such as Gong et al (2017), Urbanovsky (2015) and Blokhina et al (2016) showed on greater periods a similar correlation for these two variables, thus proving that high oil prices can create an overvaluation of the ruble's exchange rate which is characteristic of Dutch disease effects. Bresser-Pereira (2013) recalls how the exchange rate is determined: "it results from the interaction between foreign currency supply (caused by exports and by capital inflows) and the demand for foreign currency (derived from imports, net profit remittances, and capital outflows) with respect to the local currency". In addition to oil prices, the exchange rate can be influenced by a multitude of other variables affecting capital flows. This is confirmed by Jacques Sapir: "The exchange rate is, of course, influenced by movements in oil prices, but it is also heavily influenced by capital outflows and inflows"[10].

2.2 How Russian authorities have tried to mitigate its effects

Being one of the "most strategic macroeconomic price existing because of his effect on the growth and stability of a national economy"[11] the exchange rate is highly regulated by Russian authorities in order to deal with Dutch disease pressures[12]. We have identified four tools that were used to conduct this regulation for the period prior to November

[4]Such industries are crucial to increase the productivity and therefore be a source of wealth and development for a nation
[5]From 2000 to 2010, the annual average GDP growth rate of Russia was 6.5 percent
[6]Sapir Jacques, Un été agité, Marianne 2015
[7]Russian Ministry of Finance
[8]OEC
[9]Trading Economics
[10]Sapir Jacques, Les dangers d'une forte appréciation du Rouble, Marianne 2017
[11]Bresser-Pereira (2013)
[12]Barnes (2013)

2014. They are described from most to least important.

The most important one was the soft pegged exchange rate regime, making the Russian currency pegged to a dual-currency basket with US dollar and Euro. This monetary policy allowed the ruble to be stable and not subjected to oil prices fluctuations or other capital flows. By selling or buying foreign currency reserves, the Central Bank of Russia (CBR) was either supporting or undermining ruble's exchange rate against the US dollar and Euro when it exceeded its settled boundaries. The second tool used were funds (the Reserve and National Welfare Funds) which purpose was to save excess oil revenues[13] in order to use them when they were lower to ensure budgetary equilibrium, making it an effective "economic security mechanism". The third tool was an increasing taxation of oil export revenues when oil prices crossed a certain threshold. This high taxation[14] was a solution to neutralize Dutch disease effects[15]. However it made the federal budget too dependent on oil exports revenues and vulnerable to oil prices fluctuations. That is why an additional tool was created in 2008[16], named "the fiscal rule". According to Kluge (2019) it is a "legal provision that is designed to ensure the long-term sustainability of budget policy. When a country exports a large amount of its (finite) resources, a fiscal rule can be used to establish that only a portion of the revenues will be used and the rest saved", it can also "help to reduce negative effects of commodity exports on other economic sectors, known in economic jargon as the Dutch disease". In 2012 the Russian Ministry of Finance planned its budget on a fiscal rule based on an oil barrel price of 91USD.

For Barnes (2013) these tools have been successful to deal with Dutch disease pressures: "Russia has been remarkably successful since the early 2000s in dealing with the impersonal, automatic effects of high hydrocarbon revenues. It has sterilized oil revenues to counter upward pressure on the ruble, and it has stored excess funds away for when revenues decline". So great that other studies such as Bykau et al (2016) argues, after analyzing graphically the evolution of oil prices and the ruble's exchange rate that "there was, from the beginning of 2011 to November 2014, no correlation between them". However we have two elements to oppose them. First the ruble's real effective exchange rate (REER) defined by Vartapetov et al (2019) as "the trade-weighted nominal exchange rate (adjusted to inflation differentials) between Russia and its trading partners" has not been determined by the pegged exchange rate regime and contrary to the nominal exchange rate "moved in tandem with oil prices" pushing Dutch disease effects: "The ruble tended to appreciate as oil prices increase, and to depreciate as oil prices fell. This is particularly visible in the ruble's real effective exchange rate". High oil prices caused an overvaluation of the REER, and impacted the economic growth. The latter was slowing from the summer of 2012 by almost 1.5 percent per year: "the economic growth of 3.4 percent in 2012, fell to 1.3 percent in 2013, due to the lack of sufficient diversification of its economic base, and the lack of competitiveness of its industrial exports"[17]. This highlights the concrete effects of high oil prices creating an overvaluation of the country's currency (REER) impacting non-oil manufactured goods and services sectors which are becoming less competitive and ultimately damages the economic growth. Andrew Barnes that defended Russia's tools efficiency to mitigate Dutch disease effects, however believed that despite their existence, if oil revenues were to fall this "would be a significant blow for the Russian economy" that would be "forced" to change[18].

[13] See the fourth tool: "the fiscal rule"
[14] the main source of federal income
[15] Bresser-Pereira (2013)
[16] Renewed in 2012
[17] Berg Eugène, Situation et perspectives de l'économie russe, Géoéconomie
[18] Barnes (2013)

2.3 The Russian ruble crisis

The global oil market crisis, which began in July 2014, has led to a considerable drop in oil barrel prices in just a few months and damaged economies of oil exporting countries. Among the affected countries is Russia, given the importance of oil on its exports and budget revenues. At the same time (as a result of events linked to the Ukrainian crisis) financial sanctions were imposed on its economy by Western countries. The combined effect of these two events reinforced by a speculation on the value of the ruble led to the so-called "Russian ruble crisis" that lasted from July 2014 to the beginning of 2016. This crisis was characterized by a rapid and sustainable fall of ruble's value resulting from an increase of its exchange rate against other currencies such as the US dollar and Euro.

The consequences of this crisis were numerous on macroeconomic indicators, and led among others to a fall in Gross Domestic Product (GDP)[19], national currency, imports[20], but also an increase of budget deficit, inflation[21], and unemployment[22]. Some financial and monetary aspects were also at play throughout this crisis. Gross capital outflows from Russia are estimated to have been close to 250 billions of USD (153 for 2014 alone)[23], while the net flow to Western countries resulting from early repayments due to financial sanctions was 90 billions of USD[24]. These outflows contributed to the spread of the crisis and made ineffective the tools of the authorities to regulate the ruble exchange rate. The copious fiscal rule[25] becamed rapidly obsolete and the Reserve fund (one of the two sovereign funds of Russia) used to cover budget deficit, was finally entirely depleted and ceased to exist[26]. During the first months of the crisis, the CBR used its foreign currency reserves to enforce its exchange regime and keep the ruble in its settled boundaries. In October 2014 alone, 30 billion USD were spent to support the ruble, with little success[27]. The total reserves which amounted to 465 billion USD at the beginning of September 2014, decreased by 10 percent in the following two months[28] without being able to stop the combined effects of falling oil prices, financial sanctions and speculation against the ruble. Facing the inefficiency of its operations, the CBR decided to make a major change in its monetary policy by stopping to intervene on the foreign exchange market, thus allowing the ruble's exchange rate to fluctuate freely.

This change was initially planned for January 2015 but the drop in oil prices accelerated the Central bank's transition to a free-floating exchange rate in November 2014. Bykau et al (2016) explains well what it allows and why it was adopted by Russia: "Floating exchange rate as a kind of monetary policy allows the Central bank to not spend reserves to maintain the desired exchange rate of ruble, which is adjusted only on the basis of market supply and demand. In turn, the supply and demand for foreign currency derives from the changes in the balance of payments. Market self-regulation reduces the exchange rate of ruble after decrease in exports. That consequently leads to reduction of imports. Thus, the floating exchange rate prevents possible trade and budget imbalances in the period of drastic decline in exports". This is confirmed by Jacques Sapir[29] and by Sturm et al (2009). According to the latter "if the monetary policy is being constrained in tackling the challenge of commodity shocks as a result of a pegged exchange rate regime, the fiscal policy is left to carry the main burden of macroeconomic stabilization". This is highlighted by

[19] A negative GDP of 2.3 percent in 2015, Ministry of Finance
[20] A drop of 36 percent in 2015, Central Bank of Russia
[21] An increase of 13 percent in 2015, Ministry of Finance
[22] Pavlova et al, 2017
[23] Berg Eugène, Situations et perspectives de l'économie russe, Géoconomie
[24] Sapir Jacques, Pétrole et rouble, Marianne
[25] Based on an oil barrel price way to high
[26] Kluge (2019)
[27] Hansl Birgit, What is the impact of falling oil prices?, Weforum
[28] CBR data
[29] Sapir Jacques, Russie: le renouveau ?, Marianne

Bykau et al (2016) when comparing Russia with other oil exporting countries such as Venezuela, that did not change its exchange rate regime. But by operating this switch, the CBR has also left the strengthening of the relationship between the ruble's exchange rate and oil prices, the former being now subjected to the latter's variations. This is confirmed by the same study: "the inverse relationship between oil price and Russian ruble is clearly evident".

2.4 Its aftermath

The ruble crisis exposed the existence of structural weaknesses that were underestimated by the authorities, content to put in place tools that could manage possible shocks while continuing to benefit from large oil revenues. The ineffectiveness of those tools have not been predicted just like the possibility of the crisis. But studies prior to these events such as Barnes (2013) already supported a diversification of the Russian economy to overcome structural weaknesses linked to the Dutch disease. Those who suggested it afterwards, such as Bykau et al (2016), Pavlova et al (2017), and Vartapetov et al (2019) have highlighted the need for structural reforms that "could gradually facilitate economic diversification and sustainably boost economic growth"[30]. This viewpoint is not specific to the academic literature, even the president of the CBR Elvia Nabioullina, stated in 2015 "that the implementation of fundamental reforms aimed at diversifying the Russian economy is essential"[31].

This diversification was inhibited by the Dutch disease which prevented non-oil economic sectors to develop further due to an overvalued exchange rate making them less competitive. But the Russian ruble crisis which is characterized by a fall of the ruble's value could potentially be beneficial to improve the competitiveness of these sectors. Bresser-Pereira (2013) has explained that the Dutch disease "is a market failure that implies the existence of a difference between the exchange rate that balances inter-temporally the country's current account and the exchange rate that enables the existence of efficient economic sectors of tradable goods and services". The former is the nominal exchange rate determined on the foreign exchange market and the latter is the industrial one, hypothetically enabling the existence and development of other sectors. With the crisis they necessarily got closer. The weak exchange rate being now favourable to domestic firms, which are preferred on the domestic market as a result of higher-priced imports, but also on the international market since the cost of the nation's currency is cheaper. According to the World Economic Forum, the "global competitiveness index of Russia" has improved since 2014[32]. At the break of the ruble crisis, Russia was ranked 64th in the global competitiveness index, when two years later it was 45th, and 43th rank in 2019. This could result in the development of non-oil economic sectors and reduce the dependency of the economy on oil prices. If this development is sufficiently strong a dissociation (or decoupling) could occur between the ruble's exchange rate and oil prices.

Jacques Sapir's works have raised awareness on the importance of distinguishing short-term and long-term trends. If a dissociation occurs it could be the result of either a short or long-term trend. A short term trend could be for example the ruble crisis, that could have potentially modified the relationship between ruble's exchange rate and oil prices[33], but with no consequences on the existence of the Dutch disease. This is highlighted by Bresser-Pereira (2013), when it argued that the Dutch disease "cannot be corrected by a currency crisis, because it is based on long-term equilibrium such as the country's current account". Whereas a long-term trend could be for example structural reforms, that can induce a durable and concrete modification of the relationship between our two variables and potentially eliminate the Dutch disease presence. No doubt that the Dutch disease cannot be suppressed by a shock such as the Russian ruble

[30] Vartapetov et (2019)
[31] Lamort Edouard, Comprendre la crise du rouble en trois questions, L'Obs
[32] Trading Economics data
[33] Bykau et al (2016)

crisis, however the latter could be the departure point of broader structural changes that could reduce the importance of oil prices on the economy but also the strength of the relationship between oil prices and the ruble's exchange rate to eventually decouple them.

3 Data

The data-set used comes from multiple institutions both national and international: the Organization for Economic Co-operation and Development (OECD), the IMF, the CBR (Central Bank of Russia) and the Moscow Exchange. The frequency of our data is monthly with 93 observations, which is enough to conduct multiple estimations using time series as they reflect the evolution of our variables. These variables can be divided in two categories: the ones for which a monthly value corresponds to the first day of the month, from the ones for which a monthly value concerns the entire month.

For the aim of this study we have chosen to focus on data covering the period from January 2012 to September 2019, since it exhibits major upheavals that may have induced changes in the relationship between our variables. We could have studied a broader period, starting in January 2010 for example (since data is easily available) or going beyond September 2019, but we consider it unnecessary as there are no significant differences in value for our variables.

3.1 Data Description

3.1.1 Dependant Variable

The Exchange Rate of the Ruble

The exchanged rate of the ruble to US dollar represents the rate at which ruble is exchanged for US dollar in nominal terms, it can also be viewed as the value of the ruble against the US dollar. Determined on the foreign exchange market, this currency exchange is the most common one in Russia considering that the US dollar plays a great role on international trade[34] (whether for commercial or financial exchanges), holds a strong position as an alternative currency[35] and is viewed as a safe haven one in troubled times. Bresser-Pereira has recalled theoretically how the exchange rate was determined[36], but in concrete terms it can be illustrated by a situation where a foreign agent wants to buy a Russian commodity on the international market, but in that purpose he first needs to exchange his dollars for rubles. The local producer can also accept the dollars and exchange them himself for rubles, which doesn't change the fact that the US dollar supply and ruble demand will be modified inducing changes in the exchange rate level and leading to a relative appreciation of the ruble against the dollar. The only alternative could be to replace this variable by the REER, knowing that this indicator was not impacted by the switch of the exchange rate regime of November 2014 and could produce better estimations. However related data are too aggregated to be used, that is why the nominal exchange rate of the ruble to US dollar, presented in our time series by the closing value of the first day of the month is chosen to be the dependant variable.

[34] Pavlova et al, 2017
[35] Fjærtoft, 2011
[36] See section 2.1

3.1.2 Explanatory Variables

Oil Prices

Oil prices constitute the first and most important explanatory variable for this study. Determined on the international market, prices are subjected to variations from supply and demand like other commodities, but also by market sentiment which tends to create a growing speculation generating subsequent prices fluctuations[37]. Some studies have tried to explain these fluctuations[38] but we will simply note them. Oil market is not unified since it is composed of numerous countries having their own prices such as Russia with the ”Urals” brand, but this one is determined and based on the ”Brent” unit. The latter is the most widely used crude oil price globally, and a reference for a large part of oil extracted. By choosing the Brent unit as a framework, the Russian oil is perfectly integrated to world oil market. But also dependant to its denominated currency: the US dollar[39]. For these reasons and because we are interested in the evolution of the relationship between this variable and the dependant one, we choose the Brent unit as it reflects perfectly the main changes in world oil prices. These prices are provided in the related time series by the closing value of the first day of the month.

Exports

Exports can be an important variable in explaining the variations of the exchange rate, as they are one of the factors that determine the amount of foreign currency traded for ruble on the exchange market. Specifically oil exports that are the gateway to large flows of US dollar supporting allegedly the ruble's value. However non-oil sources of earnings are not negligible in the total export distribution, making it interesting to estimate a potential relationship with the ruble's exchange rate. This could give an insight of how alternative sources of earnings are influencing the ruble, but also how this relationship has evolved since the ruble crisis. Unfortunately such indicator is never brought to the fore in Russia and is not easily available, that is why total exports worth is chosen instead. They are expressed in billions of dollars and provided in our time series by monthly value, which is the smallest frequency we can get for such a macroeconomic indicator.

Reserves

Reserves are the amount of foreign currency and gold held by a central bank or other monetary institutions. In Russia, the CBR regulates these reserves taking most commonly the form of treasury bills and government bonds (enabling to earn interest). The Central bank can buy and sell foreign currencies in order to regulate exchange rates. As we saw in the literature review the scale of CBR's operations to support the ruble's exchange rate has declined sharply to switch from a dual currency soft peg to a floating exchange rate in November 2014. This switch allowed the ruble to float freely hence influencing its exchange rate. By taking non-gold reserves as an explanatory variable it is interesting to examine the strength of this relationship with the exchange rate, and what it implied in level terms for the latter. Total reserves worth is expressed in billions of dollars and are provided in our time series by monthly value.

Interbank interest Rate

The interbank rate is the prevailing interest rate on short-term loans between banks. Banks borrow and lend money on the interbank market to provide liquidity and to meet the conditions imposed on them. The 90 day interbank interest rate is a good indicator of short-term money market conditions and sentiment. It can either facilitate the circulation of money between banks or make it more difficult by reaching very high interest rates levels. This rate can influence

[37] Pavlova et al, 2017
[38] Pavlova et al, 2017
[39] This dependence has been so great that the Russian economy was considered as a dollarized one by Fjærtoft (2011)

capital movements within banks and potentially other financial markets, ultimately impacting the ruble's exchange rate value. Therefore it constitutes a potential relevant explanatory variable that needs to be estimated in our model. Provided in the related time series by the value of the first day of the month, it is expressed in percentage.

RTS

The RTS (Russia Trading System) index is one of the most important stock market indices in Russia. It is calculated by the Moscow Exchange and reflects the current market capitalization of the 50 largest and most dynamic issuers firms of Russia. Composed of very diverse companies ranging from the mastodon Gasprom[40] (producing oil and gas) to Yandex (specialized in Internet-related products and services) it can be seen as a relevant indicator of financial market movements. More than an indicator as a framework of capital flows including foreign investments in Russia, that are known to influence ruble's exchange rate[41]. It is provided in the related time series by the closing value of the first day of the month.

3.1.3 Variables notation

The following notation will be used

- RUBUSD : The Exchange Rate of the Ruble to US Dollar
- OILPRICE : The BRENT Oil Price
- EXPORTS : Total Exports
- RESERVES : Non-gold Reserves
- INTEREST : 90-day Interbank Interest Rate
- RTS : RTS Index

3.2 Graphs of Series Evolution

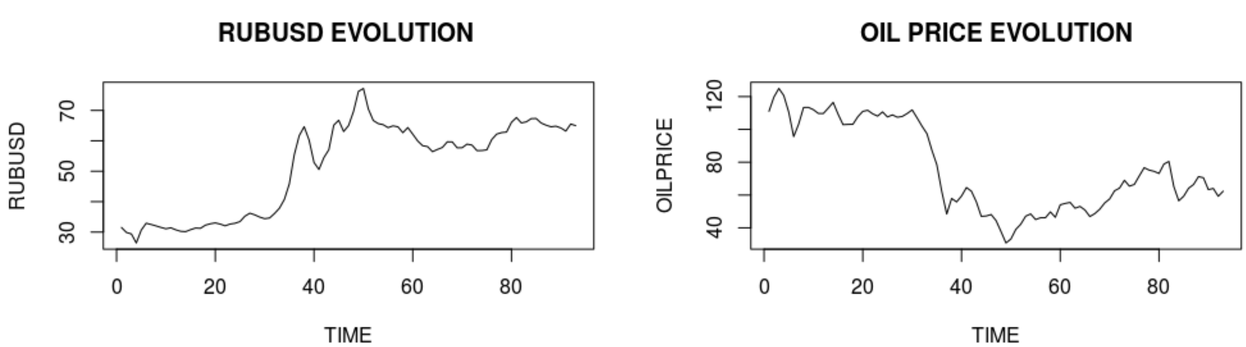

Figure 1: **Graphics RUBUSD and OIL PRICE**

These two first graphs represent the evolution of the exchange rate and oil price from January 2012 to September 2019. We observe a potential inverse relationship between these two variables: indeed trends are changing around

[40]The largest Russian company, Forbes
[41]Vartapetov et al, 2019

the 30th observation with a considerable increase of the ruble's exchange rate whereas we observe a collapse of oil prices. From these charts we can also notice the existence of three trends characterizing three sub-periods: between the 1st and 30th observations with a stagnation for these two variables, then a reversal depreciating considerably their values[42] and beyond the 50th observation with a relative stagnation. Furthermore it is difficult at first glance to notice a possible dissociation between these two variables, even if it can be said that after the 60th observation the inverse relationship is less obvious.

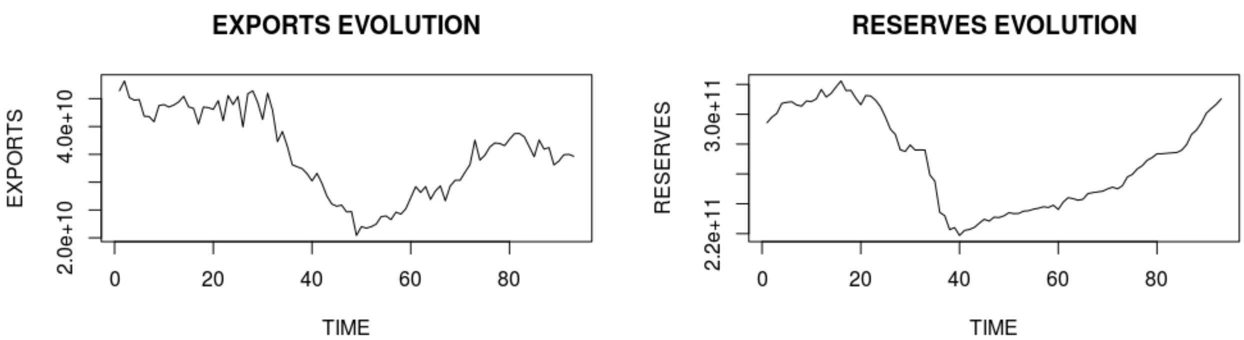

Figure 2: **Graphics EXPORTS and RESERVES**

These two next graphs represent the evolution of exports and reserves from January 2012 to September 2019. The scales are now different and expressed in hundreds of billions of dollars. There are commonalities and differences between them and with the two previous graphs. It seems that there are also three trends, with a stagnation followed by a collapse and then an increase. However we notice that the reversal comes earlier for the reserves. They plunge after the 20th observation, when other variables are still stagnating. In terms of turning point the exports chart is very close to the one of oil price, while the reserves have a very singular evolution with an increase after the 40th observation when other variables are not yet at their lowest point. We can even say that at the 40th observation when reserves start to rise the exchange rate depreciation accentuates. This could be explained by the switch in the exchange rate regime which was characterized by the ending of ruble support from the CBR. This last point is going to be verified by the estimations.

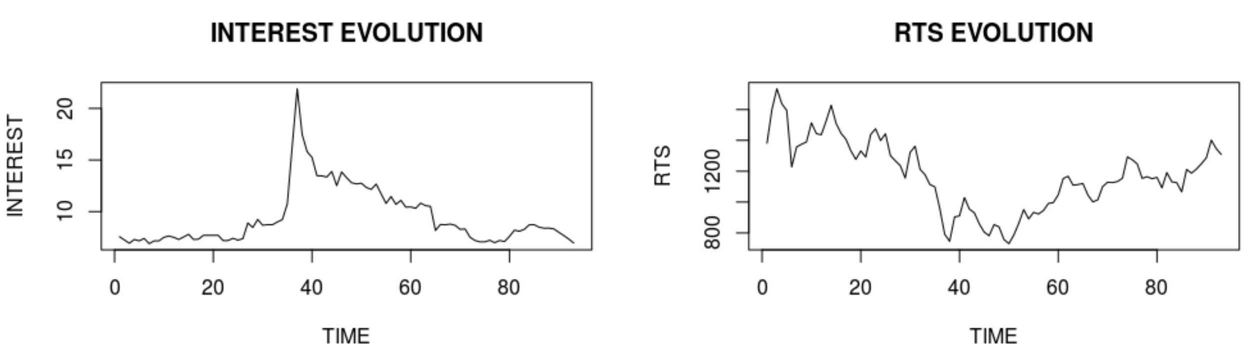

Figure 3: **Graphics INTEREST and RTS**

[42]Given that an increase in the ruble's exchange rate results in a decrease of its value against the US dollar

These last two graphs represent the evolution of the interbank interest rate and the rts index from January 2012 to September 2019. It can be seen that the interest rate has a singular evolution with an important increase around the 35th observation and then a continuous decrease until it reaches levels prior to the turning point. The peak characterizes the climax of the ruble's crisis with an interest rate above 20 percent illustrating the effects of the shock: sudden and extended. The rts's chart for its part, is representative of a stock market index with continuous fluctuations around a general direction. The three trends appointed in the two first graphs are visible on the rts one (making it closer to these two variables), even if a relationship between the rts and the exchange rate is hardly perceivable graphically.

4 Methodology

4.1 OLS methodology

This study examines the potential influence of 5 explanatory variables on the ruble's exchange rate using Ordinary Least Square (OLS) method. Our first objective is to estimate such influence for the entire period to get an overview of the relationships that link our variables. Then conduct further regressions to analyze how they evolved by comparing estimations results of three sub-periods relative to ruble's exchange rate trends which are:
January 2012 – July 2014
July 2014 – March 2016
March 2016 – September 2019

We use time series in the following multiple linear regression model:

$$rubusd_t = \beta_0 \;+\; \beta_1\, oilprice_t \;+\; \beta_2\, exports_t \;+\; \beta_3\, reserves_t \;+\; \beta_4\, interest_t \;+\; \beta_5\, rts_t \;+\; U_t \qquad (1)$$

That we linearise through logs, for reasons of scale (since some series are expressed in hundreds of billions of dollars) and in order to be able to interpret our results with percentages[43]:

$$log(rubusd_t) = \beta_0 + \beta_1 log(oilprice_t) + \beta_2 log(exports_t) + \beta_3 log(reserves_t) + \beta_4 log(interest_t) + \beta_5 log(rts_t) + U_t \qquad (2)$$

Hence in this model (betas) are coefficients linked to explanatory variables and (Ut) is the error term (the part non explained by the model). The whole purpose of the OLS method is to estimate under a certain number of hypotheses, the coefficients that will account for the potential influence of explanatory variables on the dependent one. It is done by minimizing the sum of the squared residuals between the predicted and observed values to obtain BLUE estimators[44] which are unbiased and with minimal variance. OLS assumptions needs to be verified by our model to get correct estimates. However given its shape and operations that will be conducted in the next section, the only assumption that may not be verified is the constant variance of error terms or homoscedasticity. If variance changes the model experiences heteroscedasticity which reduces the precision of the estimates in OLS linear regression[45]. To check this assumption we could create a residuals versus fitted value plot, but we prefer to be more precise and conduct a Breush Pagan test.

[43] This process does not modify the variations and trends represented in the previous graphs
[44] Best Linear Unbiased Estimators
[45] Impacting the validity of the analysis

4.2 Breush-Pagan test

The Breusch-Pagan test establishes the following null and alternative hypothesis:
H0: the variance is constant, presence of Homoscedasticity
H1: the variance is not constant, presence of Heteroscedasticity
The null hypothesis H0 is rejected for a p-value inferior to 5 percent

The method consists in first estimate the initial model by OLS and then collect the results. In a second step, regress the square of the regressions on the explanatory variable and calculate the Breusch-Pagan statistic. To ensure the presence of heteroscedasticity, the p-value must be inferior to 5 percent. This test is going to be performed on each regression.

4.3 Coefficients and associated p-values

To interpret regressions results, multiple elements have to be assessed such as coefficients and their associated p-values. The coefficients describe the mathematical relationship (the sign of the coefficient and its magnitude) between each independent variable and the dependent one. Before interpreting them is is important to ensure that they are different from zero for them to be significant. To asses this a Student's test is used with the following hypotheses:
H0: The coefficient is equal to zero
H1: The coefficient is significantly different from zero
The null hypothesis is rejected for a p-value inferior to 5 percent

The p-value establish if the relationships in the model are statistically significant, it is the probability that the t-calculated value is higher in absolute value than the theoretical value. If this probability is lower than the threshold used (here 5 percent) then the coefficient is significant. When assessing the overall significance of the model the same hypotheses are tested.

4.4 Time series

Given that we estimate time series, it can be useful to recall some properties. A time series can be said to be stationary if it has no trend, seasonality, or factors that changes over time. Generally it takes the form:

$$X_t = X_{t-1} + U_t \tag{3}$$

And has the following properties:

$$E(X_t) = \alpha \ \ \forall_t \tag{4}$$

$$V(X_t) = \sigma^2 \ \ \forall_t \tag{5}$$

$$Cov(X_t, X_s) = \phi_{s-t} \ \ \forall s \neq t \tag{6}$$

It is essential that a time series verifies these properties because stationarity is central to conduct correctly standard estimations such as regressions. If time series show trends or violate one of the previous properties, they are considered non-stationary and their estimations face a risk of spurious correlation. It characterizes a situation when results suggest the presence of significant relationships among time series variables when in fact there are none, hence distorting results.

4.5 Types of non-stationarity

If we look back at our graphs we see that our variables time series exhibit unpredictable and uncertain variations and trends during the entire period, which can denote the presence of a certain type of non-stationarity called stochastic trend. There are three types of non-stationarity, presented here with the following formulas:

$$X_t = \phi\, X_{t-1} \,+\, \alpha \,+\, \beta_t \,+\, U_t \tag{7}$$

$$X_t = \phi\, X_{t-1} \,+\, \alpha \,+\, U_t \tag{8}$$

$$X_t = \phi\, X_{t-1} \,+\, U_t \tag{9}$$

The formula (7) characterizes a deterministic form of non-stationarity with the presence of a unit root (phi), a trend (beta) and a constant (a) in the time series. The formula (8) characterizes a mixed form of non-stationarity with the presence of a unit root (phi) and a constant (a) in the time series. Finally the formula (9) characterizes a stochastic form of non-stationarity with the presence of only a unit root (phi). The latter is the cause of non-stationarity as it refers to a stochastic trend violating the second property of stationarity (5): a time-independent variance.

4.6 Dickey-Fuller test

Our hypothesis is that our variables time series have a stochastic trend, but this needs to be verified statistically with a Dickey-Fuller (DF) test. The first purpose of this calculation is to test the presence of a unit root. Two hypotheses are tested:

$$H0 : \phi = 0 \tag{10}$$

$$H1 : |\, \phi \,| > 0 \tag{11}$$

H0: There is a unit root, hence the series is non-stationary
H1: There is no unit root, hence the series is stationary
These hypotheses are going to be verified by test statistic level in comparison to critical values.

The second purpose of the DF test is to determine the nature of non-stationarity. Indeed it can test for a time series, the presence of a trend and/or a constant next to the unit root. Three DF tests are going to be conducted on formulas (7), (8), (9) relative to the types of non-stationarity. Going from most to least aggregated, we are going to proceed by elimination to estimate the most relevant type of non-stationarity. The presence of a trend and a constant is verified just like for the unit root, by the comparison between test statistic level and corresponding critical values[46].

4.7 Differencing

Determining the nature of the series non-stationarity is crucial to correct it subsequently with the appropriate method. Results are presented in the next section, but we need to specify what the differencing method is. Differencing time series means to subtract for each observation in the series the value of the previous one. It is one of the method commonly used to make a time series stationary. Conducted only on series that are DS (Difference Stationary) and relative to a certain type of non-stationarity, the outcome of this operation is verified with an Augmented Dickey-Fuller (ADF) test. The latter is different from DF test in the scope of the calculation, since ADF only test the presence of a unit root. The results are given by a p-value that verifies the following hypotheses (similar to the ones of DF test):

[46] These critical values are given (on Rstudio) by DF and MacKinnon tables

H0: There is a unit root, hence the time series is still non-stationary
H1: There is no unit root, hence the time series is stationary
H0 is rejected for a p-value inferior to 5 percent.

If differencing once a time series is enough to make it stationary, it is said that this series is integrated (I) of order (1): [I(1)]. It is also possible to difference a variable multiple times to make it stationary, its integration order will thus depend on the number of difference necessary to achieve stationarity.

4.8 Chow test

At the end the results of our regressions could lead us to explain changes in the relationships between our variables. The Chow test allows us to do that, by testing the presence of a structural change that could alter the coefficients of a regression model or given variables. It is essentially done by comparing the coefficients of the model or given variables for two sub-periods, and is based on a provided F-test. To conduct this test we must have an idea of potential dates of structural change called breakpoints. As recalled in section 2, the change in the exchange rate regime may have reinforced the influence of oil prices on the exchange rate of the ruble, which could constitute a potential structural change. Moreover, the aim of this study is to show that following the ruble crisis, oil prices had a weaker influence on the exchange rate, which could also constitute a structural change in the relationship between these two variables. All this needs to be proven in section 5 but our hypothesis is that such breaks are possible.

To help us identify the breakpoints we have at our disposal the technique of Bai and Perron (1998). It consist of using the graph related to the dependent variable time series, that illustrates vertical lines indicating breakpoints and their confidence intervals. When the most plausible breakpoints are identified, they can be tested by the Chow test. The latter is conducted with the following hypotheses:
H0: there is no structural change observed
H1: there is a structural change observed
H0 is rejected for a p-value inferior to 5 percent.

5 Results

5.1 Three Dickey-Fuller tests

RUBUSD

```
Value of test-statistic is: -1.1296 1.0507 0.7723

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.04 -3.45 -3.15
phi2  6.50  4.88  4.16
phi3  8.73  6.49  5.47
```

Figure 4: DF3 test for RUBUSD

In the figure 4 presented, three test statistics are calculated: the first related to the unit root, the second to the trend and the third to the constant. It is observed that the test value for the unit root (-1.1296) exceeds all the critical values of tau3, thus accepting H0: the hypothesis of a unit root presence. We then look at the test values of the trend and the constant, which are inferior to the corresponding critical values of phi2 and phi3, meaning that they are not significant.

```
Value of test-statistic is: -1.0182 1.3269

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.51 -2.89 -2.58
phi1  6.70  4.71  3.86
```

Figure 5: DF2 test for RUBUSD

In the figure 5 presented, two test statistics are calculated: the first related to the unit root and the second related to the constant. It is observed that the test statistic for the unit root test (-1.0182) is greater than all the associated critical values of tau2, thus accepting H0: the hypothesis of a unit root presence. We then look at the test value of the constant, which is inferior to the critical values of phi1, meaning that it is not significant.

```
Value of test-statistic is: 1.1817

Critical values for test statistics:
     1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

Figure 6: DF1 test for RUBUSD

In the figure 6 presented, one test statistic is calculated, the one related to the unit root. It is observed that the test statistic for the unit root test (1.1817) is greater than all the associated critical values of tau1, thus accepting H0: the hypothesis of a unit root presence.

We can therefore say that the RUBUSD series is non-stationary and has a stochastic trend[47], because the presence of a trend and a constant is not verified.

OILPRICE

```
Value of test-statistic is: -1.2054 0.8469 1.0465

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.04 -3.45 -3.15
phi2  6.50  4.88  4.16
phi3  8.73  6.49  5.47
```

Figure 7: DF3 test for OILPRICE

In the figure 7 presented, three test statistics are calculated: the first is related to the unit root, the second to the trend and the third to the constant. It is observed that the test value for the unit root (-1.2054) exceeds all the critical values of tau3, thus accepting H0: the hypothesis of a unit root presence. We then look at the test values of the trend and the constant, which are inferior to the corresponding critical values of phi2 and phi3, meaning that they are not significant.

```
Value of test-statistic is: -1.4476 1.2745

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.51 -2.89 -2.58
phi1  6.70  4.71  3.86
```

Figure 8: DF2 test for OILPRICE

In the figure 8 presented, two test statistics are calculated: the first related to the unit root and the second related to the constant. It is observed that the test statistic for the unit root test (-1.4476) is greater than all the associated critical values of tau2, thus accepting H0: the hypothesis of a unit root presence. We then look at the test value of the constant which is inferior to the critical values of phi1, meaning that it is not significant.

[47] Again a stochastic trend is exclusively related to the presence of a unit root

```
Value of test-statistic is: -0.7859

Critical values for test statistics:
     1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

Figure 9: DF1 test for OILPRICE

In the figure 9 presented, one test statistic is calculated: the one related to the unit root. It is observed that the test statistic for the unit root test (-0.7859) is greater than all the associated critical values of tau1, thus accepting H0: the hypothesis of a unit root presence.

We can therefore say that the OILPRICE serie is non-stationary and has a stochastic trend, because the presence of a trend and a constant is not verified.

The three Dickey-Fuller tests have been estimated and allowed us to verify the presence of a unit root and determine the nature of the non-stationarity. To not be redundant, tests of other variables are displayed in the annex. Their results are similar to RUBUSD and OILPRICE, they are all non-stationary with a stochastic trend. Hence the time series are DS (Difference Stationary) and will be stationarized through a differencing process.

5.2 Differencing Process

RUBUSD

```
        Augmented Dickey-Fuller Test

data:  rubusdPD
Dickey-Fuller = -4.0252, Lag order = 4, p-value = 0.01164
alternative hypothesis: stationary
```

Figure 10: FIRST ORDER DIFFERENCING ON RUBUSD

In the figure 10 presented, the p-value of the ADF test is (0.01164) which is lower than 5 percent, thus rejecting H0: the hypothesis of a unit root presence. The series is stationary and integrated of order one.

OILPRICE

```
        Augmented Dickey-Fuller Test

data:  oilpricePD
Dickey-Fuller = -4.2369, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary
```

Figure 11: FIRST ORDER DIFFERENCING ON OILPRICE

In the figure 11 presented, the p-value of the ADF test is (0.01) which is lower than 5 percent, thus rejecting H0: the hypothesis of a unit root presence. The series is stationary and integrated of order one.

EXPORTS

```
        Augmented Dickey-Fuller Test

data:  exportsPD
Dickey-Fuller = -2.9179, Lag order = 4, p-value = 0.1979
alternative hypothesis: stationary
```

Figure 12: FIRST ORDER DIFFERENCING ON EXPORTS

In the figure 12 presented, the p-value of the ADF test is (0.1979) which is greater than 5 percent, thus not rejecting H0: the hypothesis of a unit root presence. The series is still non-stationary after a first difference.

```
        Augmented Dickey-Fuller Test

data:  exports2D
Dickey-Fuller = -6.5236, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary
```

Figure 13: SECOND ORDER DIFFERENCING ON EXPORTS

This time in the figure 13 presented, the p-value of the ADF test is (0.01) which is lower than 5 percent, thus rejecting H0: the hypothesis of a unit root presence. Thus the variable is stationary and integrated of order two.

RESERVES

```
        Augmented Dickey-Fuller Test

data:  reservesPD
Dickey-Fuller = -3.8015, Lag order = 4, p-value = 0.02221
alternative hypothesis: stationary
```

Figure 14: FIRST ORDER DIFFERENCING ON RESERVES

In the figure 14 presented, the p-value of the ADF test is (0.02221) which is lower than 5 percent, thus rejecting H0: the hypothesis of a unit root presence. The series is stationary and integrated of order one.

INTEREST

```
        Augmented Dickey-Fuller Test

data:  interestPD
Dickey-Fuller = -4.9207, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary
```

Figure 15: FIRST ORDER DIFFERENCING ON INTEREST

In the figure 15 presented, the p-value of the ADF test is (0.01) which is lower than 5 percent, thus rejecting H0: the hypothesis of a unit root presence. The series is stationary and integrated of order one.

RTS

```
        Augmented Dickey-Fuller Test

data:  rtsPD
Dickey-Fuller = -4.8538, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary
```

Figure 16: FIRST ORDER DIFFERENCING ON RTS

In the figure 16 presented, the p-value of the ADF test is (0.01) which is lower than 5 percent, thus rejecting H0: the hypothesis of a unit root presence. The series is stationary and integrated of order one.

Of the 6 variables that have been subjected to a differencing process, 5 are integrated of order one [I(1)] because only one difference was enough to make them stationary. The variable EXPORTS is the only one that have undergone a differencing process twice, making it integrated of order two [I(2)]. This process was the last step before regressions, since all risk of spurious correlation is eliminated by stationarized time series[48]. But before analyzing our regressions, we can say that we conducted co-integration tests using Engle Granger Methodology on our first-order integrated variables. These tests presented in the annex were not conclusive because stationarized time series cannot estimate long term relationships. Hence it should be noted that our regressions which are based on short term data[49] only estimate short term relationships between our variables.

[48]Furthermore there is no risk of autocorrelation since our series were stochastic and have been stationarized

[49]The related stationarized time series graphs are presented in the annex

5.3 Regressions

5.3.1 General regressions on the entire period

Regression on all variables

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.130729 -0.012869  0.000369  0.014956  0.116358

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.006561   0.003723   1.762 0.081632 .
oilprice    -0.244701   0.052113  -4.696 1.01e-05 ***
exports      0.006649   0.039568   0.168 0.866956
reserves    -0.505678   0.236057  -2.142 0.035039 *
interest     0.036099   0.052721   0.685 0.495384
rts         -0.210818   0.060526  -3.483 0.000786 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.03534 on 85 degrees of freedom
Multiple R-squared:  0.5022,    Adjusted R-squared:  0.473
F-statistic: 17.15 on 5 and 85 DF,  p-value: 1.065e-11
```

Figure 17: REG 1

In the figure 17 presented, the results of the first regression for 92 observations. The significance of the model is confirmed by an associated p-value lower than 1 percent, hence strongly rejecting the H0 hypothesis. From the 5 independent variables, 3 are significant as their p-value are inferior to 5 percent. OILPRICE has the most precise coefficient regarding its p-value, followed by RTS, and RESERVES[50]. Looking at coefficients, we can see that a 1 percent increase of OILPRICE leads to a decrease of RUBUSD of (-0.244) percent, when the same increase for RTS and RESERVES leads respectively to a decrease of (-0.21) and (-0.5) percent for the dependent variable. The R-squared is 50 percent and the adjusted one is 47 percent, which indicate us that the model is quite good for explaining the variability of RUBUSD. We decide to remove EXPORTS of our model and estimate for further regressions only first order variables[51].

The associated Breusch-Pagan test[52] confirms the null hypothesis of homoscedasticity for a p-value of (0.9238) which is superior to 5 percent (0.05), thus rejecting the presence of heteroscedasticity.

Regression on OILPRICE

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.124641 -0.020406 -0.002424  0.013928  0.111688

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.005647   0.004112   1.373    0.173
oilprice    -0.354051   0.049925  -7.092  2.9e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.03933 on 90 degrees of freedom
Multiple R-squared:  0.3585,    Adjusted R-squared:  0.3514
F-statistic: 50.29 on 1 and 90 DF,  p-value: 2.902e-10
```

Figure 18: REG 2

In the figure 18 presented, the results of the second regression for 92 observations. The significance of the model comprising only OILPRICE has an explanatory variable is confirmed by an associated p-value lower than 1 percent, hence strongly rejecting the H0 hypothesis. Looking at the coefficient, we can see that a 1 percent increase of OILPRICE leads to a decrease of RUBUSD of (-0.354) percent. This regression enables us to see how OILPRICE alone can influence the exchange rate. It can be noticed that the

[50]The degree of significance is also represented by the number of stars
[51]The reason is explained in the result discussion
[52]They are presented in the Annex

effect is stronger than in the previous regression. The R-squared is 35 percent and the adjusted one is quite the same, which indicates that the model is reasonably good for explaining the variability of RUBUSD.

The associated Breusch-Pagan test confirms the null hypothesis of homoscedasticity for a p-value of (0.2691) which is superior to 5 percent (0.05), thus rejecting the presence of heteroscedasticity.

5.3.2 First sub-period regressions

Regression on first difference variables

```
Residuals:
     Min       1Q   Median       3Q      Max 
-0.10409 -0.01418  0.00213  0.01303  0.11186 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept)  0.0009512  0.0066562   0.143   0.8875  
oilprice    -0.4014661  0.1783279  -2.251   0.0334 *
reserves    -0.8682042  0.4552535  -1.907   0.0681 .
interest    -0.0381406  0.1417984  -0.269   0.7902  
rts         -0.0610688  0.1168699  -0.523   0.6059  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.0358 on 25 degrees of freedom
Multiple R-squared:  0.3637,    Adjusted R-squared:  0.2619 
F-statistic: 3.572 on 4 and 25 DF,  p-value: 0.01949
```

Figure 19: REG 3

In the figure 19 presented, the results of the third regression for 30 observations. The significance of the model is confirmed by an associated p-value lower than 5 percent, rejecting the H0 hypothesis. From the 4 independent variables left, only the OILPRICE is significant as its p-value is inferior to 5 percent. Looking at the coefficient, we can see that a 1 percent increase of OILPRICE leads to a decrease of RUBUSD of (-0.40) percent. The R-squared is 36 percent and the adjusted one is 26 percent, which indicate us that the model is quite weak for explaining the variablity of RUBUSD.

The associated Breusch-Pagan test confirms the null hypothesis of homoscedasticity for a p-value of (0.4641) which is superior to 5 percent (0.05), thus rejecting the presence of heteroscedasticity.

Regression on OILPRICE

```
Call:
lm(formula = rubusd ~ oilprice, data = donnees3)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.124052 -0.015775 -0.002959  0.016365  0.108719 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)   
(Intercept)  0.002634   0.006717   0.392  0.69790   
oilprice    -0.422650   0.139156  -3.037  0.00512 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03678 on 28 degrees of freedom
Multiple R-squared:  0.2478,    Adjusted R-squared:  0.2209 
F-statistic: 9.225 on 1 and 28 DF,  p-value: 0.005122
```

Figure 20: REG 4

In the figure 20 presented, the results of the fourth regression for 30 observations. The significance of the model comprising only OILPRICE has an explanatory variable is confirmed by an associated p-value lower than 1 percent, hence strongly rejecting the H0 hypothesis. Looking at the coefficient, we can see that a 1 percent increase of OILPRICE leads to a decrease of RUBUSD of (-0.422) percent. This regression enables us to see how OILPRICE alone can influence the exchange rate. It can be noticed that the effect is a bit stronger than in the previous regression. The R-squared is 24 percent and the adjusted one is 22 percent, which indicate us that the model is quite weak for explaining the variablity of RUBUSD.

The associated Breusch-Pagan test confirms the null hypothesis of homoscedasticity for a p-value of (0.123) which is superior to 5 percent (0.05), thus rejecting the presence of heteroscedasticity.

5.3.3 Second sub-period regressions

Regressions on first difference variables

```
Residuals:
      Min        1Q    Median        3Q       Max 
-0.120639 -0.021982 -0.005979  0.031862  0.072653 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)   
(Intercept)  0.002548   0.012683   0.201  0.84332   
oilprice    -0.393907   0.128158  -3.074  0.00727 **
reserves    -0.511165   0.497763  -1.027  0.31973   
interest    -0.078028   0.123606  -0.631  0.53678   
rts         -0.355146   0.149607  -2.374  0.03046 * 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.04863 on 16 degrees of freedom
Multiple R-squared:  0.6943,	Adjusted R-squared:  0.6179 
F-statistic: 9.085 on 4 and 16 DF,  p-value: 0.0004997
```

Figure 21: REG 5

In the figure 21 presented, the results of the fifth regression for 20 observations. The significance of the model is confirmed by an associated p-value lower than 1 percent, hence strongly rejecting the H0 hypothesis. From the 4 independent variables left, 2 are significant as their p-value are inferior to 5 percent. OILPRICE has the most precise coefficient regarding its p-value only followed by RTS. Looking at coefficients, we can see that a 1 percent increase of OILPRICE leads to a decrease of RUBUSD of (-0.393) percent, when the same increase for RTS leads to a decrease of (-0.355) for the dependent variable. The R-squared is 69 percent and the adjusted one is 61 percent, which indicates that the model is good for explaining the variablity of RUBUSD.

The associated Breusch-Pagan test confirms the null hypothesis of homoscedasticity for a p-value of (0.677) which is superior to 5 percent (0.05), thus rejecting the presence of heteroscedasticity.

Regression on OILPRICE

```
Residuals:
     Min       1Q   Median       3Q      Max 
-0.11045 -0.02272 -0.01419  0.03851  0.12260 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.01007    0.01303   0.773 0.449224    
oilprice    -0.48058    0.10230  -4.698 0.000157 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0549 on 19 degrees of freedom
Multiple R-squared:  0.5373,	Adjusted R-squared:  0.513 
F-statistic: 22.07 on 1 and 19 DF,  p-value: 0.0001568
```

Figure 22: REG 6

In the figure 22 presented, the results of the sixth regression for 20 observations. The significance of the model comprising only OILPRICE has an explanatory variable is confirmed by an associated p-value lower than 1 percent, hence strongly rejecting the H0 hypothesis. Looking at the coefficient, we can see that a 1 percent increase of OILPRICE leads to a decrease of RUBUSD of (-0.48) percent. This regression enables us to see how OILPRICE alone can influence the exchange rate. It can be noticed that the effect is stronger than in the fourth regression. The R-squared is 53 percent and the adjusted one is 51 percent, which indicates that the model is quite good for explaining the variability of RUBUSD.

The associated Breusch-Pagan test confirms the null hypothesis of homoscedasticity for a p-value of (0.065) which is superior to 5 percent (0.05), thus rejecting the presence of heteroscedasticity.

5.3.4 Third sub-period regressions

Regressions on first difference variables

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.004014   0.004576  -0.877   0.3859
oilprice    -0.064541   0.048042  -1.343   0.1871
reserves     0.805244   0.438467   1.836   0.0741 .
interest     0.028295   0.059225   0.478   0.6356
rts         -0.290174   0.065694  -4.417 8.04e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02118 on 38 degrees of freedom
Multiple R-squared:  0.4591,    Adjusted R-squared:  0.4022
F-statistic: 8.064 on 4 and 38 DF,  p-value: 8.253e-05
‘
```

Figure 23: REG 7

In the figure 23 presented, the results of the seventh regression for 42 observations. The significance of the model is confirmed by an associated p-value lower than 1 percent, hence strongly rejecting the H0 hypothesis. From the 4 independent variables left, only the RTS is significant as its p-value is inferior to 5 percent. Looking at coefficients, we can see that a 1 percent increase of RTS leads to a decrease of RUBUSD of (-0.29) percent. The R-squared is 45 percent and the adjusted one is 40 percent, which indicates that the model is reasonably appropriate for explaining the variability of RUBUSD.

The associated Breusch-Pagan test confirms the null hypothesis of homoscedasticity for a p-value of (0.481) which is superior to 5 percent (0.05), thus rejecting the presence of heteroscedasticity.

Regression on OILPRICE

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.047043 -0.017347 -0.002131  0.006964  0.065729

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.0008895  0.0036508  -0.244   0.8088
oilprice    -0.0937233  0.0509441  -1.840   0.0732 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02337 on 40 degrees of freedom
Multiple R-squared:  0.07801,   Adjusted R-squared:  0.05496
F-statistic: 3.385 on 1 and 40 DF,  p-value: 0.07324
```

Figure 24: REG 8

In the figure 24 presented, the results of the eighth regression for 42 observations. The significance of the model comprising only OILPRICE as an explanatory variable is not confirmed as its p-value is superior to 5 percent, hence not rejecting the H0 hypothesis. This regression shows that OILPIRCE does not influence the exchange rate, which is consistent with the previous regression. The R-squared is 7 percent and the adjusted one is 5 percent indicating that the model is very weak and not valid for explaining the variability of RUBUSD[53].

5.4 Structural change and Chow test

5.4.1 Breakpoints detection

```
         Optimal 1-segment partition:

Call:
breakpoints.formula(formula = rubusdFD ~ 1)

Breakpoints at observation number:
NA

Corresponding to breakdates:
NA
```

```
         Optimal 6-segment partition:

Call:
breakpoints.formula(formula = rubusd ~ 1)

Breakpoints at observation number:
21 34 47 60 76

Corresponding to breakdates:
21 34 47 60 76
```

Figure 25: **Breakpoints analysis**

Previous regressions have shown that OILPRICE is not significant to explain the variation of the RUBUSD during the third sub-period. We decide to check if a structural change could explain this modification in the relationship between these two variables with a Chow test. In order to conduct this test we first need to find the potential breakpoints. To find the dates that are likely to experience a structural change, we conducted a first analysis on the stationary RUBUSD series using "breakpoints" function. Unfortunately the results presented on the left side of figure 25 are null since they are based on short term data. In order to verify the existence of a structural change we need to manipulate long term ones. We decide to carry out the same operation on the non-stationary RUBUSD series. The results presented on the right side of figure 25 indicate the existence of 5 potential structural breakpoints. In order to choose the most relevant ones and conduct a Chow test, we create the following graph.

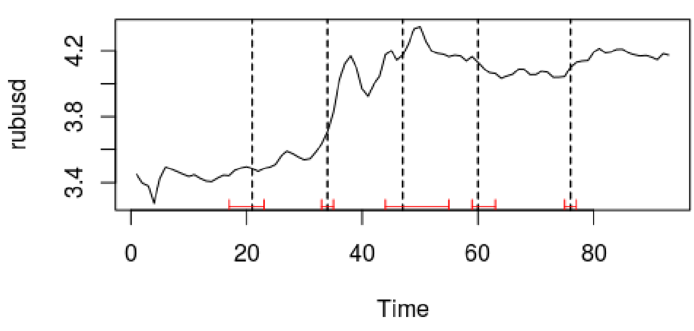

Figure 26: Breakpoints graph

The graph presented in the figure 26 allows to detect breakpoints corresponding to potential structural changes[54]. The dotted vertical lines indicate the breakpoints, the horizontal red lines indicate their confidence intervals. Five observations experience structural changes with different confidence intervals. We decide to choose the two breakpoints having the most precise ones: observation 34 corresponding to November 2014 and observation 76 corresponding to April 2018. To prove their existence we conduct two Chow tests.

[53] The associated Breusch-Pagan test confirms the null-hypothesis of homoscedasticity for a p-value of (0.157) which is superior to 5 percent (0.05), thus rejecting the presence of heteroscedasticity

[54] Bai and Perron, 1998

5.4.2 Chow tests

```
        Chow test

data:  rubusd ~ oilprice
F = 119.36, p-value < 2.2e-16
```

```
        Chow test

data:  rubusd ~ oilprice
F = 131.25, p-value < 2.2e-16
```

Figure 27: **Chow Test on observation 34 and 76**

The figure 27 presents the results of two Chow tests on the two breakpoints. The first Chow test on the left side verifies the existence of a structural breakpoint for observation 34 with a p-value inferior to 1 percent, hence strongly rejecting H0: the hypothesis of no structural break. The second chow test at the right has the same result for the observation 76. It can be concluded that the existence of these two structural breaks is confirmed at first analysis.

5.5 Result Discussion

Results shows that OILPRICE, RTS, and RESERVES variables were significant to explain RUBUSD variability from the beginning of 2012 to September 2019. The nature and strength of these relationships have evolved throughout this period which was specified by sub-periods regressions. By conducting them on a model exclusively composed of first order variables we were able to prove that OILPRICE has decoupled itself from RUBUSD.

It was showed that OILPRICE was influencing RUBUSD before the Russian ruble crisis, but with a weak model. We think we can explain this weakness by the pegged exchange rate regime which prevented the variation of RUBUSD. However this argument could be counterbalanced by the fact that RESERVES variable, which was supposed to regulate RUBUSD, is not significant during this first sub-period. The first Chow test revealed the presence of a structural change in November 2014, the date relative to the switch to a free-float exchange rate regime. It makes no doubt that this switch has permitted the significativity of OILPRICE and RTS during the second sub-period, making the model relevant to explain RUBUSD variability. Our hypothesis is that this switch reinforced the already existing relationship between OILPRICE and RUBUSD and has permitted the emergence of a new one between RTS and RUBUSD. The second Chow test supported the results of third sub-period regressions by revealing the existence of a structural change in November 2018. This breakpoint can represent the date at which the dissociation between OILPRICE and RUBUSD has occurred making the former non-significant to explain the latter's variability. The hypothesis regarding this dissociation is formulated in our conclusion, but we can say that during the third sub-period the only significant variable was the RTS for a model that was reasonably appropriate to explain RUBUSD variability.

Several limits are still to point out for our model. First, the fact that our variables time series have been stationarized by a differencing process, caused a certain loss of information which lead us to estimate short term relationships. Indeed this process subtracted for each observation in the series the value of the previous one, neutralizing past trends and preventing us to estimate long term regressions. Hence the results are only based on short term estimates and relationships between our variables expressed for a time t (in our case for each month). This is the reason behind the exclusion of EXPORTS before conducting sub-periods regressions. It was the least significant variable of our model, which can be explained by the two differences that may have undermined its values and suppressed any potential impact on RUBUSD. Furthermore this differencing was also problematic for the detection of structural breaks, since they cannot be based on stationarized time series[55]. Second, (for reasons of result consistency) we decided not to go further

[55]The stationarized time series graphs in the annex show how much they fluctuate

in the analysis of the Chow test since it estimated non-stationary time series. Testing more closely two sub-periods to see a potential difference in the coefficient that link RUBUSD and OILPRICE, implies to face the risk of spurious correlation and distorted results. That is why it was noted that the existence of two structural breaks was confirmed at first analysis, but cannot be verified statistically at 100 percent. Third, INTEREST was not a good choice of explanatory variable. After the results showed its non-significativity, we concluded that this variable was not sufficiently integrated in the determination of financial flows (contrary to RTS) to explain the RUBUSD variability.

6 Conclusion

Our study proved that the ruble's exchange rate has decoupled itself from oil prices after the Russian ruble crisis of 2014-2016. Prior to this crisis, a relationship between these two variables existed and was reinforced later due to the switch in the exchange rate regime that freed the national currency and subjected its value to the influence of oil prices and capital flows. By reasoning with Dutch disease considerations, we explained that the fall of the ruble's value caused by the Russian ruble crisis could have been beneficial to non-oil economic sectors competitiveness and development, hence reducing the economy's dependence on oil prices and ultimately dissociating these two variables. This dissociation was proved on short term estimations for the period from March 2016 to September 2019. During this period, oil prices were not significant to explain ruble's exchange rate variability. It was only influenced in our model by the rts index (representing capital flows).

The purpose of this paper was to verify the existence of this dissociation, but not to explain it outside of the theoretical basis of the Dutch disease. Leaving these considerations aside, there is nothing that suggest that the gain in competitiveness resulting from the fall of the ruble's value has led to the development of non-oil economic sectors, reduced the country's dependence on oil prices and dissociated our two variables. We cannot explain precisely where this decoupling comes from, we can only say that it is strong enough to be observed. Therefore two questions are asked: What is the real cause of this dissociation ? Does it come from a shock or from broader structural reforms ?

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8 Annex

DF EXPORTS

```
Value of test-statistic is: -1.2854 0.8474 1.2148

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.04 -3.45 -3.15
phi2  6.50  4.88  4.16
phi3  8.73  6.49  5.47
```

```
Value of test-statistic is: -1.5589 1.2722

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.51 -2.89 -2.58
phi1  6.70  4.71  3.86
```

Figure 28: **DF3 and 2**

```
Value of test-statistic is: -0.3494

Critical values for test statistics:
     1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

Figure 29: DF1

DF RESERVES

```
Value of test-statistic is: -0.4662 1.4049 2.1072

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.04 -3.45 -3.15
phi2  6.50  4.88  4.16
phi3  8.73  6.49  5.47
```

```
Value of test-statistic is: -1.3699 0.9384

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.51 -2.89 -2.58
phi1  6.70  4.71  3.86
```

Figure 30: **DF3 and 2**

```
Value of test-statistic is: 0.0093

Critical values for test statistics:
     1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

Figure 31: DF1

DF INTEREST

```
Value of test-statistic is: -1.4866 1.1772 1.7656

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.04 -3.45 -3.15
phi2  6.50  4.88  4.16
phi3  8.73  6.49  5.47
```

```
Value of test-statistic is: -1.5857 1.2575

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.51 -2.89 -2.58
phi1  6.70  4.71  3.86
```

Figure 32: **DF3 and 2**

```
Value of test-statistic is: -0.1921

Critical values for test statistics:
     1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

Figure 33: INTEREST DF NONE

DF RTS

```
Value of test-statistic is: -1.1838 1.4823 2.1487

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.04 -3.45 -3.15
phi2  6.50  4.88  4.16
phi3  8.73  6.49  5.47
```

```
Value of test-statistic is: -1.7724 1.6453

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.51 -2.89 -2.58
phi1  6.70  4.71  3.86
```

Figure 34: **DF3 and 2**

```
Value of test-statistic is: -0.4274

Critical values for test statistics:
     1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

Figure 35: DF1

DIFF GRAPHS

Figure 36: **Graphics RUBUSD and OIL PRICE**

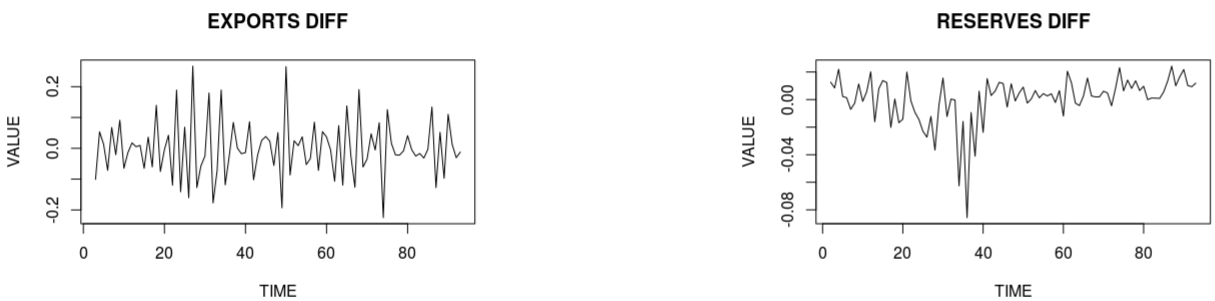

Figure 37: **Graphics EXPORTS and RESERVES**

Figure 38: **Graphics INTEREST and RTS**

COINTEGRATION TEST

```
Value of test-statistic is: -1.6861

Critical values for test statistics:
      1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

```
Value of test-statistic is: -0.4121

Critical values for test statistics:
      1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

Figure 39: **CO TEST RUBUSD OIL and RUBUSD RESERVES**

```
Value of test-statistic is: -0.588

Critical values for test statistics:
      1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

```
Value of test-statistic is: -0.2188

Critical values for test statistics:
      1pct  5pct 10pct
tau1 -2.6 -1.95 -1.61
```

Figure 40: **CO TEST RUBUSD INTEREST and RUBUSD RTS**

BREUSCH PAGAN TEST

```
        studentized Breusch-Pagan test

data:  bp1
BP = 1.4046, df = 5, p-value = 0.9238
```

```
        studentized Breusch-Pagan test

data:  bp2
BP = 1.2213, df = 1, p-value = 0.2691
```

Figure 41: **BP 1 and 2**

```
        studentized Breusch-Pagan test

data:  bp3
BP = 3.5917, df = 4, p-value = 0.4641
```

```
        studentized Breusch-Pagan test

data:  bp4
BP = 2.3751, df = 1, p-value = 0.1233
```

Figure 42: **BP 3 and 4**

```
        studentized Breusch-Pagan test

data:  bp5
BP = 2.317, df = 4, p-value = 0.6777
```

```
        studentized Breusch-Pagan test

data:  bp6
BP = 3.3994, df = 1, p-value = 0.06522
```

Figure 43: **BP 5 and 6**

```
        studentized Breusch-Pagan test

data:  bp7
BP = 3.4761, df = 4, p-value = 0.4815
```

```
        studentized Breusch-Pagan test

data:  bp8
BP = 1.9957, df = 1, p-value = 0.1578
```

Figure 44: **BP 7 and 8**