DOCTORAL DISSERTATION

Terms of Trade, Productivity Differential and the Long-run Behavior of Commodity Currencies: The Case of Norway and Colombia.

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ABSTRACT

This dissertation investigates the dynamic long-run and short-run behavior of bilateral real exchange rate of the Norwegian krone *vis-a-vis* the euro, and the Colombian Peso *vis-a-vis* the USD. The two countries elicit much research interest due to some seemingly peculiar characteristics. First, they are both heavily dependent on oil export for their foreign exchange earnings. Secondly, they are both non-OPEC members countries, thus, they can, for all intents and purposes, be classified as price takers in the oil market. Thirdly, their composition of their export reveals a strong relationship with the Euro area (for Norway), and the United States (for Colombia). Under the bounds testing procedure developed by Pesaran, Shin and Smith (2001), the model reveals a long-run equilibrating relationship between the real bilateral exchange rate and the behavioral variables. The study finds that the direction and magnitude of the effect oil terms of trade, productivity differential and interest rate differential on the real bilateral exchange rate follow a priori expectations. However, foreign reserves holding as a variable for Colombia gives an opposite sign to that expected. It is also safe to conclude that there exist a long-run and statistically significant relationship between the explanatory variables and the long run behavior of the real bilateral exchange rate for the two countries. Moreover, the forecasts reveal persistent misalignment across the sample, and the magnitude of these misalignments vary across the countries.

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To my parents.

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CHAPTER ONE: INTRODUCTION

1.1 General Introduction

Despite exchange rate equilibrium determination being an age-old economic research area, advancement in research in the field seems often anew due to the constantly changing behavior of the policy variables that influence the real exchange rate (RER). Secondly, increasing globalization implies that national economies have never been so exposed to global shocks. A single most important economic shock absorber in the international marketplace is the exchange rate. This is plausible in the absence of artificial rigidities imposed through government policies.

Purchasing power parity (PPP) prescribes a constant RER in the long run. However, the realized long-run RER is always time-varying. This phenomenon can be explained using; relative prices of commodities (Terms of Trade), Edwards and Yeyati (2005) and productivity differences across countries, the Balassa-Samuelson effect (B-S), Imai (2018). Countries like Canada, Norway, Russia, etc., are major commodity (petroleum and gas) exporting economies.

This dissertation investigates the dynamic behavior of bilateral real exchange rates of the Norwegian krone *vis-à-vis* the euro and the Colombian peso *vis-à-vis* the US dollar, for oil commodity exporters. The two countries elicit much research interest due to some seemingly peculiar characteristics. First, they are heavily dependent on oil export for their foreign exchange earnings. Secondly, they are both non-OPEC members countries, thus, they can, for all intent and purposes, be classified as price takers in the oil market.[1] Thirdly, the composition of their export reveals a heavy relationship with the Euro area. Tables 1.1 and 1.2 below, shows the export composition for Norway and Colombia, during the year 2016 and 2018 respectively. Both Norway export of petroleum products (both crude and refined) was more than 50% in value. Moreover, these oil exports were overwhelming to Europe; over 88% for Norway. In the case of Colombia, crude and refined petroleum exports amounted to over 38.65% of the total value. 31.3% of crude petroleum and 63.2% of refined petroleum were exported to the United States.

Table 1.1: **Exports composition of Norway in 2016**

Norway Exports (2016)	Classification-HS4 (HS92ID)	Value (Bil USD)	Percentage of Total Exports
Crude Petroleum	2709.00	22.70	24.00
Petroleum Gas	2711.00	21.60	23.00
Non-fillet Fresh Fish	1312.00	5.24	5.60
Refined Petroleum	2710.00	3.23	3.50
Raw Aluminum	7601.00	2.59	2.80
Fish Fillets	304.00	2.49	2.70
Non-fillet Frozen Fish	303.00	1.44	1.60
Passenger and Cargo Ship	8901.00	1.33	1.40
Processed Fish	305.00	1.15	1.20
Carboxyamide Compounds	2924.00	0.93	1.00
Others		30.10	33.20
Total		92.80	100.00

https://atlas.media.mit.edu/en/visualize/tree_map/hs92/export/nor/show/2709/2016/

[1] Other countries such as Russia and Nigerian were also considered for study. Results for Russia were not meaningful, perhaps because they have a price-setting role in the global economy (in tandem with OPEC). Nigeria and other oil-exporting countries did not have all the necessary data. Productivity data was generally not available.

Table 1.2: Exports composition of Colombia in 2018

Colombia Exports (2016)	Classification-HS4 (HS92ID)	Value (Bil USD)	Percentage of Total Exports
CRUDE Petroleum	52709	13.8	31.8
Refined Petroleum	52710	2.96	6.85
Coal Briquettes	52701	7.45	17.2
Gold	147108	1.24	2.88
Coke	52704	0.91	2.1
Coffee	20901	2.35	5.43
Cut flowers	20603	1.46	3.37
Bananas	20803	1.05	2.42
Raw sugar	41704	0.336	1
Palm oil	31511	0.452	1.04
Cars	178703	0.44	1.02
Others		11.178	24.87
Total		43.626	99.98

https://oec.world/en/profile/country/col

1.2 Commodity and commodity currency

Human beings make use of the raw materials (commodities) that they may be endowed to create a livable world, Bouchentouf (2011). For instance, they process agricultural products into food, metals to build weapons and tools, and energy for sustainability. Commodities can be classified into three categories, *Energy*, *metals*, and *agricultural products*.

Commodities are the basic units upon which the growth and development of economies depend. Generally, any tangible good which can be exchanged in a market, can be classified for the sake of this research as a commodity. Natural endowments such as oil as well as basic foods like corn are two common types of commodities.[1] The interplay of demand and supply, assuming a competitive market, determine the prices of commodities, as is applicable in other classes of assets such as stocks and bonds. Thus, a commodity must be valuable and tradable.

There are two basic economic properties a commodity possesses. First, it must be producible and traded by many suppliers (or countries). Secondly, it should homogenous.[1]

1. "What Makes Something a Commodity?" Economist.com, 3 January 2017.

In theory, consumers should not be able to differentiate between a type of commodity, even when produced by different firms. In other words, there is a high degree of substitutability. Primary materials such as coal, crude oil and metals are all examples of commodities that are produced, and their qualities are standardize in accordance with the laid-down regulatory standards. This helps to ease the prizing discrimination that may result from product differentiation.[2]

Commodities are traded on open markets just like stocks and bonds. A good example of a well-developed commodities market is the Chicago Board of Trade (CBOT) in the United States of America. The CBOT is responsible for the making of trading rules and standards, to ensure flexibility and faire trading. Commodities are mostly traded as futures because of the lapse of time between the time the transaction is entered, and the delivery period. 'Corn futures, for example, have four delivery dates: March, May, July, September, or December. In textbook examples, commodities are usually sold for their marginal cost of production, though in the real world the price may be higher due to tariffs and other trade barriers.'[3]

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2. Kennon, Joshua. "Definition and Examples of What Commodities Are." TheBalance.com, 27 October 2016.
3. Smith, Stacey Vanek. "What Is a Commodity, Anyway?" Marketplace.org, 21 November 2013.

Besides the general economic characteristics, commodities must have profitability appeal to any potential investor. Bouchentouf (2011) highlights three of such characteristics namely, *tradability, deliverability and liquidity*. Tradability entails the need for a viable investment vehicle to buy and sell the commodity. In an organized trade exchange, 'a commodity should have a futures contract assigned to it, processed by a company, and/or trackable by an exchange-traded fund (ETF). For example, radioactive primary materials like uranium, an important energy commodity, is not traded as futures contract, even when several firms specialize in its extraction and refining. Secondly, a commodity should be in a form such that it physically delivered by the seller to the buyer. A good instance is the ability to transport and delivered crude oil in barrels or gallons. Hence, currencies, interest rates, and other tradable financial instruments are not considered as commodities. Thirdly, commodities must be highly an easily tradable. The highly liquid character of commodity is critical because it gives you the option of getting in and out of an investment without having to face the difficulty of trying to find a buyer or seller. The "*commodity currency*" literature highlights the robust exchange rate response to fluctuations in world commodity prices that occurs for major commodity exporters. A good example is the high volatility of currencies of most oil producing economies during oil booms or busts.

There has been a renewed interest in the behavior of exchange rate of economies whose foreign exchange earnings are hugely dependent on oil export especially during booms and busts of oil prices. The fundamental Purchasing Power Parity theory, which postulate that the real exchange rate is constant in the long run may not hold true for oil currencies. According to Choudri and Schembri (2014), this phenomenon can be explained in two ways. The first possible explanation is the relationship between real exchange rate and the relative prices of commodities, and the second, the popular Balassa-Samuelson effect, that explains the real exchange rate as a relationship between the productivities of tradable goods for two countries: home and foreign, relative to non-tradable. The rest of the paper is structured as follows; Chapter 2 explains the theoretical underpinning of the model variable, as well as documents empirical literature that are related to our topic, while Chapter 3 explains the data and the methodology as used in the model. The results of our analyses are presented and interpreted in chapter 4. Chapter 5 concludes the dissertation.

CHAPTER TWO: LITERATURE SURVEY

2.1 Theoretical Framework

2.2.1 Exchange rate and commodity terms of trade

The general knowledge in exchange rate theory is that commodity terms of trade has a positively related to with real exchange rates. Thus, if terms of trade improve, the resultant effect is expected to be an appreciation of the real exchange rate the exporting country. The currency of an exporting country that exhibits this behavior is often refer to such as "commodity currency". However, there could exit some peculiarities for oil-exporting countries, as huge oil forex earnings have a more strongly affect their revenue in foreign exchange, their spending behavior as well as their savings (foreign reserves).

2.1.2 Balassa-Samuelson effect and terms of trade

According to the Law of One Price (LOOP), commodities that can easily be transported across borders should sell for roughly the same price, irrespective of the country or location, after taking the currency exchange rate into consideration. In practice, there are differences due to taxes and transportation costs. There is no reason to expect that, say, an iPad will sell for substantially less in a poorer country than in a richer country. Goods that are hard to ship, however, most notably services, should sell for substantially less in a developing country. Thus, it's much cheaper to hire a driver or a house cleaner in India than in Denmark.

The *Balassa-Samuelson* (*BS*) *effect* explains the phenomenon that may exist when the productivity of the tradable goods sector increases relative to the non-traded goods sector, in comparison to a trading partner as it may relates to the exchange rate between the two countries. This phenomenon is attributed to Bela Balassa (1964) and Paul Samuelson (1964). In a restricted sense, it explains the effect of economic growth that occurs as a result of increase in the productivity tradable goods on the relative prices, which would then filter into the real equilibrium exchange rate. Generally, the *BS effect* aims to give reasons for the convergence of the prices of tradable goods.

Balassa (1964) and Samuelson (1964) summarizes underlying logic to the *BS effect*, as follows. "*Let's assume that the law of one price (LOOP) holds for all internationally traded goods. In growing economies, it is plausible to consider that productivity growth is concentrated precisely in the production of these goods. This leads to an increase in wages that is not necessarily accompanied by an increase in prices. Unlike the non-tradable sector, the demand for higher wages leads to higher prices and consequently to a rise in the CPI".*

The Purchasing Power Parity (PPP) theory of exchange rates postulates that the rate of exchange between two currencies is simply the ratio of the purchasing powers of the currencies. Specifically, Absolute PPP means that exchange rates are at (strong) or tend to return to (weak) their measured PPP rate.

Real Exchange Rate (RER) = $\frac{EP^*}{P} = 1$ ------------------------------ **(1)**

Where E is the nominal exchange rate, expressed as the amount of domestic currency per one unit of foreign currency. Here, an increase in E means a real depreciation of the real exchange rate.

Relative PPP means that real exchange rates are only constant (strong) or stationary (weak) over time.

$\frac{\Delta RER}{RER} \approx \frac{\Delta E}{E} + \frac{\Delta P^*}{P^*} - \frac{\Delta P}{P} = 0$ ---------------------------------- **(2)**

In logarithmic form, equation (2) can be expressed as;

$\Delta rer = \Delta e + \Delta p^* - \Delta p = 0$ --------------------------------- **(3)**

This implies the existence of a changing trend in the price of tradable relative to non-tradable commodities, or more loosely, trend changes in the price of tradables across countries. However, empirical evidence suggest that PPP does not always hold true *(Balassa, B. (1964)*. Pricing to market can persist.

For relative PPP to hold or the real exchange rate to be stationary (I(0)), all we need is that there are no trends (I(1)) that drive a wedge between actual exchange rates and PPP.

2.1.3 Saving Behaviors of Oil Exporting Economies

Oil price volatility poses a peculiar challenge to economies that are highly dependent on oil exports for its foreign exchange, particularly in the maintenance of a healthy current account position. Monetary authorities in commodity dependent economies must consider the optimal mix of consumption, saving and investment that must be implemented. High oil price volatility translates to the sustainability of revenues (especially from oil), which in turn weakens the ability of government to meet its policy objectives of both internal and external balances.

Due to the volatile nature of the oil market, most oil dependent economies tend to concentrate their revenue as earned from oil exports on savings, rather than on investments. As argued by Cherif and Hasanov (2012), "*the returns to investment are also uncertain, and therefore, there is a tradeoff between saving in safe liquid assets and risky investment*". Oil exporting countries generally hold a portfolio of highly liquid assets such as gold and foreign currencies such as the USD and Euro.

2.1.4 Interest Rates and Exchange Rates

Economists have, over the years, debated on both the theoretical and empirical relationship between the exchange rate and the interest rate. According to the Mundell-Fleming model, In the open-economy Mundell-Fleming setting, an increase in the interest rates should stave off depreciation of the exchange rate and curb inflationary tendencies[4]. A contractionary (increase) interest rate policy can be important for the following reasons. Firstly, it is vital to exchange rate movement through policy signals to the market about the government will not to allow the rapid move in the exchange rate that the market expects, considering the existing conditions of the fundamentals of the economy, which may lead to a reduction of the inflationary expectations. This would in turn, helps in curbing the vicious cycle of high and volatile inflation and exchange rate depreciation. Secondly, it increases the attraction domestic financial assets, thus, leading to increase in capital inflow limiting exchange rate depreciation. Thirdly, it results in the reduction of the level of aggregate demand in the domestic economy through the increase in the incentive to save and invest, as well as improving the balance of payment position by reducing the level of imports. However, these important stabilization roles do not always hold true. For instance, during the East Asian currency crisis, increasing the interest rates failed to curb the volatility the exchange rate, and bring it to the desirable level during 1997-1998, thus, raising doubts in the potency of raising interest rates to defend the exchange rate. Critics argue that the high interest rates impeded the ability of the domestic firms and banks to pay back the external debt, thereby

4. For more on the Mundell-Fleming model, see Sachs and Larrain (1993).

reduce the probability of repayment. As a result, high interest rates lead to capital outflows and thereby depreciation of the currency.

We present a simple economic model to show how interest rate and exchange rate are related. Interest rate is the reward to an investor for investing in interest-bearing financial assets. Both interest rate and exchange rate adjust quickly to information in the markets. This market information influences the profit-seeking arbitrage behavior of investors, which results in an interest parity relationship between the interest rates of two countries and exchange rate of the said countries.

We use the Uncovered Interest Parity (UIP) theory to illustrate this. Given that a certain U.S. investor is to decide between investing in the U.S. or in Japan. He would have to consider three factors;

i. The interest rate in the U.S., $\boldsymbol{i_{\$}}$ and interest rate in Japan, $\boldsymbol{i_{¥}}$

ii. The spot exchange rate, *S* and

iii. The future exchange rate at maturity date, the forward rate, F.

To eliminate exchange rate risk, the investor would have to lock in a future exchange rate with a forward contract, and the existence of an arbitrage opportunity in the two markets would result in a covered interest parity (CIP) condition:

$$(\mathbf{1} + \boldsymbol{i_{\$}}) = (\mathbf{1} + \boldsymbol{i_{¥}})\frac{\boldsymbol{F}}{\boldsymbol{S}} \text{---} \textbf{(9)}$$

This may be rewritten as:

$$\frac{(1+i_{\$})}{(1+i_{¥})} = \frac{F}{S} \text{ -- } \textbf{(10)}$$

Which can be approximated for a small interest rate by:

$$i_{\$} - i_{¥} = \frac{F-S}{S} \text{ -- } \textbf{(11)}$$

This means that interest differential between a USD denominated investment instrument and a JPY denominated investment instrument is equal to the forward premium or discount on the Japanese Yen. The covered interest rate parity condition (CIP) is often used in the computation of effective *return* on a foreign investment. Equation (11) could be rewritten as below:

$$i_{\$} = i_{¥} + \frac{F-S}{S} \text{ -- } \textbf{(12)}$$

Thus, the return on a USD denominated asset is given by the Japanese interest rate, in addition to the forward premium or discount on Japanese Yen. Given that the CIP holds true, then the relation as represented by equation (12) will equally be valid.

The key question arises when the investor avoids the forward market. In this scenario, we cannot expect the effective return on USD denominated asset to be represented by equation (12) as the investor in question will not be able to get the premium on the Japanese Yen (or lose the discount). Hence, the investment is said to be uncovered. The effective return will thus, be determined by the Japanese interest rate, in addition to the change in the spot exchange rate between today and the term to maturity of the investment. By letting i_t be the domestic interest rate on a USD denominated asset between periods t and $t+1$, and similarly, i_t^* is the foreign interest rate, the effective return on a domestic currency (USD) denominated financial instrument will be given by:

$$\boldsymbol{i_t = i_t^* + \Delta S_{t+1}} \text{---} \textbf{(13)}$$

Which is $i_{\$} = i_{¥} + \Delta S$ in our illustration. The expected return is the return on the foreign (JPY denominated) investment plus the expected change in Yen exchange rate.

Given that the forward exchange rate is equal to the expected future spot rate, i.e., mathematically, $E\ [S_{t+1}\ |$ all available information$]$ equals F_t, then the forward premium or discount will also be equal to the expected change in the exchange rate. In this case, we say that uncovered interest parity, (UIP) holds true. The UIP condition means that the expected change in spot exchange rate is equal to the interest differential for the two countries.

$$\boldsymbol{\frac{E(S_{t+1}) - S_t}{S_t} = i_t - i_t^*} \text{ ---} \textbf{(14)}$$

The above analysis shows that the forward exchange rates include expectations about the future spot exchange rates. Hence, if the forward exchange rate is equal to the expected future spot rate, then the forward premium is also the expected change in the exchange rate. In this case, UIP is said to hold. Empirical studies indicate that there are often deviations. According to Su, C. et.al. (2019), the deviations are possible due to presence of transactions costs, differential taxation on the returns from investing in financial markets, government control, and political risk involved across countries.

The general assumption is that these deviations are small enough for CIP to hold true in approximation in the real-world. Thus, we can say that profit-seeking arbitrage activities help in eliminating profit opportunities in the exchange rate markets. As such, the CIP condition can be viewed as an equilibrium condition that characterizes the relationship between the spot exchange rate, the forward rate and the interest rates of two countries.

Whether UIP holds or not in the data is a more serious problem. Many studies have shown that UIP does not hold in the data, in particular, in industrialized countries. This means that the percentage change in expected future spot rate is not equal to the interest differential. In other words, the forward rate is not equal to expected future spot rate. This implies that there are deviations from UIP condition as stated inequation (14) above. That is;

$$\boldsymbol{i_t - i_t^* \ - \ \frac{ES_{t+1} - S_t}{S_t} \neq 0} \text{ ------------------------------------ } \mathbf{(15)}$$

This implies that effective difference in the returns on the investments in the two countries is not equal to zero. There are several possible explanations for this. First, there should be profit opportunities in the exchange rate market that are being exploited by the investors. This is often possible if the insider trading activities exist and are commonplace. In other words, there are informational asymmetries in the market; some investors are better informed than others. Although this may explain part of the puzzle, especially in the very short run, it is believed that these informational asymmetries do not persist in the long-run.

Second, it is possible that investors systematically make mistakes in the prediction of the future value of spot exchange rate. That is, $F_t \neq ES_{t+1}$ in the long run. period. This biases the forward rate as a predictor of future spot rate. In other words, an unbiased predictor means that it predicts on average correctly the future value of a price, so that in the long run the forward rate would have the same chance to over- or under-predict the future spot rate. An unbiased predictor does not ensure that forward rate is a good predictor. It simply means that the forward rate is just as likely to guess too high as it is too low future spot rates. There is some evidence that indicates that investors in foreign exchange rate market make systematic mistakes in predicting the future value of spot exchange rate and therefore causing systematic deviations from UIP. One can imagine scenarios where investors make mistakes in their forecast of future values of asset prices, but the magnitude of these mistakes should not be that large to account for the large deviations we observe in UIP. That is, it is hard to understand why, especially over longer time periods, investors make big mistakes in a systematic fashion. Over time, at least, we should expect these errors to shrink to a level where deviations from UIP become smaller.

A third explanation is that there could be an incentive to take a risk by not covering the investment. The effective return differential between two countries should be dependent on the perceived risk on each asset and the risk aversion of the investors. In terms of investments, two investors may assess the same degree of risk associated with two assets, but the more risk-averse investor would require a return on the riskier asset to induce him or her to hold it than the other investor. Risk here means the variability of return from the investment. If investors differ in their risk-taking behavior, we may observe that deviations in UIP and hence, changes in risk and risk aversion are associated with changes in effective return differential (that is interest differential). i.e.,

$$i_t - i_t^* - \frac{ES_{t+1} - S_t}{S_t} = f(risk, riskaversion)$$

The left-hand side of this equation is the effective return differential (or deviations from UIP). The right-hand side can be viewed as the risk premium. Since CIP condition; $i_t - i_t^* = (F_t - S_t)/S_t$ holds almost exactly, subtracting expected change in exchange rate from both sides:

$$i_t - i_t^* - \frac{ES_{t+1} - S_t}{S_t} = \frac{F_t - S_t}{S_t} - \frac{ES_{t+1} - S_t}{S_t} \text{------------------------} \textbf{(16)}$$

or

$$i_t - i_t^* - \frac{ES_{t+1} - S_t}{S_t} = \frac{F_t - ES_{t+1}}{S_t} \text{------------------------------} \textbf{(17)}$$

Thus, we find that the effective return differential (or deviations from UIP) is equal to the percentage difference between forward and expected future spot exchange rate. The right-hand side of equation (16) is usually considered to be a measure of risk premium in the forward exchange rate market. If effective return differential is zero, then the risk premium will be zero. If it is positive, then there is a positive risk premium on the domestic currency, because the expected future spot price of foreign currency is less than the prevailing forward rate. In other words, traders are offering to sell foreign currency or domestic currency in the future will receive a premium, in that foreign currency is expected to depreciate (relative to domestic currency) by an amount greater than the current forward rates. Conversely, traders wishing to buy foreign currency for delivery next period will pay a premium to the future sellers to ensure a set future price.

The nominal interest rate is the real interest rate with an adjustment for expected inflation. The relationship is called the Fisher equation:

$$\boldsymbol{i = r + \pi} \text{ - } \textbf{(18)}$$

where i is the nominal interest rate, r is the real interest rate and π is the expected

inflation rate. An increase in π will tend to increase the nominal interest rate. If the real rate of interest is the same in both countries, then the Fisher equation can be combined with CIP equation:

$$\boldsymbol{i_{\$} - i_{¥} = \pi_{US} - \pi_{JP} = \frac{F-S}{S}} \text{ - } \textbf{(19)}$$

Equation (19) says that if real interest rates are the same internationally, then nominal interest rate differential differ solely by differences in expected inflation. Note that the relative exchange rate is given by the inflation differential and assuming that PPP, the Fisher equation, and the interest rate differential hold, then real interest rates are equalized across countries.

There are several interest rates. Short run interest rates, long run interest rates, namely 1 month, 3-month, 6-months etc. For this study, we shall use the 10-year government (treasury) bond yield in our analysis.

2.2 Empirical Evidence

There exists an extensive literature on the empirical relationship between oil price shocks and exchange rate, among which very few inculcates the effect of productivity differential- the Balassa-Samuelson effect on exchange rate. Baak (2012) measures the extent to which the real effective exchange rate of the Korean won is misaligned from its equilibrium value by estimating the equilibrium value, using the behavioral equilibrium exchange rate (BEER) approach. Using quarterly data from 1982Q1 to 2009Q4, economic fundamentals such as the terms of trade, the relative price of non-traded to traded goods, net foreign assets and real interest rate differentials are employed to assess the equilibrium exchange rate. It proxies the Balassa-Samuelson effect with the ratio of the consumer price index (CPI) to the producer price index (PPI). However, Choudhri and Schembri (2014) examine the Canada-US real exchange rate behavior based on the influence of sectoral productivities and commodity prices and captures the Balassa-Samuelson effect with productivity ratios. Their empirical analysis finds that both variables exert a significant long-run effect. However, the relation for the real exchange rate has shifted as the effect of each variable has become stronger and a positive trend is present since 1990. The effect of productivity, moreover, is opposite to that predicted by the standard Balassa-Samuelson theory.

More empirical literature focuses on the relationship between oil prices and the exchange rate. Among which is Yang, Cai and Hamori (2018), which obtain the long-term correlation between oil prices and exchange rates by employing the dynamic conditional correlation-mixed data sampling (DCC-MIDAS) model and identifies the factors that influence the long-term correlation using panel data analysis. A negative long-run correlation is found between oil prices and exchange rates for all oil exchange rate markets except Japan. More so, both inflation and term spread (short and long-term components of volatility) have negative effects, while the risk-free interest rate has a positive effect on the long-term correlation between oil prices and exchange rates. Importantly, the empirical results show that an increase in inflation will significantly damage the real value of the currency itself. Al Rasasi (2018) evaluates the response of G7 real exchange rates to oil supply and demand shocks and finds evidence suggesting that oil shocks are associated with the appreciation (depreciation) of real exchange rates for oil exporting (importing) countries. Further evidence, based on the analysis of forecast error variance decomposition, indicates that oil-specific demand shocks are the main contributor to variation in real exchange rates, whereas oil supply shocks contribute the least. With respect to the role of monetary policy in responding to oil and exchange rate shocks, evidence shows that monetary policy reacts only to oil-specific demand and aggregate demand shocks in three countries, whereas monetary policy responds to real exchange rate fluctuations in four countries.

Further work by Yang, Cai and Hamori (2017) analyszes the co-movement between the crude oil price and the exchange rate markets by studying their dynamics in the time and frequency domain. Employing a wavelet coherence framework, they find that the degree of co-movement between the crude oil price and the exchange rates deviates over time. Additionally, there is a strong but not homogenous links around the year 2008 for all the countries included in the study and from 2005 onwards for the oil-exporting countries. However, the strong interdependence is limited for the oil-importing countries. Moreover, they observe a negative relationship between the returns of the crude oil price and the exchange rates for the oil-exporting countries, while the relationships for the oil-importing countries are uncertain. Mensah, Obi and Bokpin (2017) further examines the long-run dynamics between oil price and the bilateral US dollar exchange rates for a group of oil-dependent economies before and after the 2008-2009 Global Financial Crises. The dependence on crude oil of these economies is either because fiscal revenues are primarily reliant on oil export receipts or because industrial production is heavily dependent on petroleum. Empirical results show evidence of a long run equilibrium relationship between oil price and exchange rate, especially for currencies of the key oil-exporting countries. This relationship is more evident in the post-crisis period, which is also the period when both exchange rate volatility and the inverse relationship between oil price and exchange rate experienced a significant increase.

Chen, et. al. (2016) also investigate the impacts of oil price shocks on the bilateral exchange rates of the U.S. dollar against currencies in 16 OECD countries. The empirical findings indicate that the responses of dollar exchange rates to oil price shocks differ greatly depending on whether changes in oil prices are driven by supply or aggregate demand. It also finds that oil price shocks can explain about 10% to 20% of long-term variations in exchange rates. The explanatory ability of oil shocks to exchange rate variations becomes much greater after the global financial crisis. Volkov and Yuhn (2016) investigates the effects of oil price shocks on exchange rate movements in five major oil-exporting countries: Russia, Brazil, Mexico, Canada, and Norway. The volatility of exchange rates associated with oil price shocks is significant in Russia, Brazil, and Mexico, but weak in Norway and Canada. It takes much longer for the exchange rate to reach the initial equilibrium level in Russia, Brazil, and Mexico than in Norway and Canada. The asymmetric behavior of exchange rate volatility among countries seems to be related to the efficiency of financial markets rather than to the importance of oil revenues in the economy.

Bouoiyour, et. al. (2015) studies the nexus between oil price and Russia's real exchange rate, conditioning upon potential control variables at well-specified horizons and on a frequency by frequency basis. This research accounts also for the possible transient linkages and signal discontinuities. A major finding of this paper is deeply suggestive of a sharp causality running from oil price to real exchange rate in lower frequencies. This implies that Russia should better tackle the turbulence triggered by oil price and continue to reduce its energy dependency via drastic and proactive measures. The economic and fiscal initiatives of Putin administration may help to cope with sudden shocks, to lessen the great oil dependence and to build confidence needed for economic recovery. While the research does not say much about the routes through which oil price may affect real exchange rate, it clearly indicates the presence of short-term relationship conditional to GDP, government expenditures, terms of trade and productivity differential. The conditional analysis and signal detection appear as meaningful exercises to find new insights into the focal issue. Chen and Chen (2007) investigates the long-run relationship between real oil prices and real exchange rates by using a monthly panel of G7 countries from 1972:1 to 2005:10. It is shown that real oil prices may have been the dominant source of real exchange rate movements and that there is a link between real oil prices and real exchange rates. The ability of real oil prices to forecast future real exchange returns is also examined.

CHAPTER THREE: DATA and METHODOLOGY

3.1 Description and the Sources of Data

This study uses monthly bilateral real exchange rates (BRER) of Norwegian krone and Colombian Peso vis-a-vis the Euro and the USD respectively. Other data used include the going market price of crude oil (source: U.S EIA), value of imports (source: IMF-IFS), import price indices (source: IMF-IFS) industrial productivity indices (IMF-IFS), foreign reserves (IMF-IFS), import value, interest rates (10-year G-bond), inflation rate, and the CPIs. We collected and used data on the Norwegian Krone and the Colombian Peso bilateral nominal exchange rate to the Euro, sourced from the Norges bank; the central bank of Norway and the Federal Reserve Bank of St. Louis (henceforth, referred to as FRED) respectively.

We shall define exchange rate; for the purpose of this work, as the domestic currency value of a Euro for Norway and domestic currency value of the USD for Colombia. The nominal bilateral exchange rate is converted to the real value, for instance by multiplying by the ratio of the consumer price index (CPI) for the euro area to the domestic CPI. In this scenario, an increase in the value of BRER implies a depreciation of the real value of the currency against the Euro or USD. All country's CPIs were sourced from FRED.

The commodity-based Terms of Trade as used here refers to Oil Terms of Trade (OTOT). Rather than the index of the exports the country divided by the import price index of that country; we want to construct a terms of trade index, with its numerator being an index of the country`s main commodity export particularly, oil price.

The oil price series for Norway is the spot price of the Brent crude oil, sourced from the United States Energy Information Administration (EIA) database. The data is indexed using 2010 = 100. Oil terms of trade (OTOT) is the ratio of oil price index to the import price index, while productivity ratio refers to the ratio of the domestic productivity index to the productivity index of the Euro area and the USA for Norway and Colombia respectively. To construct the OTOT, we convert the USD-priced Brent to local currency for Norway. The import price index for Norway is already in local (Krone) currency.

The reserve was used in the analysis as a ratio of import value. This is done to get the picture of the buffer the foreign reserves give to any imports shocks on the euro bilateral real exchange rate. We shall construct the monthly real interest rates differential (RIRD) by subtracting the 10-year government bond interest rate data from the corresponding data for the two countries, after deducting inflation rate. Both interest rates and inflation data are collected from FRED database. All the data used in the model are transformed from nominal data to real values and all data in monetary value such as oil and reserves are converted to local currencies. All data series for Norway and Colombia ranges from 1999M01 to 2018M02 (230 data points) and 2003M01 to 2017M02 (170 data points) respectively. The movement of the transformed series over our sample period are shown in graph plots below.

Figure 1: Bilateral Real Exchage Rate versus Oil Terms of Trade for Colombia.

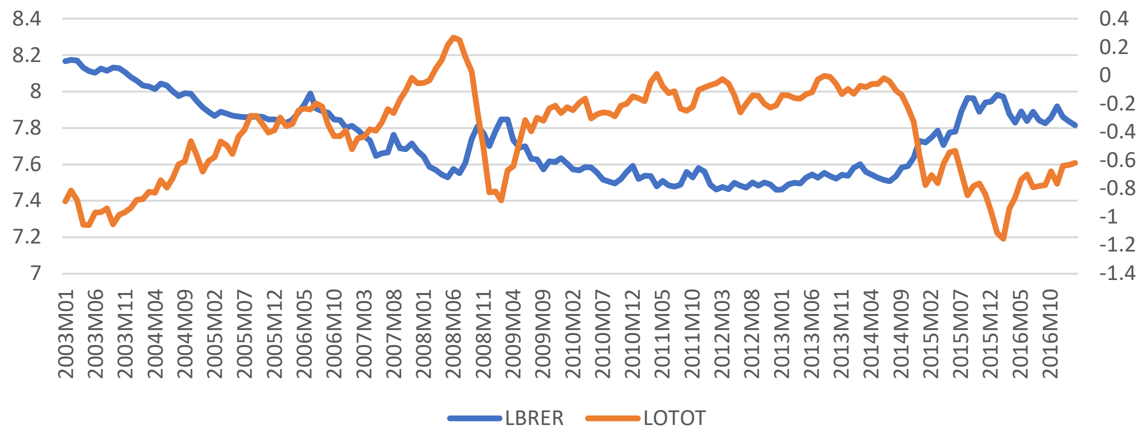


Figure 2: Bilateral Real Exchange Rate versus Ratio of Traded to Nontraded Goods for Colombia.

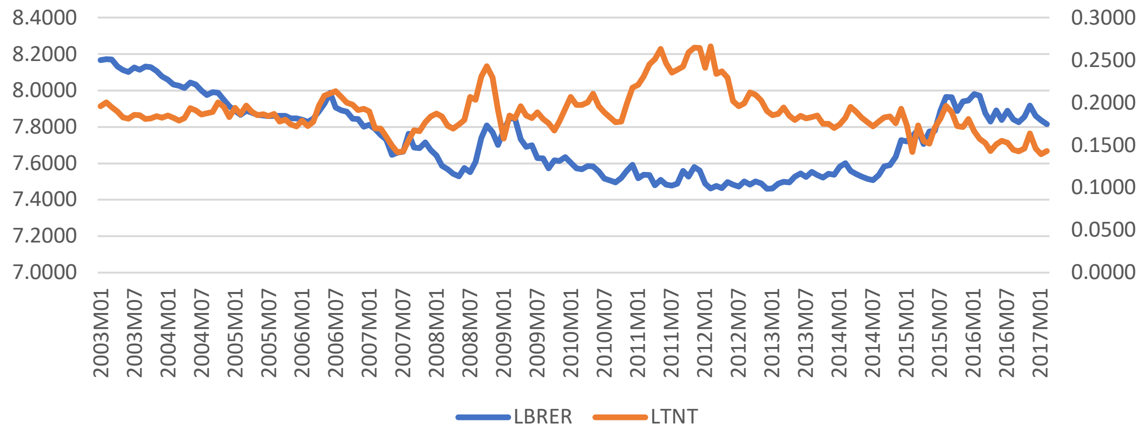


Figure 3: Bilateral Real Exchange rate versus foreign Reserves for colombia.

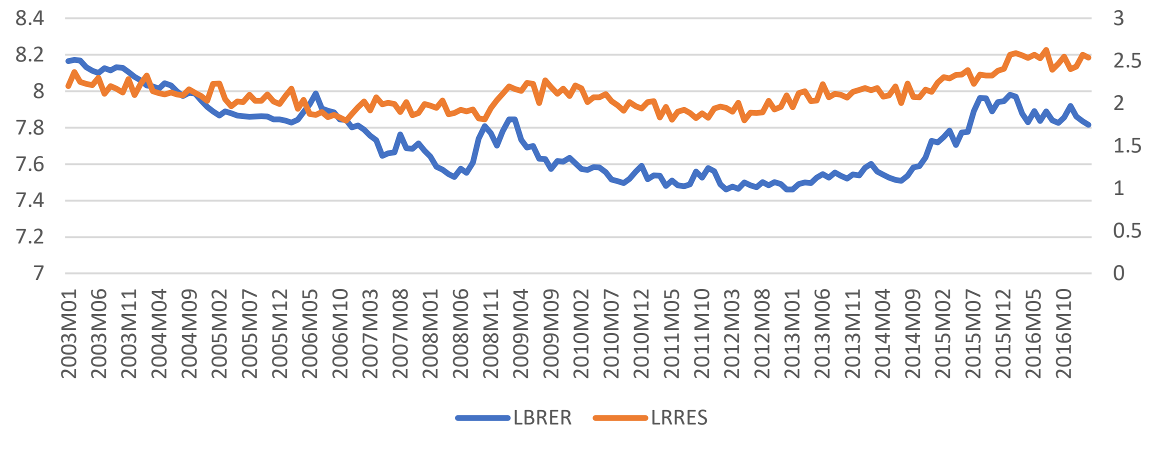
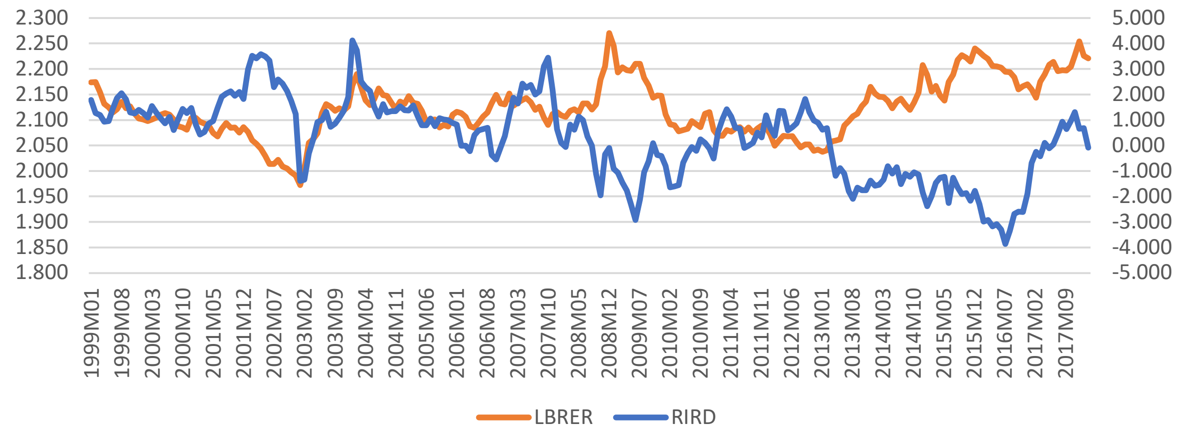


Figure 4: Bilateral Real Exchange Rate versus Real Interest Rate Differential for Norway.



3.2 METHODOLOGY

We aim at building a model that explains the relationship between the economic data as we explained in section 3.1. We conduct econometric analysis to determine the possibility of a long-run relationship between the real bilateral exchange rate and oil terms of trade, productivity ratios (capturing the Balassa-Samuelson effect), foreign reserves and interest rate differential. We would use the Bounds Test as developed by Pesaran, Shin and Smith (2001), the Bounds test is implementable even when the variables a mix of I(0)s and I(1)s. Please see tables 1.1 and 1.2 for the mixed results of the Augmented Dickey-Fuller unit root tests.

Table 3.1: Unit Root Test - Norway

Variable	Level		Critical Value			First Order Difference		Critical Value			Decission
	Test Statistic	P-Value	1%	5%	10%	Test Statistic	P-Value	1%	5%	10%	
LBRER	-2.56	0.1020	-3.46	-2.87	-2.57	-11.22	0.0000	-3.46	-2.87	-2.57	I(1)
LOTOT	-3.45	0.0103	-3.46	-2.87	-2.57	-13.81	0.0000	-3.46	-2.87	-2.57	I(0)
LPDTR	-3.01	0.0355	-3.46	-2.87	-2.57	-14.54	0.0000	-3.46	-2.87	-2.57	I(0)
LRRES	-2.56	0.1038	-3.46	-2.87	-2.57	-4.71	0.0001	-3.46	-2.87	-2.57	I(1)
RIRD	-1.98	0.2949	-3.46	-2.87	-2.57	-7.01	0.0000	-3.46	-2.87	-2.57	I(1)

Table 1.2: Unit Root Test - Colombia

Variable	Level		Critical Value			First Order Difference		Critical Value			Decission
	Test Statistic	P-Value	1%	5%	10%	Test Statistic	P-Value	1%	5%	10%	
LBRER	-2.18	0.22	-3.46	-2.87	-2.57	-12.32	0.0000	-3.47	-2.88	-2.58	I(1)
LOTOT	-2.46	0.1264	-3.46	-2.87	-2.57	-9.73	0.0000	-3.47	-2.88	-2.58	I(1)
LPDTR	-1.78	0.3899	-3.47	-2.88	-2.58	-12.52	0.0000	-3.47	-2.88	-2.58	I(1)
LRRES	-0.43	0.9000	-3.47	-2.88	-2.58	-15.14	0.0000	-3.47	-2.88	-2.58	I(1)
RIRD	-2.86	0.0526	-3.47	-2.88	-2.58	-11.20	0.0000	-3.47	-2.88	-2.58	I(0)

Choudhri and Schembri (2014) noted that "*this approach is appealing because it avoids pre-testing the variables to see if they have a unit root of the same order or not. One limitation of unit root tests is that they have low power against an alternative of highly persistent stationary process, especially for limited time series data*." We apply the test by estimating the following error correction model in equation 20.

$$\Delta log(brer)_t = \delta_0 + \pi_1 log(brer)_{t-1} + \pi_2 log(otot)_{t-1} + \pi_3 log(pdtr)_{t-1} + \pi_4 log(rres)_{t-1} + rird_{t-1} + \sum_{s=1}^{n} \pi_{5s} \Delta log(brer)_{t-s} + \sum_{s=0}^{n} \pi_{6s} \Delta log(otot)_{t-s} + \sum_{s=0}^{n} \pi_{7s} \Delta log(pdtr)_{t-s} + \sum_{s=0}^{n} \pi_{8s} \Delta log(rres)_{t-s} + \sum_{s=0}^{n} \pi_{9s} \Delta rird_{t-s} + \mu_t \text{ - - - - } (20)$$

Where:

brer = Bilateral real exchange rate, defined as the per Euro value domestic currency

otot = Oil terms of trade, defined as the ratio of oil price to the imports price.

pdtr = the ratio of the Productivity of the home country to that of the foreign.

rres = Ratio of foreign reserves to the imports value.

rird = Real interest rate differential, represents the trend variable.

μ = Stochastic error term.

In keeping with Clark and MacDonald (1998), a priori, we expect the coefficients of the independent variables to have the relationships as shown in equation 21 below.

$$BRER_t = f\{OTOT_t (-), PDTR_t (-), RRES_t (-), RIRD_t (-)\} \text{ - - - - - - - - - - - - - - - - - } (21)$$

The opposite signs for our priors are the reverse of those of Clark and MacDonald as we have defined out exchange as the inverse of theirs. In our definition, an increase in the exchange is a depreciation, so that we expect that as a nation's Terms of Trade improve, its exchange rate will fall (i.e. appreciate).

Under the ARDL model, the Bounds test requires the estimation of equation 20. We shall test the null hypothesis of no level relationship. We do not reject the null hypothesis if the F-value is greater in absolute value than the upper bound, at 5% level of significance, and rejected otherwise. In the ARDL model, the error correction term; ECT (Z_{t-1}) is replaced with lagged BRER and lagged other independent variables as used in our model. The corresponding Error Correction Model, analogous to equation 20., is as shown by equation 22., below.

$$\Delta log(brer)_t = \delta_0 + \theta Z_{t-1} + \sum_{s=1}^{n} \pi_{5s} \Delta log(brer)_{t-s} + \sum_{s=0}^{n} \pi_{6s} \Delta log(otot)_{t-s} + \sum_{s=0}^{n} \pi_{7s} \Delta log(pdtr)_{t-s} + \sum_{s=0}^{n} \pi_{8s} \Delta log(rres)_{t-s} + \sum_{s=0}^{n} \pi_{9s} \Delta rird_{t-s} + \mu_t \text{ ---- (22)}$$

The corresponding long run equation and the ECM under our model, is as given in equations 22 and 23 below;

$$log(brer)_t = \mu_0 + \mu_2 log(otot)_t + \mu_3 log(pdtr)_t + \mu_4 log(rres)_t + \mu_5 rird_t + \varepsilon_t \text{ ---------------------------------- (23)}$$

$$Z_t = log(brer)_{t-1} - b_0 - b_1 log(otot)_{t-1} + b_2 log(pdtr)_{t-1} + b_3 log(rres)_{t-1} + b_4 rird_{t-1} \text{ ------------------------------ (24)}$$

CHAPTER 4: COLOMBIA- MODEL ESTIMATION and INTERPRETATION

4.1 Basic characteristics of the variables

We explore the behavior of the real exchange rate of domestic currencies of Colombia (Peso) vis a vis the USD. Using the following explanatory variables, oil commodity prices (LOTOT), relative price of nontraded to traded good (LTNT), international reserves (LRRES) and interest rate differential (RIRD). The relationship between these variable and the bilateral real exchange rate (LBRER) are as shown in the graphs of Figs. 1 through 4. of Appendix 1, for Colombia. We also report a quick check on the correlations between the different series are shown in Tables 4.1.

Figs. 1 shows the movements of oil terms of trade and exchange rates for Colombia. As explained in the theoretical literature on commodity terms of trade in chapter 2, this movement is expected to be in the opposite direction, given our definition of the exchange rate. This seems to hold true for Colombia during our sample periods. However, figs 2 and examines the relation between the log of Colombia's ratio of traded to nontraded goods and the log of the bilateral real exchange rate (***LBRER***), defined as the real value of the Krone and the Peso *vis-à-vis* the euro and the USD, respectively. We observe that this seems to be consistent with our *a priori* expected negative relationship. In the standard Balassa– Samuelson model, higher traded goods productivity in Colombia would result in the depreciation of the Peso, in real terms. Thus, the two variables are expected to be negatively related.

These variables would, however, be positively related if traded goods are differentiated and the terms of trade effect is strong enough to more than offset the conventional Balassa–Samuelson effect (via the relative price of non-traded goods). In the same vain, figure 3 which graph the relationship between exchange rate and foreign reserves seems to be consistent with our *a priori* expectation.

Table 4.1: Correlation matrix for the variables - Colombia

Sample: 2003M01 - 2017M02
Included observations: 170

Correlation	**LBRER**	**LOTOT**	**LTNT**	**LRRES**
LBRER	1.0000			
LOTOT	-0.8253	1.0000		
LTNT	-0.3036	0.3827	1.0000	
LRRES	-0.5993	-0.6520	0.0503	1.0000

4.2 Bounds Test: Long-run Relationship

Formal tests to examine whether a long-run relation exists between the real exchange rate and oil terms of trade, relative price of traded to nontraded goods and foreign reserves are undertaken in this section. We use a bounds testing procedure developed by Pesaran, Shin, and Smith (2001), to test for a level relation between our model variables regardless of whether they are I(0) or I(1). Thus, we estimate equation 20 as explained in chapter 3. We assume a null hypothesis that the oil terms of trade, the ratio of traded to nontraded goods, foreign reserves and interest rate differential have no long-run impact on BRER of the Peso to the USD. With this assumption, the null hypothesis of no level relationship is tested by a Wald-type test of the restriction that the coefficients are jointly not significant, that is; $\pi_1 = \pi_2 = \pi_3 = 0$.

Pesaran, Shin and Smith (2001) provide critical bounds of the asymptotic distribution of the test statistics (F-statistic for lagged independent variable). The null hypothesis is accepted if the absolute value of the test statistic is below the lower (I(0)) bound, rejected if it is above the upper (I(1)) bound, and the test is inconclusive if the statistics is within the bounds. In our analysis of unit root test, we settled for intercept and no trend. Given that we have 3 explanatory variables, we read the figures corresponding to **k = 3** and under 10% significance level. Likewise, using the t-statistic (for lagged dependent variable) under the t-Bounds test for small sample, the null hypothesis is accepted if the absolute value of the test statistic is below the lower bound, rejected if it is above the upper bound, and the test is inconclusive if the statistics is within the bounds. The bound test results show that there exists a long run relationship for both Norway and Colombia.

Table 4.2: Estimates of ARDL for COLOMBIA

Panel A: Short-Run Coefficient Estimates				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**p-value**
C	0.849349	0.250984	3.384072	0.0009
$LBRER^*_{t-1}$	-0.093991	0.028672	-3.278155	0.0013
$LOTOT_{t-1}$	-0.048926	0.022207	-2.203140	0.0290
$LTNT_{t-1}$	-0.353833	0.144553	-2.447778	0.0155
LRRES**	-0.036455	0.024584	-1.482880	0.1401
$\Delta(LBRER)_{t-1}$	-0.221146	0.083098	-2.661261	0.0086
$\Delta(LOTOT)_{t}$	-0.132322	0.035654	-3.711253	0.0003
$\Delta(LOTOT)_{t-1}$	-0.114043	0.038279	-2.979235	0.0033
$\Delta(LTNT)_{t}$	1.623463	0.290715	5.584377	0.0000
$\Delta(LTNT)_{t-1}$	0.477047	0.278566	1.712512	0.0888

* p-value incompatible with t-Bounds distribution.

Table 4.2 Panel B: Long-Run Coefficient Estimates for Colombia

Variable	Coefficient	Std. Error	t-Statistic	p-value
LOTOT	-0.520541	0.131254	-3.965894	0.0001
LTNT	-3.764550	1.683910	-2.235600	0.0268
LRRES	-0.387859	0.235901	-1.644161	0.1021
EC = LBRER - (-0.5205*LOTOT -3.7645*LTNT -0.3879*LRRES)				

Tables 4.3 show the long-run coefficients for the explanatory variables for Colombia, respectively. The models reveal that all explanatory variables are statistically significant and follows the a priori expectations.

As the first major step of the ARDL analysis, we test for the presence of long-run relationships as discussed in equation (20). Our result for Colombia reveals an equilibrating long-run relationship between the Peso-USD real exchange rate and our explanatory variable of Oil Terms of Trade (LOTOT), ratio of traded to nontraded sector (LTNT), and foreign reserves (LRRES). The F- statistic of the Bounds test is 3.7373. This is in the boundary of the I(1) bound critical value of 3.77 at 10% level of significance. The details of this results are shown in table 4.4 above.

Thus, the null hypotheses of no cointegrating relationship are rejected, implying long-run cointegration relationships amongst the variables for Colombia.

Table 4.2 Panel C: Bounds Test

H_0: No levels relationship for Colombia

Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	3.737323	10%	2.72	3.77
k	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61
Actual Sample Size	168		Finite Sample: n=80	
		10%	2.823	3.885
		5%	3.363	4.515
		1%	4.568	5.96

t-Bounds Test			Null Hypothesis: No levels relationship	
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-3.278155	10%	-2.57	-3.46
		5%	-2.86	-3.78
		2.5%	-3.13	-4.05
		1%	-3.43	-4.37

4.3 Error Correction Test: Short-run dynamics

The results of the short-run dynamic coefficients associated with the long-run relationships obtained from the ECM equation 22 of chapter 3 are given in Table 4.5 for Colombia.

Table 4.3
ARDL Error Correction Regression for Colombia.

Dependent Variable: D(LBRER)
Selected Model: ARDL(2, 2, 2, 0)
Sample: 2003M01 2017M02
Included observations: 168

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.849349	0.218052	3.895159	0.0001
$\Delta(LBRER)_{t-1}$	-0.221146	0.081964	-2.698082	0.0077
$\Delta(LOTOT)_{t}$	-0.132322	0.034133	-3.876660	0.0002
$\Delta(LOTOT)_{t-1}$	-0.114043	0.036473	-3.126752	0.0021
$\Delta(LTNT)_{t}$	1.623463	0.279723	5.803816	0.0000
$\Delta(LTNT)_{t-1}$	0.477047	0.268541	1.776437	0.0776
CointEq(-1)*	-0.093991	0.024082	-3.902965	0.0001

R-squared	0.286871	Mean dependent var	-0.002128
Adjusted R-squared	0.260295	S.D. dependent var	0.039922
S.E. of regression	0.034335	Akaike info criterion	-3.864532
Sum squared resid	0.189801	Schwarz criterion	-3.734367
Log likelihood	331.6207	Hannan-Quinn criter.	-3.811705
F-statistic	10.79429	Durbin-Watson stat	2.010249
Prob(F-statistic)	0.000000		

* p-value incompatible with t-Bounds distribution.

The last period's deviation from the long-run has a profound influence on the short-run dynamics of the dependent variable. However, this deviation equilibrium is expected to be corrected, at least partially in the next period. This equilibrium correction is modelled by the coefficient of the error correction term. Tables 4.5 above reports this model Colombia.

The coefficient estimates for the ECT: - 0.0934 (-3.903) for Colombia is both highly statistically and with the correct sign.

This coefficient of the ECT term is the speed of adjustment or correction of the deviation from equilibrium in the next period i.e., the speed at which the bilateral real exchange rate returns to equilibrium, after the changes (shocks) to the explanatory variables. This imply a high speed of adjustment to equilibrium. Approximately 9.4% of disequilibria from the previous month's shock reverts to the long-run equilibrium in the current month for Colombia.

4.4 Long Run Model Under ARDL.

Consequently, our long run equation under the linear ARDL is illustrated in equations 25 for Colombia below. For the details of the long-run Bound test results, please see tables 4.3. of the appendix.

COLOMBIA:

$$lbrer_t = \underset{(3.3841)}{0.8493} - \underset{(-3.9659)}{0.5205} lotot_t - \underset{(-2.2356)}{3.7646} ltnt_t - \underset{(-1.6442)}{0.3879} lrres_t + \boldsymbol{\varepsilon}_t \text{ - - - - - - - - - - - - } (25)$$

4.5 Measuring Misalignments.

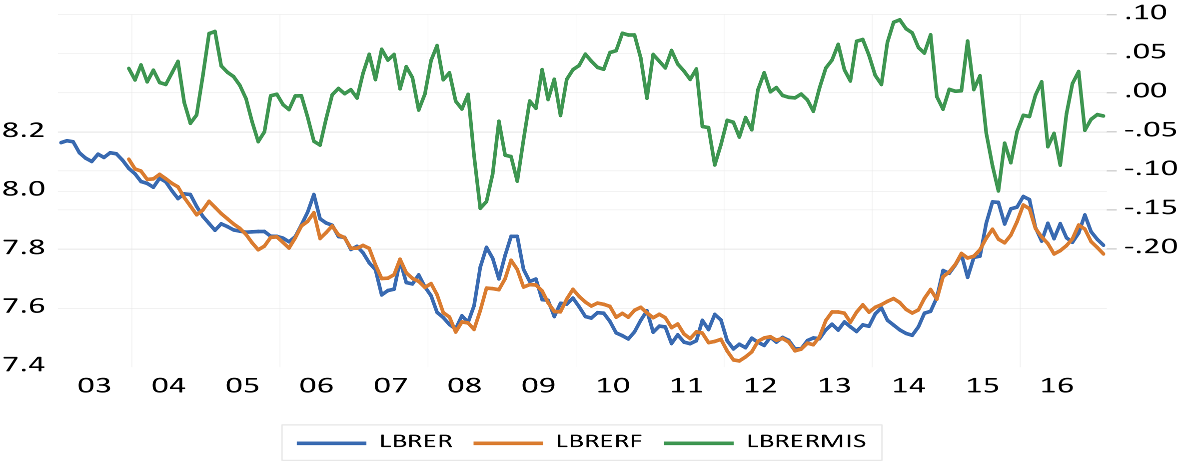


Fig 4.1: Colombia - Forecast real exchange rate versus the actual values.

The USD-Peso exchange rate is as illustrated in figure 4.1 with the blue line. Whereas, the estimated values as shown by the orange line is modeled by equation 25. Our aim is to calculate the current misalignment by differencing the actual USD-Peso exchange rate and the estimated BEER (LBERF – LBER). This difference is shown by the green line of figure 4.1.

Although the absolute PPP theory of exchange prescribes a constant real exchange rate in the long run, the relative PPP allows for the dynamism of real exchange rate in the short run. That is, the actual real exchange rate can deviate from its long run value. Figure 4.1 shows that the actual RER deviates constantly (misaligned) from the corresponding estimated values over our sample period. This misalignments as shown by the green line reveals a mean-reverting series, confirming the relative PPP theory of exchange rate.

4.6 Diagnostic tests: Serial Correlation and Model Stability

We check our model for the existence of residual autocorrelation, using the Breusch-Godfrey LM-test for serial correlation. Tables 4.6 shows the results for Colombia. The probability values associated with the chi-square statistic are both greater than 5%. Thus, we cannot reject H_o, and conclude that there is no evidence of serial correlation for both models.

Table 4.4: Breusch-Godfrey Serial Correlation LM Test: Colombia

Null hypothesis: No serial correlation at up to 2 lag			
F-statistic	0.240465	Prob. F(2,137)	0.7866
Obs*R-squared	0.534798	Prob. Chi-Square(2)	0.7654

The CUSUM test for stability reveals that the model for Colombia is stable within the 5% confidence bound. Please see this result in the graph of figure 4.2 below.

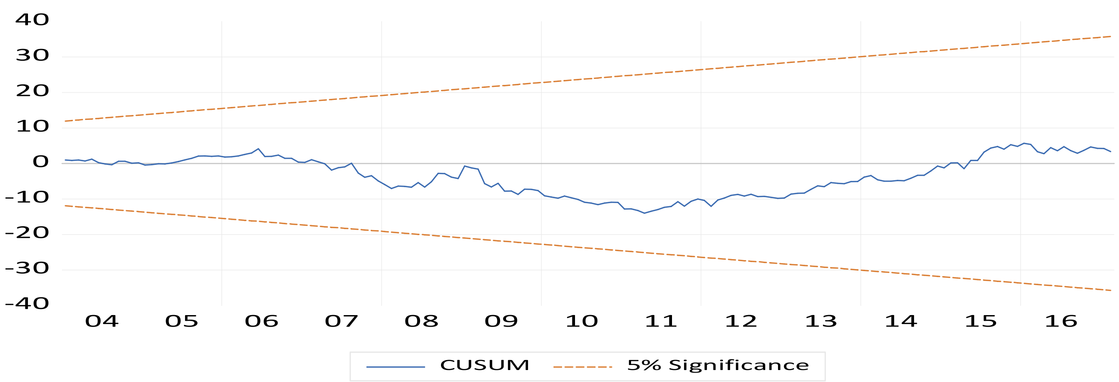


Fig 4.2: Colombia – Stability test.

CHAPTER 5: NORWAY- MODEL ESTIMATION and INTERPRETATION

5.1 Basic characteristics of the variables

This chapter seeks to study the response of the bilateral real exchange rate of domestic currency of Norway (Krone) vis a vis the Euro. An important switch in monetary policy was adopted by the Norway monetary authority when it replaces a long period of exchange rate targeting with a flexible inflation target in March 2001. According to Bjornstad and Eilev (2007), this 'regime shift reverses the causal ordering between changes in the nominal exchange rate and changes in the interest rate. When the central bank targets the exchange rate, interest rates are rarely changed independently of foreign interest rates and only to counteract large movements in the exchange rate after interventions have failed to stabilize the exchange rate'. As it is the policy with inflation targeting, the interest rate is the major tool, used in stabilizing the domestic economy.

The switch probably accounts for the lack of statistical significance of all other variables as considered in the estimation of exchange rate of the Colombian peso, except the interest rate differential (RIRD). Thus, oil terms of trade, ratio of traded to nontraded goods and foreign reserves were not considered in the Norway model. The relationship between real interest rate and real bilateral exchange rate can be observed in figure 5.1 below.

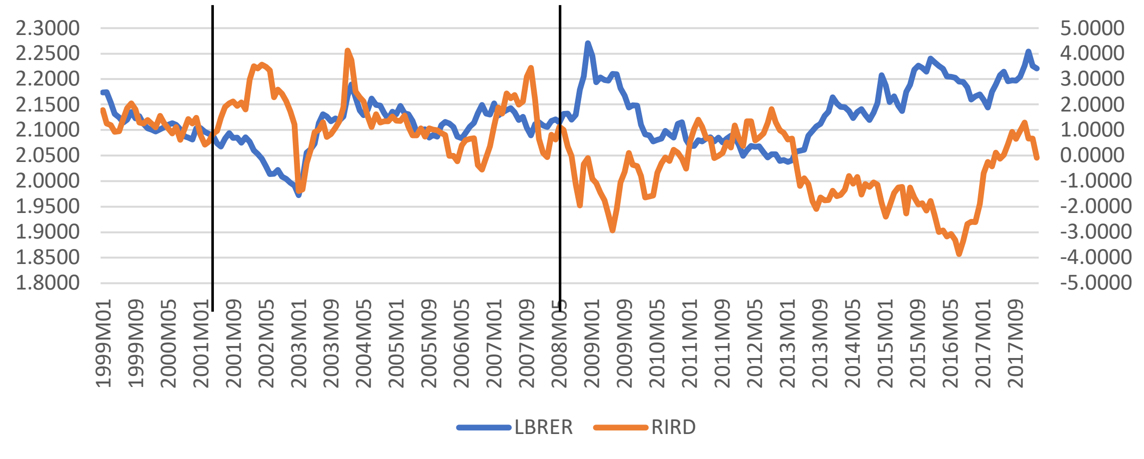


Figure 4: Bilateral Real Exchange Rate versus Real Interest Rate Differential for Norway.

Clearly as revealed in the figure above, interest rate tracked exchange rate pretty closely until about March 2001, revealing the impact of the policy switch from exchange rate targeting to inflation targeting. However, a clearer pattern of the two variables was revealed post 2008 global financial crises. Further examination of the relationship between exchange rate and interest rate is done using the correlation analysis in table 5.1. this result reveals a negative relationship between the two variables, over the sample period under examination. This is in line with the a priori expectation.

Table 5.1: Correlation matrix for the variables - Norway

Sample: 1999M01 - 2018M02
Included observations: 230

Correlation	LBRER	RIRD
LBRER	1.0000	
RIRD	-0.4608	1.0000

5.2 Bounds Test - Long-run Relationship

We conduct the formal test to examine whether a long-run relation exists between the real exchange rate interest rate differentials in this section, using the Pesaran, Shin, and Smith (2001) bounds testing procedure. unlike the case for Colombia, we conduct a bivariate test. The estimated equation remains equation 20 as explained in chapter 3. We assume a null hypothesis that the interest rate differential has no long-run impact on BRER of the Krone. With this assumption, the null hypothesis of no level relationship is tested by a Wald-type test of the restriction that the coefficient is not statistically significant, that is, $\pi_1 = 0$. Pesaran, Shin and Smith (2001) provide critical bounds of the asymptotic distribution of the test statistics (F-statistic for lagged independent variable).

Table 5.2: Estimates of ARDL for NORWAY

Panel A: Short-Run Coefficient Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.1598	0.0486	3.2883	0.0012
$LBRER^*_{t-1}$	-0.0749	0.0229	-3.2766	0.0012
$RIRD_{t-1}$	-0.0020	0.0008	-2.5679	0.0109
$\Delta(LBRER)_{t-1}$	0.2500	0.0663	3.7731	0.0002
$\Delta(LBRER)_{t-2}$	-0.1363	0.0679	-2.0071	0.0460
$\Delta(LBRER)_{t-3}$	0.0997	0.0675	1.4773	0.1410
$\Delta(RIRD)_t$	-0.0002	0.0019	-0.0877	0.9302
$\Delta(RIRD)_{t-1}$	0.0042	0.0020	2.1134	0.0357

* p-value incompatible with t-Bounds distribution.

Given that we have only one explanatory variable, we read the figures corresponding to **k = 1** and under 5% or 10% significance level. Likewise, using the t-statistic (for lagged dependent variable) under the t-Bounds test for small sample, the null hypothesis is accepted if the absolute value of the test statistic is below the lower bound, rejected if it is above the upper bound, and the test is inconclusive if the statistics is within the bounds. The bound test results show that there exists a long run relationship for Norway.

Table 5.2 Panel B: Long-Run Coefficient Estimates for NORWAY

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$RIRD_t$	-0.026799	0.009597	-2.79243	0.0057
EC = LBRER - (-0.0268*RIRD)				

As the usual first major step of the ARDL analysis, we test for the presence of long-run relationships as discussed in equation (20). Our result for Norway reveals an equilibrating long-run relationship between the krone-euro real exchange rate and our explanatory variable Interest Rate differential (RIRD). The F- statistic of the Bounds test of 5.9764 is higher than I(1) bound critical value of 5.73, at 5% level of significance. Reinforcing the asymptotic significance is the t-statistic. Given our sample size, n-226, the t-statistic value of -3.2766 is higher than the I(1) critical value of -3.22 (in absolute terms), at the 5% level of significance. The details of this results are shown in table 5.4 below. This result emphasis the effectiveness of momentary policy in a developed economy such as Norway and proves particularly, the interest parity theory of exchange rate determination.

Table 5.2 Panel C: Bounds Test – H_0: No levels relationship for NORWAY

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	5.976379	10%	4.04	4.78
k	1	5%	4.94	5.73
		2.5%	5.77	6.68
		1%	6.84	7.84
Actual Sample Size	226		Finite Sample: n=80	
		10%	4.135	4.895
		5%	5.06	5.93
		1%	7.095	8.26

t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-3.276623	10%	-2.57	-2.91
		5%	-2.86	-3.22
		2.5%	-3.13	-3.5
		1%	-3.43	-3.82

Thus, the null hypotheses of no cointegrating relationship are rejected, implying long-run cointegration relationship between interest rate differential between Norway the Euro zone and the NOK/euro real bilateral exchange rate.

Tables 5.3 shows the long-run coefficients for the explanatory variable; interest rate differential for Norway. The models reveal that the explanatory variable is statistically significant. It is interesting to also note that the coefficient follows the a priori expectations as explained in equation 21 of chapter 3.

5.3 Error Correction Test – Short-run dynamics

The results of the short-run dynamic coefficients associated with the long-run relationships obtained from the ECM equation 22 of chapter 3 are given in Table 5.5 below.

Table 5.3: ARDL Error Correction Regression for Norway

Dependent Variable: D(LBRER)
Selected Model: ARDL(4, 2)
Case 3: Unrestricted Constant and No Trend
Sample: 1999M01 2018M02
Included observations: 226

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.1598	0.0460	3.4726	0.0006
$\Delta(LBRER)_{t-1}$	0.2500	0.0657	3.8034	0.0002
$\Delta(LBRER)_{t-2}$	-0.1363	0.0674	-2.0217	0.0444
$\Delta(LBRER)_{t-3}$	0.0997	0.0668	1.4921	0.1371
$\Delta(RIRD)_{t}$	-0.0002	0.0019	-0.0893	0.9289
$\Delta(RIRD)_{t-1}$	0.0042	0.0020	2.1360	0.0338
CointEq(-1)*	-0.0749	0.0216	-3.4652	0.0006

R-squared	0.120315	Mean dependent var	0.000395
Adjusted R-squared	0.096214	S.D. dependent var	0.016093
S.E. of regression	0.0153	Akaike info criterion	-5.491498
Sum squared resid	0.051263	Schwarz criterion	-5.385552
Log likelihood	627.5393	Hannan-Quinn criter.	-5.448742
F-statistic	4.99214	Durbin-Watson stat	1.959492
Prob(F-statistic)	0.000082		

* p-value incompatible with t-Bounds distribution.

The last period's deviation from the long-run has a profound influence on the short-run dynamics of the dependent variable. However, this deviation equilibrium is expected to be corrected, at least partially in the next period. This equilibrium correction is modelled by the coefficient of the error correction term. Tables 5.5 reports these models for Norway. The estimated coefficient for the ECT: - 0.0749 (-3.4652) for Norway is both highly statistically significant and with the correct sign. This imply a high speed of adjustment to equilibrium. Approximately 7.5% of disequilibria from the previous month's shock reverts to the long-run equilibrium in the current month for Norway,

5.4 Long Run Model Under ARDL

Consequently, our long run equation under the linear ARDL is illustrated in equations 25 and 26 for Norway below. The corresponding long-run model for Norway is depicted by equations 26 below. For the details of the long-run Bound test results, please see tables 5.3

NORWAY:

$$lbrer_t = \underset{(3.2883)}{0.1598} - \underset{(-2.7924)}{0.0268} rird_t + \boldsymbol{\varepsilon}_t \text{ - - - - - - - - - - - - } (26)$$

5.5 Measuring Misalignments

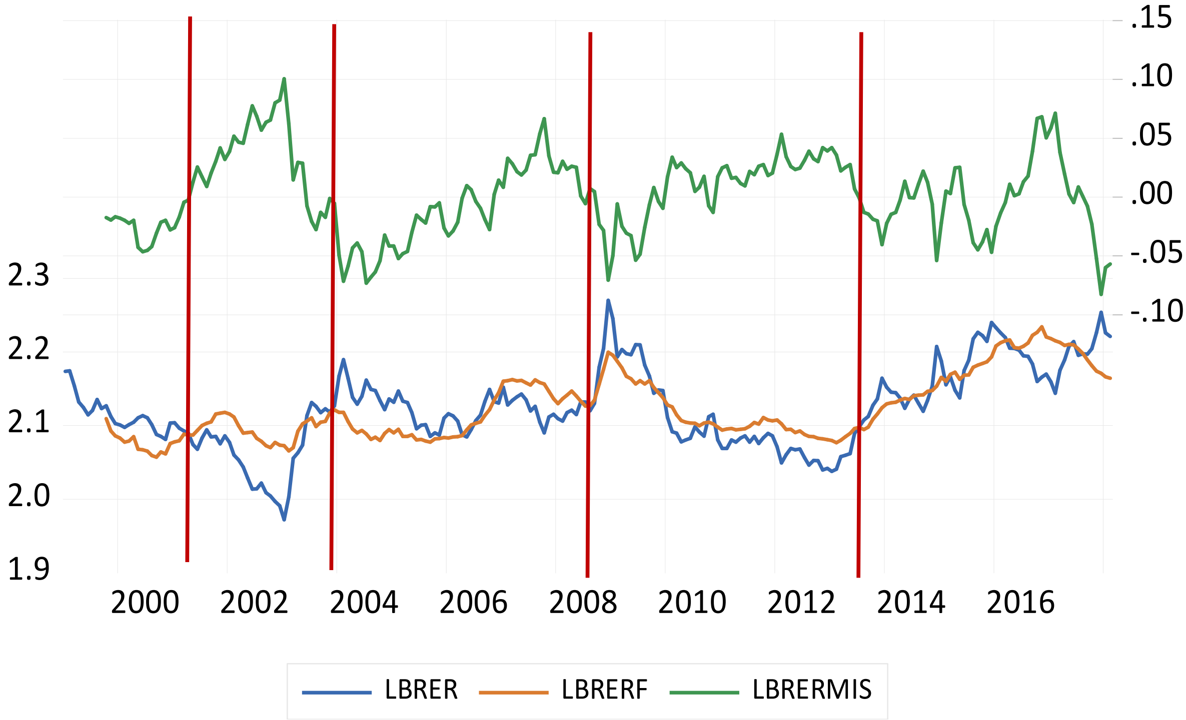


Fig 5.1: Norway - Forecast real exchange rate versus the actual values.

The Norway model is best explained by the Uncovered Interest Parity (UIP) theory of exchange rate. This states that the difference in interest rates between two countries will equal the relative change in currency foreign exchange rates over the same period. This theory is explained in section 2.1.4.

Figure 5.1 illustrate the deviation of actual exchange rate from the estimated values (LBRERF – LBRER) as modeled by equation 26 above. This deviations (misalignments) are observed to be stationary over our sample period, with observed five-year trend, pre and post the 2008/2009 financial crisis.

CHAPTER 6: CONCLUSION and POLICY RECOMMENDATIONS.

The main objective of this dissertation is to investigate the effects on the bilateral real exchange rates of Norwegian krone vis à-vis the Euro and the Colombian Peso exchange rates vis a-vis the USD, of behavioral economic factors: oil terms of trade, productivity differential, foreign reserves and the interest rate differential. Under the bounds testing procedure developed by Pesaran, Shin and Smith (2001), The model reveals a long-run relation equilibrating relationship between the real bilateral exchange rates of the Krone and the Peso and the behavioral variables. The study finds that the direction and magnitude of the effect of the oil terms of trade, the productivity differential and the interest rate differential follow the expected a priori for Norway. It is safe to conclude that foreign reserves have no statistically significant effect on the long-run behavior of the bilateral real Krone-Euro exchange rate.

In the case of Colombia, it was found that the real interest rate differential has no statistically significant consequence for the long run equilibrium of the bilateral exchange rate between the Colombian Peso and the USD, using the ten-year government bond rate. This could be a consequence of the high and volatile inflation rate, as well as overall higher riskiness for a developing country like Colombia. Clearly, focusing on a more precise, and easily tracked measure of terms of trade, namely a commodity terms of trade, can help explain real exchange movements for some commodity exporting countries. This should help policymakers and monetary authorities in these countries. While data available is a constraint, more studies like should be conducted as data becomes available. Also, other econometric methods may be applied to confirm these findings here. This is a rich field for future research.

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