Long Term Neutral Real Interest Rate for Honduras

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Abstract

The purpose of this document is to present a first estimate of the Neutral or Natural Real Interest Rate (NRIR) for Honduras, which is defined as the unobservable interest rate consistent with the potential Gross Domestic Product (GDP) of an economy and with an unemployment rate that does not accelerate inflation (NAIRU); therefore serves as a reference for the analysis of the monetary policy stance of central banks. For its measurement, quarterly information is used for the 2005-2016 period, using several methodologies that although they differ in their approach, they do not present much variation in their results. On the other hand, because there is not a consensus on which is the most appropriate technique, the methodologies used for the estimations for Honduras are selected on the basis of the available information for the country. Therefore, the reults are obtained using: the average of the ex ante real interest rate for a long period in which inflation behaved relatively stable; the Hodrick-Prescott (HP) filter to extract the trend of the real interest rate; and the Baxter and King filter (BK) to extract the cyclical element from a series. In addition, an estimate is obtained from the uncovered interest rate parity condition and from a semi-structural model using the Kalman filter adapted to the conditions of the Honduran economy. The estimates obtained from these different techniques reveal an average for the period analyzed for the Neutral Interest Rate in current values between 6.69% to 8.08% and in real values from 0.77% to 2.16%; similarly, it is found that in recent years the interest rate has shown a gradual decrease associated in part to a lower Monetary Policy Rate (MPR), combined with low levels of inflation and relatively stable economic growth.

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1. INTRODUCTION

The NRIR is a term widely discussed within the context of central banks, mainly because it is consistent with a level of potential output and a stable inflation rate; according to Wicksell (1898) in the economy there is an interest rate that is neutral to prices, that is to say, one that does not tend to decrease or increase the level of prices and that serves to identify if the monetary policy stance is contractionary, when the real interest rate is above the neutral rate or if it is expansionary, when it is below, thus influencing the decision making of the monetary authority.

The estimation of this variable is not so simple, because it is not observable, varies over time, and is related to the long-term evolution and real characteristics of the economy; however, there are different ways to approach it, either through the behavior of certain financial variables or using semi-structural models that describe the evolution of the economy and estimate the equilibrium interest rate.

In this document, we estimate the neutral rate for Honduras, using quarterly information for the period 2005Q2-2016Q4 and implementing five different methodologies. The first one considers the analysis of the trend of the ex ante real interest rate registered during a period of relative inflation stability; two different univariate analysis, one consisting of extracting the trend of the series from the real interest rate through the HP filter and the other using the BK filter to extract the cyclical element from the series in which seasonal components (short term) and the trend component (long term) are eliminated. The remaining methods are based on multivariate analysis, one is under the condition of uncovered interest rate parity for a small economy which is open to international trade and the other is a semi-structural model proposed by Laubach and Williams (2001) for the United States of America (USA) adapted to the Honduran economy (method in which the algorithm of the Kalman filter is used, under a stage of state space used for approximations of non-observable variables).

The research is structured as follows: Section 2 reviews the literature and empirical evidence under different approaches; Section 3 shows the methodologies used in the estimation; Section 4 analyzes the results obtained and their comparison between methodologies;

finally, sections 5, 6 and 7 present the conclusions, appendices, and bibliography, in this order.

2. REVIEW OF LITERATURE AND EMPIRICAL EVIDENCE

2.1 Review of Literature

According to the literature available, the NRIR is known under different concepts, such as the neutral real interest rate, natural interest rate, or the equilibrium real interest rate; the name has also been differentiated according to the time periods or horizons, either short or long term. However, the notion of the natural rate goes back to the late nineteenth century, when Knut Wicksell argued that the observed interest rate did not necessarily balance supply and demand in the market, since it was normal to see increases and decreases in the level of prices when there are differences between the observed interest rate and what would be a neutral interest rate that stabilizes the market. Wicksell (1898) commented that the NRIR was by definition, that which did not cause pressures of movement neither upwards nor downwards in prices.

On the other hand, Archibald and Hunter (2001) stated that the long-term equilibrium real interest rate is the most stable, with which the economy and markets are balanced. Because it is often difficult to capture a state of equilibrium, the neutral rate is the proxy that guides the goods, money, and labor markets, and that is consistent with production, inflation and potential output[1].

Under the context of neo-Keynesian general equilibrium models, the natural rate is the level of real interest rate that would prevail in equilibrium under the absence of nominal rigidities (Galí, 2002). This is equivalent to saying that the NRIR is the appropriate interest rate to maintain the level of aggregate demand on par with the potential product, once the transitory effects of the economy cease (Blinder, 1999). The New Keynesians associate it with the steady state or long-term interest rate.

Laubach and Williams (2003) found for the USA an explicit relationship between the NRIR and the trend growth rate of the potential

1 Laubach and Williams (2003), Garnier and Wilhelmsen (2005).

output. All this after estimating several equations such as the IS and Phillips curve, among others, by means of the maximum likelihood method using the Kalman filter, concluding in the end that the natural rate varies with time.

In an attempt to answer the question of how the central bank should conduct monetary policy in practice, given the objective of achieving low and stable inflation rates and reaching full employment, Orphanides and Williams (2002) estimated the NRIR specifying that this it is compatible with the natural rate of unemployment and with low and stable inflation. Likewise, they conclude that the natural rate varies with time, since it is likely to be influenced by variables such as fiscal policy and household preferences.

Finally, Brzoza-Brzezinay and Kotlowski (2012), affirm that the estimates of the NRIR, given its applicability to a monetary policy regime under inflation targeting, have contributed to achieving price stability.

2.2 Empirical Evidence

There are several methods for estimating the neutral interest rate, whose results differ among them, given certain limitations depending on the amount of information required, which are applicable according to the economic conditions of each country. However, despite this, they help estimate this indicator, which is a relevant tool for conducting and making monetary policy decisions.

One of the most important researchs available for the NRIR is carried out by Laubach and Williams (2001 and 2003) for the USA, using a Kalman filter to jointly determine the neutral real interest rate, the potential output, and the growth trend; emphasizing that the variations in the growth trend are a determining factor in the movements of the rate. In addition, they demonstrated that the variations of the neutral real interest rate have important implications in the design and implementation of monetary policy, since the adjustments in this rate are crucial for the fulfillment of the stabilization goals in both the short and the long term.

Fuentes & Gredig (2007) rely on several methods to obtain the neutral interest rate for Chile, the first through the economic theory implicit in the prices of financial assets and through statistical models using macroeconomic data; followed by a semi-structural model with unobservable components through the Kalman filter algorithm, allowing the latter to simultaneously estimate the natural real interest rate and the output gap.

On the other hand, González, Ocampo, Pérez, and Rodríguez (2013) use different methodologies to estimate the NRIR for Colombia, two of which are based on statistical filters and the third is the estimation of a semi-structural model for a small and open economy. Neiss and Nelson (2001) examine the properties of the neutral real interest rate using a dynamic stochastic general equilibrium (DSGE) model. Cartaya, Fleitas, and Vivas (2007) measure this indicator for the Venezuelan economy, based on the marginal productivity of capital and in another case taking into account the gap and the potential growth of the non-oil product; it is demonstrated that under both approaches the neutral real interest rate shows very little variability during the estimation period, in comparison with the observed values.

Similarly, Giammarioli, and Valla (2003) made estimates for the Euro Zone with a model that contains historical series of the short-term interest rate. These authors argue that the NRIR in the area has gradually decreased since the mid-1990s, from around 4.0% to approximately 3.0% in 2000.

As a final point, Table 1 shows the different methodologies and results obtained by several countries when calculating the NRIR.

Table 1

ESTIMATION OF THE NEUTRAL REAL INTEREST RATE (NRIR) BY COUNTRY

Author	*Country*	*Methodology*	*Period*	*Result*
Brzoza & Brzezina (2004)	Poland	• Structural VAR • Kalman Filter	2003	4.0%
Basdevant, et al. (2004)	New Zealand	• Performance Curve • Kalman Filter	2004	3.3%-4.3%
Calderón y Gallego (2002)	Chile	• Uncovered interest rate parity • Indicators of Financial Markets • Marginal Productivity of Capital. • Kalman Filter	2002	4.8%
Dacass (2011)	Jamaica	• Extracting the Trend with the Hodrick Prescott Filter • Kalman Filter	1990-2011	5.0%-10.0%
Fuentes y Gredig (2008)	Chile	• Kalman Filter	2008	2.8%
González, et al (2013)	Colombia	• Extracting the Trend with the Hodrick Prescott Filter • Kalman Filter	1994-2011	2.0%-5.0%
Giammarioli & Valla (2003)	Euro zone	• General Equilibrium Model	2000	3.0%
Humala & Rodríguez (2009)	Perú	• Kalman Filter	2008	8.0%
Hernández & Amador (2008)	México	• Extracting the Trend with the Hodrick Prescott Filter • Kalman Filter	1997-2008	2.8%-3.7%

Author	*Country*	*Methodology*	*Period*	*Result*
Laubach & Williams (2003)	United States of America	• Kalman Filter	2002	1.5%-3.0%
Magud y Tsounta (2012)	Latin America	• Uncovered interest rate parity • Kalman Filter • Extracting the Trend with the Hodrick Prescott Filter	2000-2012	2.0%-5.1%
Muñoz & Tenorio (2007)	Costa Rica	• Average level of the Ex Ante Real Interest Rate in a Period of Stable Inflation. • Uncovered interest rate parity • Kalman Filter • Effective Real Interest Rates. • Extraction of the Trend with the Hodrick Prescott Filter	2006	3.3%
Paredes Evelio, Santana Lisette, Sanchez Armando, Torres Francisco (2013)	Dominican Republic	• Taylor Rule by CVAR. • Uncovered interest rate parity • Kalman Filter • Marginal Capital Productivity • Monetary Policy Rule (Taylor Rule).	2013	3.5%-5.5%

Source: own elaboration based on each document made by the authors.

3.ESTIMATIONS METHODOLOGIES

According to the empirical evidence, the methods widely used to obtain an unobservable variable such as the NRIR are the HP and Kalman filters, since they have the advantage of detecting structural changes or large shocks that may occur in the economy; however, there is no consensus on which of the different methods available is the most appropriate and therefore analysis are carried out with several approaches in order to have a better estimate.

As a result of the above, in order to obtain the NRIR of Honduras, the following methodologies are used:

- Average of the ex ante real interest rate for periods of stable inflation.
- Extraction of the trend through the HP filter.
- Baxter and King bandpass filter.
- Uncovered interest rate parity.
- Semi-structural model using the Kalman filter.

3.1 Average of the ex ante real interest rate for periods of stable inflation

When considering the NRIR as an unobservable variable, Laubach and Williams (LW) (2001) argue that, as a first approximation, it can be obtained from the average of the ex ante real interest rate (RIR), which is calculated as the difference between the monetary policy interest rate and inflation expectations, for a period where inflation is relatively stable. However, this approach has its weaknesses, such as the values used for inflation expectations and that it does not consider the variability of the RIR observed over time; but, even so, it is used to establish comparisons with the results found with other methodologies.

3.2 Extraction of the trend through the HP filter

Under this approach, Hodrick and Prescott propose the separation of a time series in its trend component (using this as a proxy of the natural-level of the series) and cyclical component, carefully selecting the basic lambda smoothing parameter to obtain favorable results. Like the previous method, it provides good estimates in periods of stable inflation and output growth; nevertheless, it does not provide a good estimation when inflation is more volatile since it tends to underestimate the neutral rate for periods when inflation increases and overestimate it when inflation decreases.

3.3 Baxter and King bandpass filter

This method extracts the components of a series, whose frequency is within a certain time range, into very slow or low frequency movements (trend), medium components (cycle), and high frequency components (seasonal). Baxter and King (1999) argue that the perfect filter is one that remains unchanged during a certain time interval, in which the density at all other frequencies is almost zero. This allows us to identify a route that the filter considers appropriate and to see if the estimated variable, in this case the NRIR, is near or far from the values expected by the filter.

3.4 Uncovered interest rate parity

In a small and open economy, the long-term equilibrium interest rate should not move away from the international interest rate, according to Calderón and Gallego (2002), since free goods trade would promote equal capital returns between nations and in the same way with the international interest rate. In this sense, we have:

$$NRIR = r^* + E(e) + \rho$$

Being (r^*) the external real interest rate, $E(e)$ the expectations of real depreciation and (ρ) the country risk premium. The equation described above is understood as the rate at which investors are indifferent between maintaining their financial assets in their country or abroad. Something very important is that the parity of real interest rates adjusted to country risk establishes relations - both short and long term - between the national real interest rate and the international real interest rate.

3.5 Semi-structural model from the Kalman filter

A multivariate method of maximum likelihood proposed by LW (2001), composed of six equations, four of them responsible for estimating unobservable variables such as NRIR and Potential GDP, in a state-space form that combines maximum likelihood techniques. The foundation of this model is to find the equilibrium between aggregate supply (Phillips curve) and demand (IS curve), from where an implicit NRIR can be obtained, measured from the GDP, inflation, and interest rates gaps.

Due to the characteristics of the Honduran economy, some modifications were made to the original model proposed by the mentioned authors (Appendix I), according to the relevant variables that affect the monetary policy of the country, this being stated as follows:

1 $$y_t = a_1(y_{t-1} - y^p_{t-1}) + a_2(r_{t-2} - r^p_{t-2}) + \varepsilon_{1t}$$

2 $$\pi_t = a_1\pi_{t-2} + a_2(y_{t-1} - y^p_{t-q}) + a_3(rer_{t-1} - rer^p_{t-1}) + \varepsilon_{2t}$$

3 $$r^n_t = c * g_t + z_t$$

4 $$z_t = \delta z_{t-1} + \varepsilon_{3t}$$

5 $$y^p_t = y^p_{t-1} + g_{t-1} + \varepsilon_{4t}$$

6 $$g_t = g_{t-1} + \varepsilon_{5t}$$

Equation (1) shows a reduced IS curve in the form of aggregate demand, comprised by: the output gap, the difference between real Gross Domestic Product (GDP) $\left(y_t\right)$ and Potential GDP $\left(y_t\right)$ the differential of the ex ante real interest rate[2] $\left(r_t\right)$ and the natural interest rate[3] $\left(r_t^p\right)$ finally, the lags[4] that are incorporated into the variables and the error term that must be uncorrelated, reflect the short-term dynamics and the transitory disturbances that the economy may present.

On the other hand, equation (2) refers to the Phillips Curve, which is a proxy of the aggregate supply, which models the dynamics of inflation, incorporating: the inflation with two lags; the output gap, which is the difference between real GDP $\left(y_t\right)$ and Potential GDP $\left(y_t^p\right)$ and the real exchange rate (RER) gap, observed RER $\left(rer_t\right)$ minus potential RER $\left(rer_t^p\right)$ The first two equations are usually called signal, since they describe the behavior of the economy over time by means of observable variables.

Equation (3) describes the neutral real interest rate, by adding the trend growth rate of the economy $\left(g_t\right)$ and random elements $\left(z_t\right)$ such as intertemporal consumption preferences, financial innovations, variations in public spending, which are obtained from the estimation of equation (4). Finally, equations (5) and (6) correspond to the potential GDP and its trend growth rate, which evolve over time following a random process with a residual term of zero mean and constant variance. It is worth mentioning that these last four identities are called transition equations, since they generate optimal estimators at each moment in time based on the last information available (and updating each time when new information is incorporated, making them ideal for obtaining parameters that change over time.

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2 Being the differential between the Monetary Policy Rate (MPR) and inflation expectations.

3 Like the potential real exchange rate, these were obtained by applying the HP filter to the ex ante real interest rate and the effective real exchange rate, with a first estimate as a requirement for this equation.

4 The number of lags guarantees the elimination of the problem of autocorrelation and they are chosen according to the significance of the lag that precedes it (calibration of the model), that is, if the first is not significant at 5% or 10%, we continue with the following.

4. RESULTS OBTAINED AND COMPARATIVE ANALYSIS

4.1 Data

The study is developed with quarterly variables using data from June 2005 to December 2016, the series used include real GDP (adjusted seasonally and in logarithm form), the year-on-year growth rate of the Consumer Price Index (CPI), the ex ante real interest rate, the real exchange rate, the US real interest rate, inflation expectations[5], the expected depreciation of the exchange rate[6] and a country risk premium[7]; the information is obtained from the Central Bank of Honduras (CBH) and the Federal Reserve of the United States (FED). Similarly, each variable was subjected to the unit root[8] test to identify the stationarity of the series', since without evaluating these results, the coefficients estimated can be spurious if the series are related to each other.

It is worth noting that the MPR was used for the estimations, since it is used by the CBH as an operational and signaling variable to regulate the levels of liquidity within the economy, and there are studies that refer to the use of lending and deposit interest rates when there is no a relevant monetary policy rate, since countries often use other financial instruments according to their economic policy. The Figure 1 shows the behavior of interest rates for Honduras. Similarly, Figure 2 shows the trajectory of the MPR and the ex ante RIR, the latter being widely used in the following calculations.

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[5] See Appendix II, comparasion of the observed inflation vs. inflation expectations.

[6] Includes the first backward lag of the exchange rate (t-1) multiplied by the weighted sum of the depreciation expectation and the first forward lag of the exchange rate (t + 1).

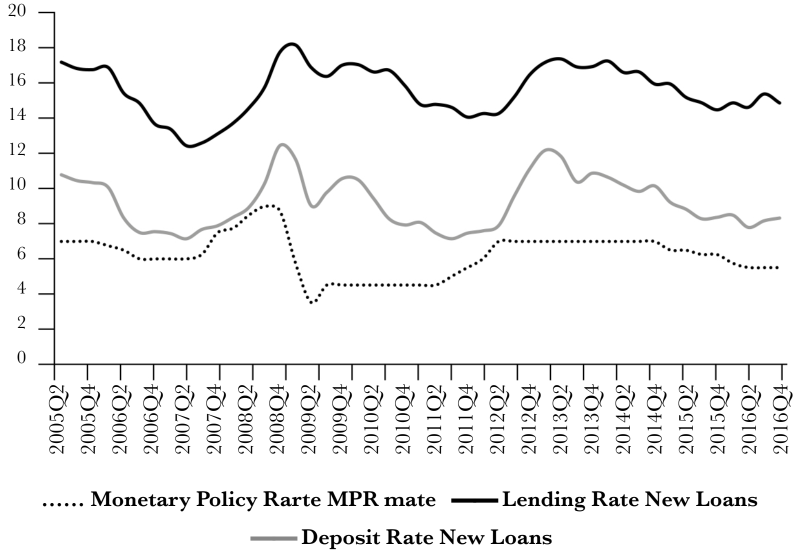
[7] Difference between the Monetary Policy Rate and the Interest Rate of the US Federal Reserve (FED), main commercial partner.

[8] Dickey and Fuller (1981) and Phillips and Perron (1986) unit root tests, in order to identify the degree of integration of the variables, if they are I (0) (stationary, there is no unit root); I (1) (non-stationary, there is a unit root) Appendix III.

Figure 1

MONETARY POLICY RATE, LENDIND AND DEPOSIT RATES ON NEW LOANS PERIOD 2005Q2-2016Q4

Percentage

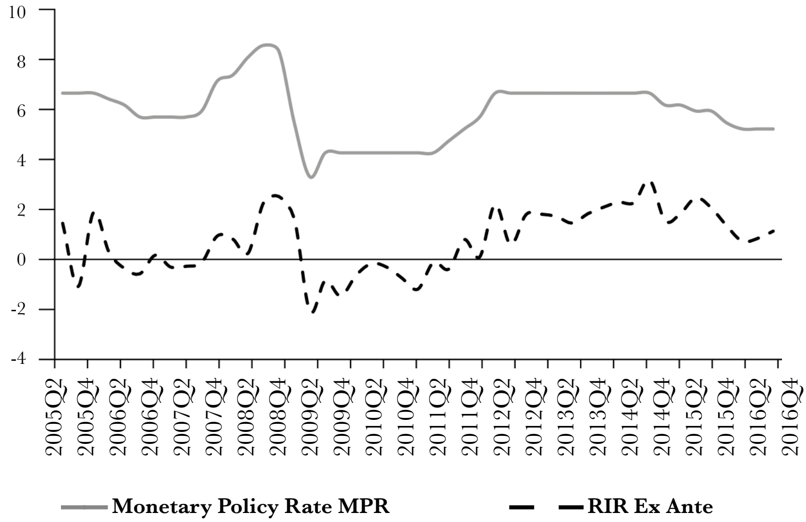


Source: own elaboration.

Figure 2

MONETARY POLICY RATE (MPR) AND EX ANTE REAL INTEREST RATE PERIOD 2005Q2-2016Q4

Percentage

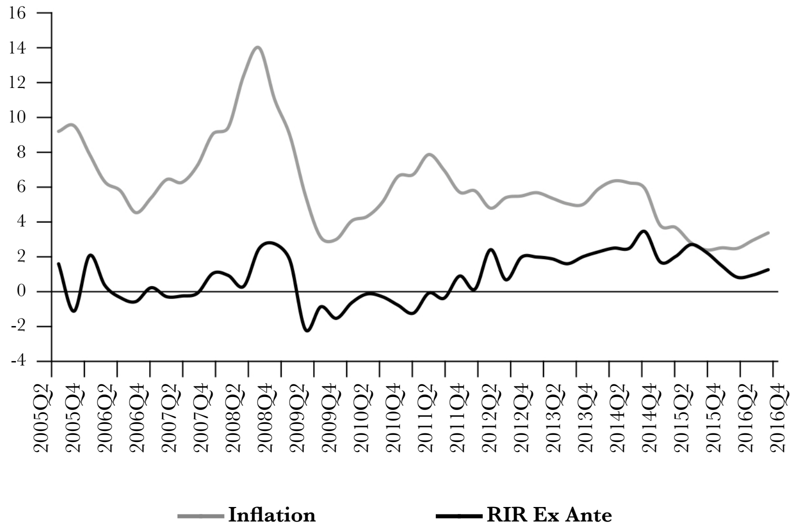


Source: own elaboration.

Figure 3

INFLATION AND REAL EX ANTE INTEREST RATE, NEUTRAL REAL INTEREST RATE AS AN AVERAGE OF THE REAL EX ANTE INTEREST RATE PERIOD 2005Q2-2016Q4

Yearly Relative Variation and Percentage

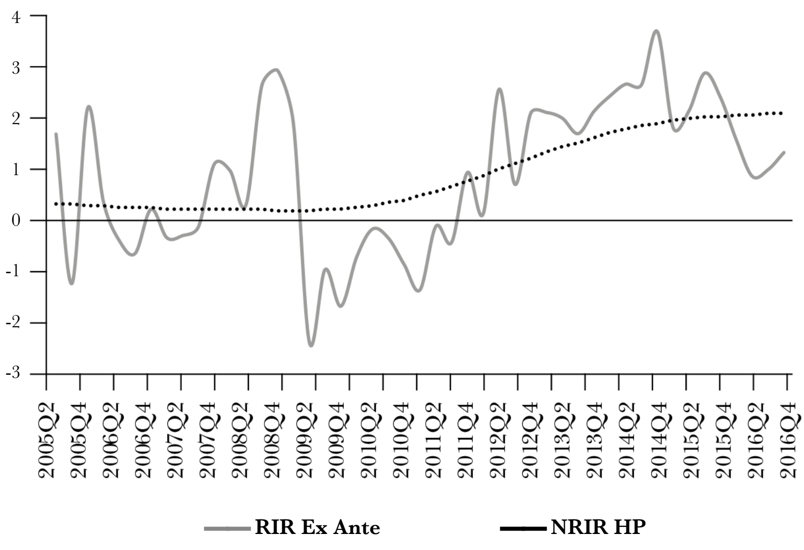


Source: own elaboration.

Figure 4

REAL EX ANTE INTEREST RATE AND NEUTRAL REAL INTEREST RATE HP PERIOD 2005Q2-2016Q4

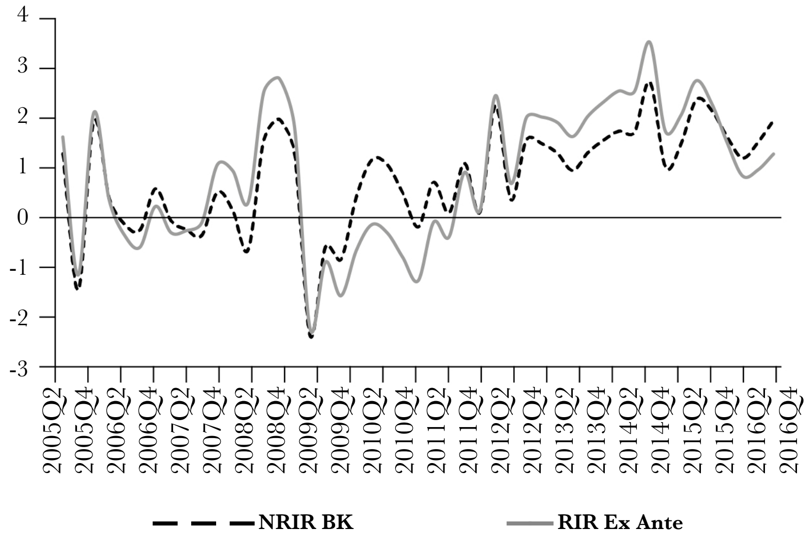
Percentages



Source: own elaboration.

Figure 5

REAL EX ANTE INTEREST RATE AND NEUTRAL REAL INTEREST RATE BK PERIOD 2005Q2-2016Q4
Percentages



Source: own elaboration.

4.2 Results and Comparative Analysis

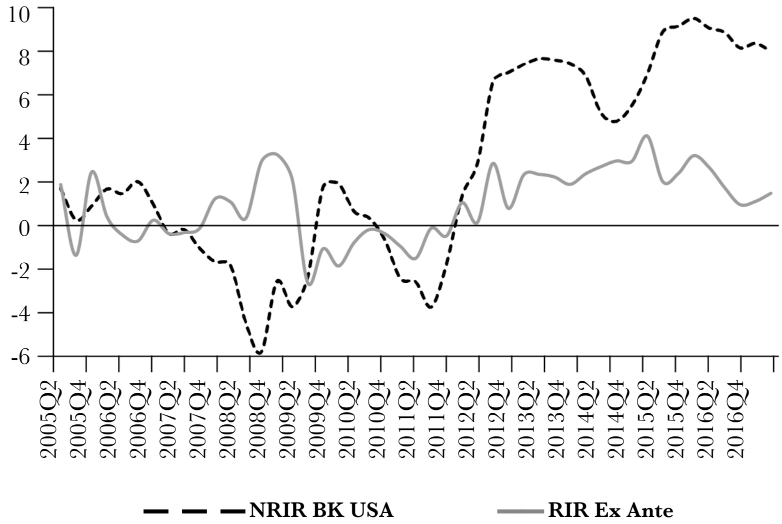
According to LW (2001), a first approach to obtain the NRIR is through the average of the ex ante real interest rate registered during long periods of stable inflation. In the case of Honduras, the period from 2009Q1-2016Q4 was used, where inflation did not show significant upward or downward behavior, exhibiting some stability (Figure 3). This is the starting point to obtain the first approximation of the neutral rate, which results in an average of 0.92% with an average inflation for the period of 4.88%.

Secondly, the calculation of the NRIR for the period 2005Q2 - 2016Q4 was performed using the HP filter method; incorporating different values of lambda in accordance to those applied in different studies, such as that of Segura and Vásquez (2011), in addition to using the standard value of 1600 used by many countries for quarterly data. The results among all the smoothing methods of the series

Figure 6

REAL EX ANTE INTEREST RATE AND NEUTRAL REAL INTEREST RATE UNCOVERED INTEREST RATES PARITY PERIOD 2005Q2-2016Q4

Percentages



Source: own elaboration.

were very similar, projecting an average value of the natural rate of 0.81% (Figure 4).

Another method used was Baxter and King's filter (1999), which extracts the cyclical element from a series, so that the result is a filtered series that eliminates seasonal (short-term) components and the trend (long-term) component with a duration according to the years imposed on the economy to be analyzed. This period usually comprises between 3 and 8 years, which is the average amount of time that economic cycles usually last. This technique differs from the HP filter whose objective is to extract the trend. The result obtained with this approach was an average NRIR of 0.77% (Figure 5).

In the following approach, based on the uncovered interest rate parity, using variables such as: the US interest rate, Honduras main trading partner; a country risk premium proxy and expectations of depreciation of the nominal exchange rate; as these variables are available in nominal terms, they were subsequently transformed to real values using the inflation for the analyzed period. This method resulted in an average NRIR value of 2.16% (Figure 6).

Finally, a semi-structural model was applied using the Kalman filter, which has some advantage over the methodologies previously shown, since it not only estimates a value for the neutral rate, it also generates a potential GDP growth rate, this being another unobservable variable of great utility for macroeconomic analysis. Based on a definition of the previously described model, this part of the results will briefly show the interaction of the variables, since economic theory tells us that the neutral rate is related to other variables that are measurable or observable, therefore economic relations are very important under this approach.

As a first step, the first two equations, the IS Curve and the Phillips Curve, are estimated by ordinary least squares (OLS), for each of them the errors of each regression are saved ε_{1t} and ε_{2t} Likewise, as the first estimate necessary for the Kalman filter, the potential GDP g, the neutral rate from the RIR, and the potential RER are obtained from the HP filter (long-term trend); then, a first estimate of z_t (equation 4) is elaborated, which starts from the first estimation of the NRIR; subsequently, a regression is made with the latter in terms of the growth of the potential GDP g, saving the errors from this regression, which are used to identify the autoregressive process z the errors are also saved to obtain ε_{3t} and the coefficient δ According to LW (2001), it may be the case that g and z are nonstationary, that is, they have unit roots; for this, the method proposed by Stock and Watson (1996) was used to prevent that the standard deviations of the errors ε_{4t} and ε_{5t} are skewed to zero, applying the following estimators if so:

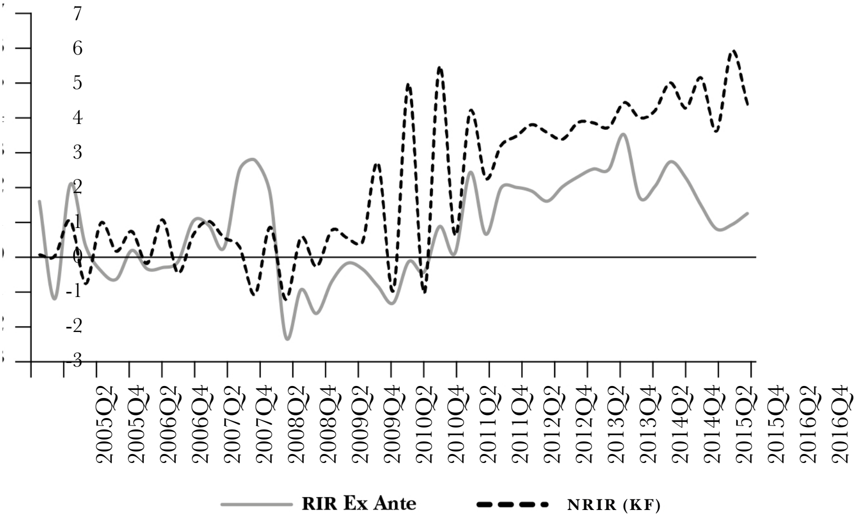
7 $$\lambda_g = \frac{\sigma_5}{\sigma_4}$$

8 $$\lambda_z = \frac{\sigma_2}{\sigma_1} \frac{a_r}{\sqrt{2}}$$

Figure 7

REAL EX ANTE RATE AND NEUTRAL REAL INTEREST RATE (KALMAN FILTER) PERIOD 2005Q2-2016Q4

Percentages

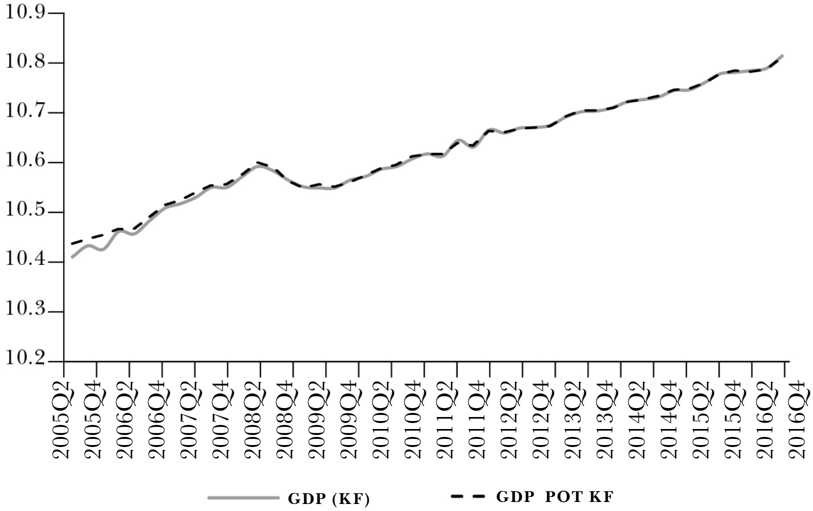


Source: own elaboration.

Figure 8

REAL GROSS DOMESTIC PRODUCT (OBSERVED) AND REAL GROSS DOMESTIC PRODUCT KALMAN FILTER PERIOD 2005Q2-2016Q4

Percentages



Source: own elaboration.

Of both variables, the one that turned out to be nonstationary is, to which the equation 8 is applied, rescuing the values of λ_z then, the restriction is included for the case of z_t in the complete model and the statistical method of Wald exponential is used, as recommended by Stock and Watson to finally proceed with the estimation of the Kalman filter. After analyzing the obtained regression, the variables turn out to be statistically significant, with non-zero errors for z_t and all other equations, which is consistent with the empirical evidence; once the Kalman filter is implemented (Appendix 4), the NRIR and Potential GDP are obtained as shown in Figures 7 and 8, the first showing an average value of 1.90%.

Table 2

STANDARD DEVIATIONS, AVERAGES AND GAP OF THE NEUTRAL REAL INTEREST RATE BY METHODOLOGY: 2005Q2-2016Q4

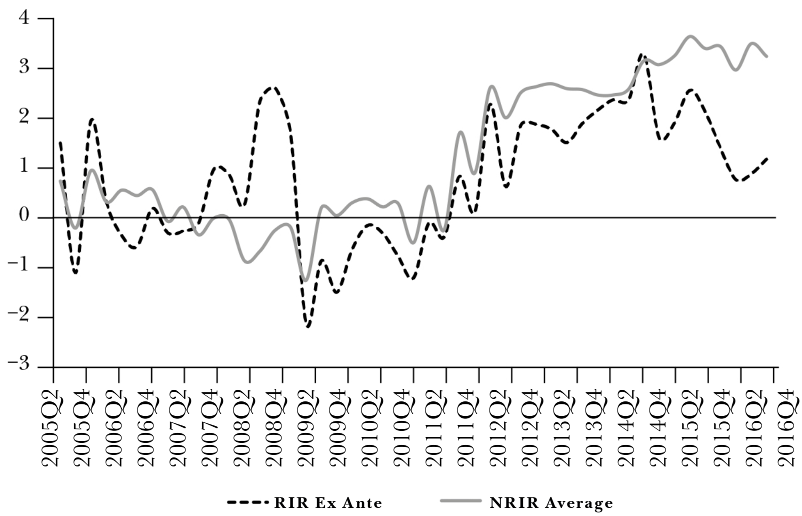
	Average 2005-2016	*NRIR_ Average Inflation**	*NRIR_ HP*	*NRIR_ BK*	*NRIR_ UIRP*	*NRIR_ FK*
Stand_Desv.	1.31	0.89	0.67	1.01	3.63	2.01
Neutral Current Interest Rate	6.73	5.80	6.73	6.69	8.08	7.82
Neutral Real Interest Rate	0.81	0.92	0.81	0.77	2.16	1.90
Average MPR	6.22	5.83	6.22	6.22	6.22	6.22
Interest Rate Gap Current Values	−0.51	0.03	−0.51	−0.47	−1.86	−1.60

Note:* period 2009Q1-2016Q4.
Source: own elaboration.

Figure 9

REAL EX ANTE INTEREST RATE AND AVERAGE NEUTRAL REAL INTEREST RATE PERIOD 2005Q2-2016Q4

Percentages



Source: own elaboration.

Finally, Table 2 and Figure 9 show the estimates obtained by each method, both for current and real values. The volatility of the uncovered interest rate parity (UIRP) approach with a standard deviation of 3.63% stands out, being this the highest of all the methods used. On the other hand, we can observe the gap of the policy interest rate with respect to the neutral interest rate for current values being -0.47% to -1.86%. When analyzing by method, we can see that the HP filter when considering only the trend of the series can lead to a bias in the projection by not considering the changes over time. The Baxter King filter has the advantage that it does not eliminate the irregular and seasonal components of the series that it studies.

However, the most complete approach is the Kalman algorithm, which is based on the relationship between economic variables in order to have a better projection of the NRIR, which shows a decrease in its values for the last quarters. Finally, with respect to the relationship between the ex ante real interest rate and the estimated average of the neutral rate from the five remaining methods, Figure 9 reveals to a certain extent what the country's monetary policy stance has been; that is, when the ex-ante RIR is located above the NRIR, monetary policy seems to have been contractionary during those periods, on the contrary, if it is below it has been expansionary.

5. CONCLUSIONS

- As a result of the estimates obtained from the different methods, it is possible to obtain an estimate of the Neutral Real Interest Rate for Honduras in current values ranging from 6.69% to 8.08% and from 0.77% to 2.16% in real values.
- The neutral rate is consistent with a GDP that converges to its potential level.
- Similarly, it is observed that the NRIR varies over time and that it currently has a downward trend.
- From the beginning of 2007 to the beginning of 2009, the ex ante RIR was above the natural rate, revealing a contractionary monetary policy during that period. On the other hand, during the period 2012-2016 it can be observed that the ex ante RIR was below the NRIR, showing an expansionary policy mainly for the years 2015-2016.
- Finally, considering that the present study is a first approximation of the neutral policy interest rate, there is still more to be done on the subject, since there are other advanced methods through the use of dynamic general equilibrium models, which would allow to strengthen more the results obtained.

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APPENDIX

I. Original model by Laubach and Williams:

1 IS Curve: $\tilde{y}_t = A_y(L)\tilde{y}_{t-1} + A_r(L)(r_{t-1} - r^*_{t-1}) + \varepsilon_{1t}$

2 Phillips Curve: $\pi_t = B_\pi(L)\pi_{t-1} + B_y(L)\tilde{y}_{t-1} + B_x(L)x_t + \varepsilon_{2t}$

3 GDP Gap: $\tilde{y}_t = y_t - y^*_t$

4 Potential GDP: $y^*_t = y^*_{(t-1)} + g_{(t-1)} + \varepsilon_{3t}$

5 Growth of Potential GDP: $g_t = g_{t-1} + \varepsilon_{4t}$

6 Real Interest Rate (equilibrium): $r^*_t = c * g_t + z_t$

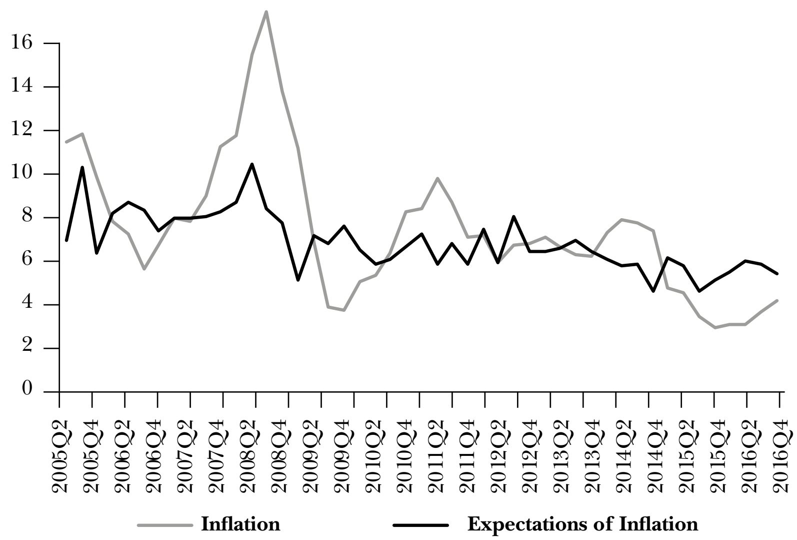
7 Demand Shock: $z_t = \delta z_{t-1} + \varepsilon_{5t}$

8 Real Interest Rate: $r_t = i_t + \pi_{t/AR(3)t}$

II. Comparative Inflation (Observed) vs. Expectations of Inflation:

Figure A.1

COMPARATIVE INFLATION (OBSERVED) VS. EXPECTATIONS OF INFLATION PERIOD 2005Q2-2016Q4
Yearly Relative Variation



Source: Central Bank of Honduras and own elaboration.

III. Unit Root Test of the Variables:

UNIT ROOT TEST

Variables	*Level*	*First Difference*
Real Gross Domestic Product (log)	−1.769	−9.427
Real Interest Rate	−3.419	−5.756
Real Exchange Rate	−4.838	−7.023
Inflation	−5.149	−7.553
Expected inflation	−7.289	−6.038
Waste Curved IS	−6.358	−7.986
Waste Curve Phillips	−8.077	−12.516
Waste Variable Z	−3.605	−4.990

Note: All the variables in first difference were I (0), that is stationary.

IV. Specification of the Model State Space (Eviews ®):

```
@MPRIOR VSINI
@VPRIOR COV_C
@SIGNAL PIB = SLY+C(1)*PIB-C(1)*SLY+C(2)*R-C(2)*SR1+[VAR=(C(3)^2)]
@SIGNAL INFLA = C(4)*INFLA-C(5)*SLY1+C(5)*PIB+C(6)*TCRBRE+[VAR=C(7)^2)]
@SIGNAL SLY = SLY(-1)+SG(-1)+[VAR=(C(8)^2)]
@STATE SLY1 = SLY(-1)
@STATE SLY2 = SLY1(-1)
@STATE = SG(-1)+[VAR=(C(9)^2)]
@STATE SG = SG(-1)+C(10)*(SG(-1))+SZ(-1)
@STATE SR1 =SR(-1)
@STATE SR2 = SR1(-1)
@STATE SZ = C(11)*SZ(-1)+[VAR=(C(12)^2)]
```