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Working Paper

Better Policymaking and Analysis with a New

Dynamic Behavioral Equilibrium Exchange Rate Model

for Small, Open Economies

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Abstract

Exchange rate modeling allows Central Banks to understand and forecast currency movements, which are an integral part of conducting effective monetary policy, managing inflation and ensuring financial stability. By analyzing factors like interest rate differentials, changes in price levels, trade balances, and global risk, regulators can assess the "fair value" or equilibrium exchange rate and identify potential misalignments. This understanding helps in determining whether to intervene in foreign exchange markets, adjust interest rates, or implement other measures to mitigate adverse effects of excessive currency volatility on economic growth, competitiveness, and price stability.

Exchange rates are notoriously difficult to model accurately as they are influenced by a vast array of constantly changing variables, including economic fundamentals like interest rates, inflation, trade balances, but also geopolitical events, market sentiment and speculation. The relative importance and interaction of these factors are not always consistent or easily quantifiable. Also, the efficiency of exchange markets allows them to incorporate information rapidly, such that future exchange rate movements are largely driven by unanticipated shocks, which are unpredictable by definition. Thus, empirical studies have shown that many complex models struggle to outperform a simple "random walk".

This paper proposes a Dynamic Behavioral Equilibrium Exchange Rate model that extends one of the most commonly used methods for studying medium- to long-term exchange rate dynamics. In this new approach, the BEER is dynamically estimated on rolling windows of different length to capture shorter-term effects. This allows for a more precise adaptation of the model to the analytical needs of the policymaker. With an additional regressor, the Remittances / GDP indicator, which is important for small, open economies, added to the traditional mix of fundamentals incorporated in BEER models, the newly proposed approach significantly outperforms existing models, scoring a higher R^2 metric.

The paper also introduces two additional performance indicators – the Dynamic Partial R^2 and the Relative Dynamic Partial R^2. The new measures quantify temporal dynamics of the explanatory power that each variable exerts in the model, allowing for identification of key drivers in the system and their evolving importance in time. The proposed innovations enable policy-makers to study transmission mechanisms in an economy, determine the main channels through which macroeconomic and financial variables influence the exchange rate, analyze turning points where tendencies and relationships between variables change and make policy-relevant observations about crisis events, captured by changing performance metric dynamics.

Keywords: exchange, rate, equilibrium, behavioral, dynamic, regression, model, policy, Central Bank

JEL Classification: C51; F24; F31; E58.

1. Introduction

Exchange rate determination remains a complex and persistently challenging area within international finance and macroeconomics, yet its accurate assessment is important for central banks and policymakers. The field of exchange rate modeling is split into two main approaches: long-term and short-term, each rooted in unique theoretical assumptions and empirical findings. While long term methods allow for a rich theoretical analysis, their short-term predictive powers have been called into question. Conversely, short-term models are designed specifically to capture current fluctuations, but fail to make a link with macroeconomic variables that financial policy makers track and aim to influence.

The equilibrium real exchange rate is a key indicator for ensuring macroeconomic stability and effectively conducting monetary policy. It enables central banks to analyze the exchange rate's impact on inflation, GDP growth, and the output gap, which contributes towards making optimal monetary policy decisions. Among the various equilibrium exchange rate concepts, the Behavioral Equilibrium Exchange Rate (BEER) model holds particular importance for central bank policy-making, being the most frequently used approach by institutions for estimating the real equilibrium exchange rate. According to a study performed by Komárek and Motl (2024) at the Czech National Bank (CNB), the BEER model is used in 14 of the 16 Central Banks participating in the survey that they conducted.

This paper aims to bridge the gap between the long-run and short-run modeling paradigms by proposing a Dynamic Behavioral Equilibrium Exchange Rate model. The BEER, in and of itself, is a method allowing for efficient medium-term analysis due to its adoption of a moving equilibrium target. To further refine the analysis and bring the model closer to the short-run dynamics that have proven to be relatively elusive to model, this paper shows that estimating the BEER dynamically, on rolling windows of different sizes, allows for a more precise investigation of the dynamics that interest the policy-maker – be they short-term movements or longer-run equilibrium. Furthermore, the method produces a better fit, capturing more of the variability in the data and significantly improving upon the R^2 metric, when compared with other papers estimating models of this class.

However, as noted in the literature, performance metrics for exchange rate models have been known to improperly capture the true contributions of equilibrium models, in particular. Because of this, two new performance measures are introduced in this paper - the Dynamic Partial R^2 and the Relative Dynamic Partial R^2. They allow for a better understanding of the contribution that each regressor has in explaining the variability in the data, and when placed in a dynamic context, enable for a temporal analysis of the key driving factors within the estimated behavioral model, and the shifts that occur during periods of financial or economic crisis. This enriches the analysis of shocks and contributes towards a better understanding of the transmission mechanisms and channels that effects pass through within the financial system and the wider economy, thereby allowing regulators to make better policy decisions.

Finally, another novelly of this paper resides in the introduction of an additional regressor to the traditional BEER model – the Remittance/GDP indicator. Indeed, remittances are shown to have both a significant long- and short-run effect within a small, open economy setting, where a large portion of the population works abroad.

2. A visual literature review

The literature on exchange rate modeling is broadly characterized by a fundamental dichotomy between long-term and short-term modeling approaches, each grounded in distinct theoretical assumptions and empirical observations. Long-term models, such as Purchasing Power Parity (PPP) and various equilibrium exchange rate frameworks, posit that currencies gravitate towards values consistent with underlying macroeconomic fundamentals and sustainable external balances. These approaches, while providing a theoretical anchor for long-run trends, often struggle to explain the high-frequency volatility observed in financial markets, leading to the well-documented "exchange rate disconnect puzzle."

Figure 1. Literature dedicated to studying short term and long-term exchange rate dynamics

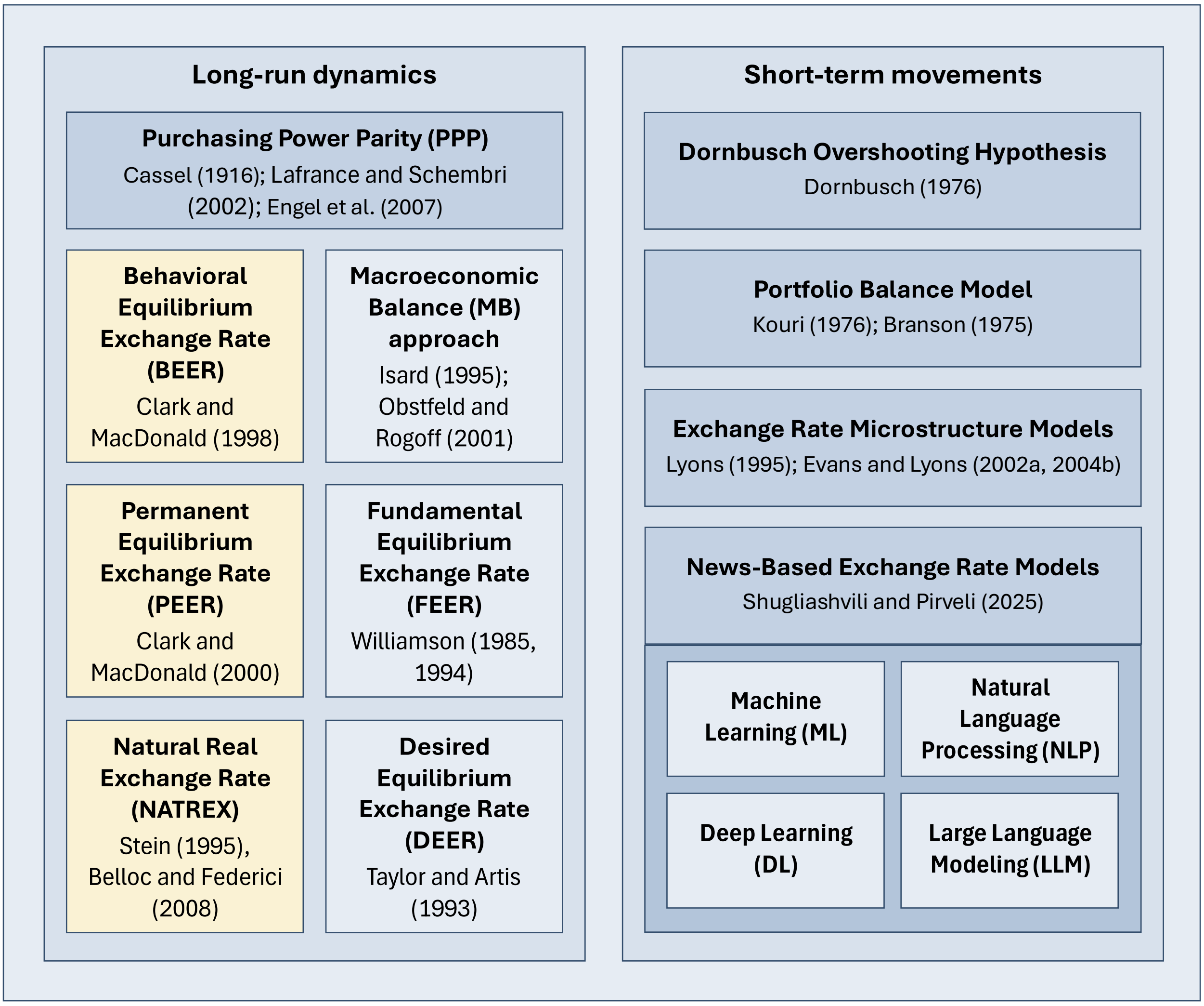


Figure 1 presents a visual review of the exchange rate modeling literature. Two strands of papers have emerged: one focusing on the long-term equilibrium and another on short-term fluctuations. The main modeling approaches alongside the authors of key contributions are listed for each of the two strands.

BEER models are flexible and well-suited for estimating equilibrium values in both the short and long term, providing direct measures of deviation from equilibrium. This allows policymakers to assess whether observed exchange rate deviations are strong and persistent departures from equilibrium levels, which can have substantial bearing on growth prospects, price dynamics or even financial stability.

Conversely, short-term exchange rate models typically emphasize the rapid adjustment of financial markets, the role of expectations, and the impact of information flows. Theories like the Dornbusch Overshooting Hypothesis and Portfolio Balance Models highlight how sticky goods prices and imperfect asset substitutability can lead to significant short-run deviations from long-run equilibrium.

More recent advancements, including Exchange Rate Microstructure Models and News-Based Exchange Rate Models, delve into the granular details of trading activity and the real-time processing of information, demonstrating considerable explanatory power for daily exchange rate movements. Finally, next-generation models are harnessing the power of Machine Learning and Deep Learning applied to Natural Language Processing to analyze large news and trends datasets in order to derive information about exchange rate movements.

For a detailed review of the exchange rate literature, its historical short-term – long-run dichotomy, as well as the performance metrics for some of the key models estimated across a broad range of methods, see Monahov (2025).

3. Methodology

3.1. The Behavioral Equilibrium Exchange Rate (BEER) Model

The Behavioral Equilibrium Exchange Rate (BEER) is an economic model used to determine the equilibrium level of a country's real effective exchange rate (REER). The "behavioral" aspect of the model refers to its focus on explaining the actual movements of the exchange rate over the medium to long term by identifying the economic fundamentals that systematically influence its behavior.

In essence, the BEER model posits that while exchange rates can be volatile in the short run due to temporary factors and market sentiment, they tend to revert to a path determined by a set of key macroeconomic variables. By estimating the relationship between the real exchange rate and these fundamental drivers, the model can calculate the equilibrium exchange rate at any given point in time.

Clark and MacDonald (1998) provide a detailed overview of the BEER and compare it with another commonly used methodology - the Fundamental Equilibrium Exchange Rate. The paper discusses how both techniques are used in modeling exchange rates based on economic fundamentals. Their analysis contributes to the ongoing debate on exchange rate misalignments and their implications for policy decisions.

Fidora et al. (2017) build upon a Behavioral Equilibrium Exchange Rate (BEER) model to assess real effective exchange rate misalignments across 57 countries since 1999. They discuss a broad set of regressors that can be used to estimate the equilibrium RER, touching upon factors such as the Balassa-Samuelson effect, net foreign assets, terms of trade, interest rate differentials and government expenditure.

Given the essential role that the Balassa-Samuelson effect plays in explaining real exchange rate movements based on productivity differentials within the BEER framework, and existing difficulties in obtaining productivity data for developing economies, research was done to construct various proxies which might capture this effect. Couharde et al. (2019) propose five measures of the Balassa-Samuelson effect: GDP per capita, labor productivity, consumer-price-to-producer-price ratio, three-sectors' value-added deflator and six-sectors' value-added deflator.

An advantage of the BEER is that it can be estimated as a one equation model, with a varying number of regressors, thereby facilitating the analysis and interpretation of results. In determining the optimal number of regressors to be used, Ca' Zorzi and Rubaszek (2023) investigate whether adding explanatory variables to a BEER model significantly improves its performance. They find that a well-specified three-variable parsimonious model cannot be outperformed by more complex variants.

3.2. Testing for stationarity

An assumption of BEER models is that the variables used to model the RER, such as fundamentals like the productivity level differential or terms of trade, should be stationary or trend-stationary. The ADF test helps determine whether these fundamental variables are stationary over time. Using non-stationary data in regression analysis can lead to spurious results, where significant relationships appear due to trends rather than a true underlying relationship. The results of the ADF test can confirm whether differencing or detrending is necessary to render the data stationary.

The results of ADF tests suggest that differencing is required for multiple explanatory variables. The results of the tests for the variable in levels are presented in Table 1 below.

Table 1. ADF test results

Variable	Dickey-Fuller	p-value
Real Exchange Rate	-4.0000	0.0117
Balassa-Samuelson Effect	-6.7892	0.0100
Remittances / GDP	-1.8255	0.6490
Terms-of-Trade	-1.7332	0.6874
Interest-differential	-4.1363	0.0100
Net Foreign Assets	-1.9097	0.6141

Table 1 presents the output of the ADF test for the variables included in the BEER model. The results suggest that the Remittances / GDP, Terms of Trade and Net Foreign Assets variables manifest non-stationarity and require differencing.

Given the results of the ADF test and after considering combinations of explanatory variables which do not require differencing expressed in levels or differenced, alongside the RER in level and differenced form, the performance of the model is maximized when differencing all variables except for the interest differential which does not require differencing by construction. As such, in what follows, all results will pertain to differenced variables, with the exception of the interest rate differential.

3.3. The dynamic regression model

Dynamic linear regression is an extension of traditional linear regression models, incorporating time-dependent structures and adjustments to better capture temporal dynamics in datasets. This methodology is particularly useful in areas where the data exhibits trends or cycles over time.

Traditional linear regression assumes that the relationship between the independent variables (predictors) and dependent variable (outcome) remains constant throughout the dataset. However, this assumption may not hold true for time series data, which often exhibit patterns such as cyclicality, seasonality, trends or autocorrelation. Dynamic linear regression addresses these issues by allowing model parameters to evolve over time. This flexibility can capture shifts in relationships due to external factors or inherent changes within the system being modeled.

A straightforward implementation of dynamic linear regression models involves estimation over a rolling or moving window of n quarters. This allows the model to adapt to changes within each specified time frame, capturing local dynamics more effectively. The approach is particularly useful in settings where relationships between variables can change over time, such as financial or foreign exchange markets.

The general form of the model considers a dynamic linear regression with one dependent variable y_t and multiple explanatory variables represented by the vector X_t. The model can be specified for each window of w quarters.

For each time period t, where $t = 1, 2, \dots, T - w + 1$:

$$y_{t+j} = X_{t+j}\beta^{(t)} + Z_{t+j}\gamma^{(t)} + \epsilon_{t+j} \tag{1}$$

Where:

$j = 0, 1, \dots, w - 1$ – Index within the window.

y_{t+j} – Dependent variable at time $t + j$.

X_{t+j} – Matrix of explanatory variables at time $t + j$.

Z_{t+j} – Matrix for dynamic components (e.g., lagged values) at time $t + j$.

$\beta^{(t)}, \gamma^{(t)}$ – Coefficient vectors specific to window starting at t.

$\epsilon_{t+j} \sim N(0, \sigma^2)$ – Error term assumed to be normally distributed with mean zero and variance σ^2.

Within each rolling window of size w, the parameters $\beta^{(t)}$ and $\gamma^{(t)}$ are estimated using least squares or other suitable estimation techniques:

$$\left(\widehat{\beta^{(t)}}, \widehat{\gamma^{(t)}}\right) = \arg\min_{\beta,\gamma} \sum_{j=0}^{w-1} \left(y_{t+j} - X_{t+j}\beta - Z_{t+j}\gamma\right)^2 \tag{2}$$

As the window moves forward by one quarter (or any other specified period), the model is re-estimated using the new data in the updated window, dropping the oldest observation.

The primary benefit of the method resides in its ability to capture shifts in relationships within each window period, providing more responsive modeling of data dynamics, thereby allowing researchers and practitioners to better understand and anticipate changes in relationships over time. Furthermore, it allows for increased flexibility in choosing an appropriate window size based on domain knowledge and specific research questions.

However, with the aforementioned benefits come a number of considerations, such as the choice of window size. Too small a window may lead to overfitting, while a window that is too large may miss local changes. It is also worthwhile noting that repeated estimation for overlapping windows can be computationally intensive, especially with large datasets.

3.4. Assessing predictors with the partial R^2

In the context of multiple regression analysis, it is important to understand the contribution of each predictor variable to the overall explanatory power of the model. This enables an enhanced identification of regressors that have a significant contribution towards determining the variance of the dependent variable, beyond what is explained by other predictors. One effective measure for this purpose is the partial R^2.

Multiple regression analysis involves modeling the relationship between one dependent variable and several independent predictors. The overall fit of such a model is traditionally assessed using the coefficient of determination, R^2, which quantifies the proportion of variance in the dependent variable that is explained by all included predictors collectively.

While R^2 provides a global measure of explanatory power, it does not offer insights into the unique contributions made by individual predictors. To address this limitation, partial R^2 serves to isolate and quantify the contribution of each predictor variable while controlling for the effects of others in the model.

To compute the partial R^2 for a specific predictor within a multiple regression framework, one typically follows a three-step approach.

Step 1. Initially, two regression models are constructed.

- A full model (FM) that includes all predictors.
- A reduced model (RM) that excludes the predictor of interest but retains all other variables.

Step 2. R^2 values are computed for both models.

R^2_{FM} – The R^2 value for the full model.

R^2_{RM} – The R^2 value of the reduced model.

Step 3. The partial R^2 is derived.

The partial R^2 for a specific predictor is calculated using the formula:

$$R_P^2 = \frac{R^2_{\mathrm{FM}} - R^2_{\mathrm{RM}}}{1 - R^2_{\mathrm{RM}}} \tag{3}$$

The calculation reflects the proportion of variance explained uniquely by the predictor, after accounting for other variables.

A larger partial R^2 indicates that a predictor has substantial explanatory power on its own. It signifies that removing the specific variable from the model would lead to a notable reduction in the overall R^2, highlighting its importance.

By evaluating partial R^2 values across predictors, it is possible to rank variables based on their unique contributions, facilitating more informed decisions during model selection and refinement. The partial R^2 complements other statistical tests, such as t-tests for individual coefficients, by providing a nuanced understanding of predictor importance from a variance-explanation perspective. As such, the indicator proves useful in both theoretical exploration and applied research scenarios where distinguishing between overlapping explanatory variables is important.

3.5. Introducing the dynamic partial R^2 and the relative dynamic partial R2

3.5.1. The dynamic partial R2

The dynamic partial R^2 applies the dynamic regression method to the partial R^2. It is consequently calculated on a linear model estimated using a rolling window approach.

This new approach to calculating the partial R^2 allows for the time-varying contributions of individual regressors towards explaining the variability of the model to be captured. Coupled with the time-varying estimation coefficients, this allows for a more complete analysis of the contribution of individual parameters to the model fit. The added dynamic component enables researchers to capture the complexities of cyclical dynamics and evolving trends which change the nature of the linear dependencies that exist within the model, as well as the explanatory power of the regressors.

The dynamic partial R^2 is calculated according to a set formulas specific to the dynamic regression.

$$dR_P^2 = \frac{dR_{\mathrm{FM}}^2 - dR_{\mathrm{RM}}^2}{1 - dR_{\mathrm{RM}}^2} \tag{4}$$

$$dR^2 = 1 - \frac{dSSR}{dSST} \tag{5}$$

$$dSSR = \sum \left(y_{t+j} - \hat{y}_{t+j}\right)^2 \tag{6}$$

$$dSST = \sum \left(y_{t+j} - \bar{y}\right)^2 \tag{7}$$

Where:

$t = 1, 2, \dots, T - w + 1$ – Time index.

$j = 0, 1, \dots, w - 1$ – Index within the window.

w – The window length.

y_{t+j} – Dependent variable at time $t + j$.

$\hat{y}_{t+j}$ – Estimated dependent variable at time $t + j$.

$\bar{y}$ – Sample average.

$dSSR$ – Dynamic Residual Sum of Squares over the regression window.

$dSST$ – Dynamic Total Sum of Squares over the regression window.

dR_{FM}^2 – the dynamic R^2 of the full model.

dR_{RM}^2 – the dynamic R^2 of the reduced model.

dR^2 – the dynamic R^2 of either the partial or the full model (both calculated using the same formula, only applied to a different set of regressors, as specified by the full or reduced model).

3.5.2. The relative dynamic partial R^2

The relative dynamic partial R^2 expresses the dynamic partial R^2 as a share of the total dynamic partial R^2 calculated for the ensemble of explanatory variables included in the model. This allows for a detailed and comprehensive analysis of the relative contribution power of each variable.

The dynamic partial R^2 takes the form of a ratio:

$$rdR_P^2 = \frac{dR_{P_i}^2}{\sum_{i=1}^{n} dR_{P_i}^2} \tag{8}$$

Where:

n – the number of regressors.

$dR_{P_i}^2$ – the dynamic partial R^2 of regressor i.

Higher values of the rdR_P^2 denote larger shares of the total explanatory power of the variables included in the model. The dynamic nature of the indicator makes it possible to track the evolution of the explanatory power in time. Furthermore, the construct enables sophisticated visualizations of the relative contributions to be produced.

Taken together, the dynamic regression coefficients and significance levels, the partial R^2, as well as the newly proposed dynamic partial R^2, alongside its sibling-indicator, the relative dynamic partial R^2 – enable policy-makers to position a country's macroeconomic variables within the economic and financial cycle, but also within the transmission mechanisms of shocks, by linking the current effects seen in the indicators with the theoretically-anticipated signs for the particular stage of the cycle or transmission channels being analyzed.

4. Data sources, choice of variables and the economic environment

The model is estimated for Moldova, a small, open economy with a large proportion of the population working abroad. Utilizing data from a small, open economy for exchange rate modeling offers distinct advantages. The inherent openness of the economy means the exchange rate is highly sensitive to external factors like international capital flows, global trade dynamics and foreign interest rate differentials. This heightened responsiveness provides a clearer signal of how these external forces directly translate into exchange rate movements, allowing for an isolation and analysis of specific transmission channels more effectively than in larger, more complex economies where domestic factors might obscure important relationships. Furthermore, the often-limited size of the domestic market and relative dependence on trade can simplify the identification of key drivers of exchange rate fluctuations, facilitating the construction and testing of parsimonious, yet robust exchange rate models. This allows for a deeper and more focused analysis of exchange rate dynamics, which can then offer valuable insights applicable, with appropriate adjustments, to other economies.

Furthermore, it is of particular interest to study the data of an economy with a large portion of the population working abroad. The significant remittances sent by the diaspora can act as a substantial and relatively stable inflow of foreign currency, directly impacting the supply and demand for the domestic currency and thus influencing the equilibrium exchange rate. Traditional models might understate this effect, making a behavioral approach essential in capturing its nuances. Also, a large working-age population abroad can alleviate domestic labor market pressures and affect consumption patterns, which in turn can influence the country's trade balance and capital flows – key determinants in a BEER framework. Understanding how these unique demographic and economic features interact through the construction of a BEER model enables a better estimation of the true underlying value of the currency in a distinct economic context.

As the BEER model requires certain measures to be calculated relative to a trading partner, Romania was chosen due to the large volume of trade that it has with Moldova. As such, any future references to the "foreign economy" or "trading partner" will refer to Romanian data, whose sources are outlined below and whose frequency and duration match the Moldovan data.

The macroeconomic data for this analysis was taken from the National Bureau of Statistics of Moldova (BNS) and the National Statistics Institute of Romania (INS), and for certain series where historical data was not readily available within the BNS database, IMF and World Bank (WB) statistics were used. Additionally financial data from the National Bank of Moldova (BNM) and National Bank of Romania (BNR) were used.

Table 2. Summary of the data

Data characteristic	**Value**
Frequency	Quarterly
Start date	1996Q1 (1997Q1 for specification in differences)
End date	2024Q4
Number of observations	116 (112 for specification in differences)
Number of variables	6
Seasonal adjustment	Performed where necessary

Table 2 presents a summary overview of key data characteristics, highlighting the quarterly frequency of the data and the duration of the series which spans the period 1996-2024.

In selecting the variables to be used within the model, consideration was given to the existing literature and an initial specification began with the variables adopted by Faruqee (1995), Lane and Milesi-Ferretti (2004) and, more recently, Ca' Zorzi et al. (2021) in an ECB analysis. Additionally, the interest rate differential between the domestic and foreign economy which has been used in equilibrium exchange rate modeling was also added to the specification. Finally, because Moldova is a small, open economy with a significant proportion of the working population working abroad, a remittance indicator is added to take into account the inflow of currency resulting from monetary transfers by migrant workers.

A detailed discussion of the variables selected for inclusion in the model is provided below and section 4 summarizes the expected impact of these variables on the target and presents the expected signs of the impact, as a function of the economic conjecture that is observed.

The Real Exchange Rate

The real exchange rate (RER) is an economic measure that adjusts the nominal exchange rate between two currencies to account for differences in price levels between the two countries. The real exchange rate indicates how the purchasing power of a given amount of domestic currency compares to its equivalent in a foreign market after conversion, showing how many times more (or fewer) goods and services it can purchase abroad than at home. It is expressed as:

$$RER = E * \frac{P^*}{P} \tag{9}$$

Where:

E – nominal exchange rate

P* – foreign price level

P – domestic price level

When the RER takes values that are higher than 1, domestic goods are relatively cheaper than foreign goods, making domestic products more competitive. Conversely, values of the RER below 1 mean that domestic goods are relatively more expensive than foreign goods, signifying that foreign products are more competitive.

By encompassing both exchange rate dynamics, as well as the price differential, the RER is a better measure of international competitiveness than the nominal exchange rate. Policymakers therefore prefer to use the RER when analyzing inflation, currency devaluation and competitiveness issues.

The Balassa-Samuelson Effect

Given the lack of productivity data, the Balassa-Samuelson effect (BSE) is proxied using the GDP per capita differential with respect to a key trading partner. This proves to be a practical approach for a developing economy, but has also been used in ECB research as an alternative to the traditional sectoral-based indicator.

The BSE is presented as the ratio of GDP per capita of the domestic economy divided by that of the foreign economy.

$$BSE = \frac{GDP}{Pop} \,/\, \frac{GDP^*}{Pop^*} \tag{10}$$

Where:

GDP – the seasonally adjusted GDP of the domestic economy

GDP* – the seasonally adjusted GDP of the foreign economy

Pop – the population of the domestic economy

Pop* – the population of the foreign economy.

GDP per capita aggregates economic output adjusted for population size, providing an average income indicator across the economy. In absence of other data, it is an approximation of the productivity of a country. By comparing the dynamics of GDP per capita across two different economies, one can infer potential shifts in productivity. As the gap between the two economies widens, so does the assumed productivity differential.

Recognizing that GDP per capita is a broad measure, it is unable to help us identify the sectoral provenance of productivity gains within the economy or other influencing factors like technological advancement. As such, it offers a macro-level view of economic performance trends, helping to identify broader productivity dynamics. In situations with limited data, GDP per capita differentials can highlight potential productivity shifts and guide further research or policy decisions based on a proxy indicator.

Remittances-to-GDP

Remittances, which are funds sent by migrants working abroad back to their home country, can significantly influence economic dynamics, particularly in small, open economies. Remittances contribute directly to a country's foreign exchange reserves as they are typically received in foreign currency. This influx strengthens the domestic currency, leading to an appreciation of the real exchange rate. A stronger currency makes imports cheaper and exports more expensive on the international market.

With increased income from remittances, households may boost their consumption levels, often increasing demand for imported goods. This leads to an increase in the demand for foreign currency and may also increase price levels abroad, if the foreign country's supply is limited.

On the other hand, if the inflow of remittances leads to higher domestic demand without an immediate increase in domestic supply capabilities, this can result in inflationary pressures. Inflation differentials between the home country and its trading partners influence the real exchange rate by altering relative price levels.

Finally, if remittances are used for productive investment, they can enhance the economy's long-term growth potential by boosting capital formation and productivity. This can mitigate some of the negative impacts on the trade balance associated with increased imports due to higher consumption. Over time, a more competitive export sector can counterbalance any short-term real exchange rate appreciation.

It is also worth considering that Central Banks may respond to remittance inflows and their effects on inflation and currency valuation. Tightening monetary policy in response to inflationary pressures could lead to higher real interest rates, attracting foreign capital inflows and further appreciating the real exchange rate.

For this analysis, remittances alone have insufficient explanatory power. Therefore, a better performing Remittance / GDP indicator is constructed whose significance level warrants inclusion in the model.

Net Foreign Assets

Net Foreign Assets (NFA) impact a country's Real Exchange Rate (RER) through a complex mechanism which can pass through several channels: income, wealth and consumption, but also portfolio balance and capital flows.

A country with positive NFA has external assets in excess of liabilities and is, therefore, a net lender to the rest of the world. This generates a stream of net income from abroad in the shape of interest and dividends. To utilize this income, the country needs to increase its domestic absorption (consumption and investment) relative to its production. This increased demand for domestic goods and services, including non-tradables, tends to appreciate the RER.

Looking from another perspective, an accumulation of NFA represents an increase in national wealth. This can lead to a "wealth effect" where households and the government feel richer and increase their consumption. If a significant portion of this increased consumption is directed towards non-tradable goods and services, it will drive up their prices relative to tradable goods, leading to an appreciation of the RER.

Finally, changes in NFA reflect capital flows. If a country is accumulating NFA, it implies net capital outflows – in other words, investing abroad. On the short term, this outflow can reduce the demand for domestic currency, potentially leading to a depreciation of the nominal exchange rate, which in turn can influence the RER. However, the long-run impact often revolves around the income flows and their effect on the RER.

Due to data availability constraints for the entire duration of the analysis period, a similar, but slightly broader measure - the Net International Investment Position (NIIP) is used as a proxy for NFA.

Terms of Trade

Improvement in a country's Terms of Trade (TOT) occurs when export prices rise relative to import prices, or import prices fall relative to export prices. This means a country can purchase more imports for a given quantity of exports. This is generally seen as beneficial as it implies an increase in national income and purchasing power.

The extent of impact on the real exchange rate depends on how changes in TOT are transmitted to domestic prices (price pass-through). If export revenues lead directly to higher domestic prices without an increase in money supply, this appreciates the real exchange rate. Conversely, if demand for foreign goods increases as a result of the extra income, import prices rise. Therefore, the increased income does not translate into domestic price increases and the impact on the real exchange rate might be muted.

Interest rate differential

The interest rate differential between the domestic and foreign economy plays an important role in influencing the Real Exchange Rate (RER). This relationship is primarily channeled through capital flows and expectations, though its precise manifestation can be more complex.

The core mechanism of the impact passes through the capital inflow channel. When a country offers higher interest rates compared to other countries, it becomes more attractive for foreign investors who seek higher returns on their savings and investments. To invest in domestic assets like bonds or bank deposits, foreign investors need to buy the domestic currency. This increased demand for the domestic currency in the foreign exchange market leads to an appreciation of the nominal exchange rate.

If domestic prices do not adjust immediately or fully, which is often the case in the short to medium term due to "sticky prices", the nominal appreciation will translate into a real appreciation of the domestic currency. This means domestic goods and services become relatively more expensive compared to foreign goods and services.

The theoretical backdrop of the impact of interest rates on the RER is given by a condition known as the Uncovered Interest Rate Parity (UIP). The UIP states that the expected return on domestic assets should equal the expected return on foreign assets, after accounting for the expected change in the nominal exchange rate.

$$1 + i = (1 + i^*) \times \frac{E_{t+1}^e}{E_t} \tag{11}$$

Where:

i – domestic nominal interest rate

i^* – foreign nominal interest rate

E_t – current nominal exchange rate (domestic currency per foreign currency)

E_{t+1}^e – expected future nominal exchange rate

Rearranging, we obtain:

$$i - i^* = \frac{E_{t+1}^e - E_t}{E_t} \tag{12}$$

This implies that if the domestic interest rate is higher than the foreign interest rate $(i > i^*)$, the domestic currency is expected to depreciate in the future to offset the higher interest rate payouts.

The direction of the relationship does not, however, hold for increases in the interest rate. In fact, an increase in the domestic interest rate produces the opposite effect of appreciating the national currency, due to the capital inflow mechanism described above.

As such, for this study, the interest rate differential was not adjusted, despite other variables having been differenced.

Furthermore, there are some important nuances to consider when analyzing the impact of the interest rate differential on the RER. Oftentimes the capital flow effect does not hold perfectly in reality due to the presence of a "risk premium." Investors consider not just interest rate differentials but also the perceived riskiness of investing in a particular country. Considered risks may include political instability, default risk or liquidity risk. Indeed, failure to offer an interest rate sufficient to compensate for higher perceived risk can limit or even reverse the expected capital inflow and currency appreciation.

Finally, the market's reaction to an interest rate differential can depend on whether it is perceived as temporary or permanent. A temporary increase would have a smaller, short-lived impact compared to a sustained differential.

Lagged Real Exchange Rate

In certain BEER models, the lagged value of the Real Exchange Rate (RER) is also included as an explanatory variable. There are several considerations that can serve to justify the inclusion of the lagged RER.

As economies often adjust to deviations from equilibrium gradually rather than instantaneously, including a lagged RER variable helps to capture the progressive adjustment process. Additionally, exchange rates tend to exhibit persistence over time due to factors like market inertia, expectations of future policies, and the slow adjustment of fundamental economic variables. A lagged RER accounts for this autoregressive tendency. Finally, the inclusion of a lagged term can capture the influence of past exchange rates on current expectations and sentiment among market participants, which can affect current exchange rate dynamics.

From a technical standpoint, including a lagged dependent variable also helps to mitigate endogeneity issues where explanatory variables are correlated with the error term due to omitted variable bias or measurement error.

5. Constructing the BEER model

5.1. Model specification

As is traditional for a BEER model, the specification takes the form of the RER explained by a number of variables that represent fundamentals driving exchange rate dynamics.

$$RER_t = \beta_0 + \beta_1 BSE_t + \beta_2 RER_{t-1} + \beta_3 \frac{Rem_t}{GDP_t} + \beta_4 TOT_t + \beta_5 (r_t - r_t^*) + \beta_6 NFA_t + \varepsilon_t \qquad (13)$$

Where:

RER – the real exchange rate

BSE – Balassa-Samuelson effect

$\frac{Rem}{GDP}$ – Remittance to Gross Domestic Product ratio

TOT – Terms-of-Trade

$r - r^*$ – the interest rate differential between the domestic and foreign economy

NFA – Net Foreign Assets proxy

t – the time period

The model is estimated on the entire sample, as well as dynamically on windows of 3 and 10 years of data to produce an overall effect, accompanied by transitory cycle-based effects.

5.2. Anticipated impact of fundamentals on the RER

Analyzing the expected signs of the coefficients before estimating a linear regression model provides insight into both the theoretical underpinnings and the empirical validity of the model. First, it helps in verifying whether the theoretical expectations align with the hypothesized relationships between variables. For example, according to economic theory, certain factors such as relative price levels, interest rates, and productivity differentials should, as a function of the economic mechanisms at play, have specific directional impacts on the real exchange rate. By establishing expected signs for these coefficients based on theoretical frameworks, such as purchasing power parity (PPP), uncovered interest rate parity (UIP), or Balassa-Samuelson effects one can set a benchmark against which to evaluate the empirical results.

Table 3. Expected coefficient signs

Indicator	Expected sign	Explanation
Balassa-Samuelson Effect	-	**Purchasing Power Parity effect** If domestic GDP per capita increases when compared to foreign GDP per capita, this may imply that domestic prices are rising, thereby leading to an appreciation of the RER.
	-	**Capital flow effect** Higher domestic GDP per capita may attract foreign investments due to better returns on capital. This leads to an appreciation of the real exchange rate as foreign currency inflows increase.

	-	**Wage effect** Increasing GDP pe capita may translate into higher wages. If the increased labor force remuneration is passed onto prices, this leads to an appreciation of the RER.
	+	**Trade balance passthrough effect** Increasing GDP per capita may signal a transition from less competitive (or productive) industries to more competitive ones, making exports less expensive relative to foreign goods. This leads to a depreciation of the RER.
Lagged RER	+	**Persistence** The size of β indicates how strong the persistence effect is. A coefficient close to 1 suggests very high persistence – the RER tends to stay near its previous value. A coefficient closer to zero indicates weaker persistence and faster adjustment.
	-	**Mean Reversion** If very strong forces push the RER back towards its long-run equilibrium, mean reversion can outweigh the persistence effects. This means that deviations from equilibrium are quickly corrected.
Remittances / GDP	-	**Direct effect** The increased inflow of foreign currency leads to an appreciation of the domestic currency.
	+	**Consumption effect** If the increase in remittances is accompanied by a growth in consumption of foreign goods, this resulting demand for foreign currency can offset or neutralize the direct effect.
	-	**Price effect** If domestic demand increases without a corresponding increase in supply, the resulting increase in price levels leads to an appreciation of the RER.
	+	**Investment effect** If remittance proceeds are invested towards growing the productive capacity of the nation, the resulting increase in productivity offsets any short-term exchange rate appreciations from the price and direct effects.
Terms of Trade	-	**Income effect** An improvement in the terms of trade increases the country's real income, which boosts demand for all goods, including non-tradables. The resulting price increase cause an appreciation of the Real Exchange Rate,
	-	**Substitution effect**

		If export prices rise relative to import prices, it incentivizes domestic producers to shift resources towards the booming export sector. This leads to resource scarcity and thus higher prices for other domestic goods, including non-tradables, further contributing to real appreciation.
	+ / -	**Wealth effect** Terms of trade improvements increase a country's wealth, which leads to higher consumption. Depending on the type of goods consumed (import or domestic), the RER can either depreciate or appreciate.
Interest rate differential	-	**Capital flow effect** An increase in the domestic interest rate attracts capital inflows, leading to an appreciation of the nominal exchange rate. With sticky prices, this translates into a real appreciation.
	+ / -	**Risk premium effect** Investors factor in the increased level of perceived risk such that, if not covered by means of a higher interest offering, it may lead to an inversion of the capital flow effect.
Net Foreign Assets	-	**Income effect** A country which has positive NFA is a net lender to the rest of the world. The stream of income from abroad that it generates tends to appreciate the RER.
	-	**Wealth effect** An accumulation of NFA can lead to a "wealth effect" whereby an increase in consumption, drives up prices, leading to an appreciation of the RER.
	+	**Portfolio balance and capital flows** Accumulating NFA imply net capital outflows as investments abroad are made. This outflow reduces the demand for domestic currency, leading to a nominal exchange rate depreciation, which in turn influences the RER.

This table shows the expected sign of the regressors' impact on the Real Exchange Rate.

As seen from the discussion of the expected impact of the explanatory variables on the Real Exchange Rate, due to the complexity of the mechanisms involved, it is possible that under different circumstances, each one of the regressors can manifest a differentiated effect.

Furthermore, it is reasonable to assume that the effects that are observed change throughout time as a result of the position in the economic and financial cycle of the country, as well as in response to exogenous shocks. As such, one cannot assume constancy of the parameter estimates throughout the entire data series. In this context, it becomes important to produce estimates for shorter periods of time that capture current dynamics and inform the policy-maker of the position of the economy within the transmission mechanisms outlined above.

6. Analyzing the results

The model is estimated in three stages covering: the entire data sample, sequences of 10-year windows and sequences of 5-year windows to provide an account of general effects, long-run tendencies and short to medium-term dynamics. Estimation on shorter horizons would be difficult with quarterly data and would, therefore, be best left for an exercise involving monthly observations.

6.1. Model estimation on the entirety of the data

Running the regression on the entire sample of data highlights the overarching relationships that dominate the dynamics throughout the entirety of the dataset. Analyzing data over the near 30-year period paints a broad picture of the slow-moving economic, social, or technological evolutions that only become apparent over a long horizon.

Since exchange rates are often driven by long-run equilibrium relationships based on fundamentals, a full-sample analysis can help identify persistent relationships over long periods of time, which provides a better understanding of the underlying drivers of exchange rate movements.

Furthermore, from a purely technical standpoint, with more data points, estimates tend to have smaller standard errors, making the results of the full-sample estimations potentially more robust and reliable. This helps in obtaining precise parameter estimates, which can be important for policy-making or strategic decisions based on historical trends.

Table 4. Regression results for the model estimated on the entire sample of data

	Estimate	Std. Error	t value	Pr(>|t|)	Signif. code
(Intercept)	0.012924	0.007763	1.665	0.098949	.
BSE	-0.456510	0.048574	-9.398	1.49E-15	***
lag(RER)	0.298347	0.066749	4.470	0.000020	***
Rem/GDP	0.102751	0.026911	3.818	0.000229	***
TOT	0.335053	0.141312	2.371	0.019581	*
(r – r*)	0.214907	0.074559	2.882	0.004796	**
NFA	-0.088730	0.037353	-2.375	0.019366	*

Multiple R-squared:	0.7733
Adjusted R-squared:	0.7602
F-statistic: 59.13 on 6 and 104 DF, p-value: < 2.2e-16	

The typical real exchange rate appreciation from the Balassa-Samuelson effect and increases in net foreign assets is observed, alongside the expected positive impact of the dependent variable's lag. When run on the full dataset, increases in the remittance/GDP ratio, terms of trade and interest rate differential depreciate the RER. This highlights the dominance of the consumption and wealth effects, with a propensity for consumption of imported goods. Furthermore, the interest rate differential's effect suggests that the risk premium may not be sufficiently well captured by the real interest rate, despite being internalized by the market. In particular, throughout crises accompanied by inflationary pressures, the rise in interest rates fails to cover the increase in the risk premium, thereby leading to an inverse effect in the dynamics of the calculated interest rate differential.

The quality of fit can also be evaluated visually by plotting the predicted values of the dependent variable alongside the actual real exchange rate, expressed as a growth rate. The predicted series closely follows the actual values and manifests deviations from the fundamentals around crisis events. In such cases, the predicted series tends to over- or under-estimate the magnitude of the change in the original data, but remains aligned with the direction of the movement.

Figure 2. Regression quality of fit

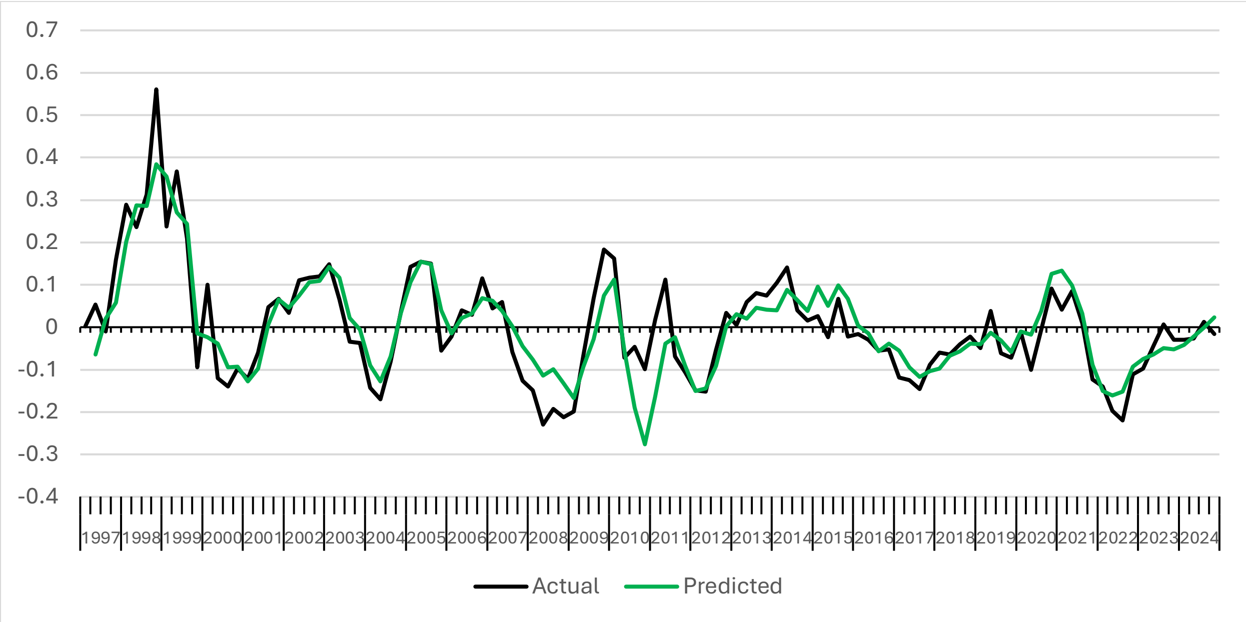


Figure 2 shows the predicted values of the dependent variable which closely track the dynamics of the actuals. At certain points, particularly around crises, the predicted series under- or over-estimates. The gap between the predicted and actual value is the deviation of the rate of change in the exchange rate from the fundamentals, caused by exogenous shocks.

6.2. Long-run dynamic ten-year window regression

Long-run dynamics can also be estimated using a shorter sample of data. Specifically, a 10-year window offers a good overview of medium to long-term dynamics without necessarily retaining influences related to long ago or one-off crises which may no longer be representative of the current conjuncture. In this way, coefficient estimates may be estimated closer to current dynamics. It is also possible to study the evolution of coefficient values to determine changes in magnitude and eventual sign inversions. This helps to determine the key transmission mechanisms at play, channels of effects and can be used to trace the position within the economic and financial cycles.

Long-term windows provide a sufficiently comprehensive view of how variables interact over an extended period, offering insights into historical contexts that have shaped the current relationships between the variables included in the model. Longer-term windows also allow for a study of the medium to long-run impact of financial crises and shocks and integrate more persistent dynamics into the analysis.

In total, 72 models were estimated over the period from 2007Q1 to 2024Q4 capturing dynamics specific to three crises – the Great Recession, the Moldovan Banking Fraud and the Covid Pandemic, as well as the interim periods of calm.

A set of figures presents the dynamic coefficient estimates for each of the regressors included in the model. The graphs make it easy to identify sign inversions and periods of significance.

Figure 3. Balassa-Samuelson Effect dynamic regression coefficient estimates, 10-year window

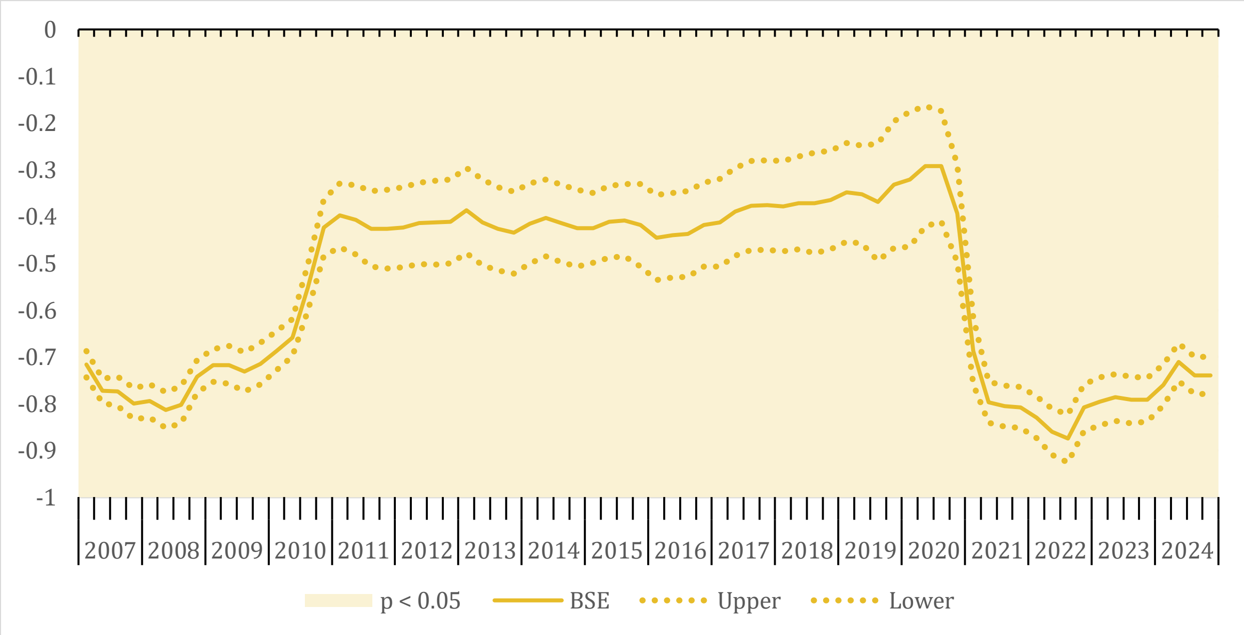


Figure 3 presents the dynamic coefficient estimates for the Balassa-Samuelson effect. Shaded areas represent periods when the estimates' p-value is lower than 0.05. The Balassa-Samuelson effect proves to be highly significant in all the estimated models and manifests no sign deviations from the expected baseline effect.

Over a ten-year estimation window, the Balassa-Samuelson effect consistently emerges as the most robust driver of the real exchange rate, demonstrating maintained statistical significance across all analyzed timeframes. The predicted relationship between relative prices and the RER holds true throughout the entire decade, though its strength fluctuates considerably depending on prevailing economic conditions. This suggests that differences in productivity growth between countries – the core tenet of the Balassa-Samuelson effect – exert a persistent influence on real exchange rate movements, even amidst other competing forces. The consistency of this effect is particularly noteworthy given the dynamic and often volatile nature of the economy.

However, the impact of the Balassa-Samuelson effect is not uniform. Periods characterized by economic or financial crises witness a distinct downward pressure on estimated parameter values, stemming from the combined influence of Purchasing Power Parity (PPP), capital flows, and wage dynamics – what one could term the “tri-channel” effect. This suggests that crisis periods are not simply marked by heightened volatility but also by a systematic shift in the underlying drivers of real exchange rate behavior.

Conversely, during periods of relative economic stability and tranquility, the Trade Balance Passthrough effect gains prominence, exerting an upward force on estimated parameter values.

While this effect does counteract the downward pressure observed during crises, it's important to note that the parameter never crosses into positive territory throughout the entire estimation period. This implies a persistent underlying tendency of the Balassa-Samuelson Effect to appreciate the real exchange rate.

Furthermore, the precision with which we can estimate these effects varies depending on the prevailing economic conditions. During crisis periods, where the tri-channel effect dominates, the confidence bands surrounding the parameter estimates are notably narrow. This indicates a higher degree of certainty regarding the magnitude and direction of the impact during times of stress. However, as the intensity of the estimated parameters diminishes – particularly in calmer periods – the width of these confidence intervals expands. While this widening reflects increased uncertainty, it's important to emphasize that the confidence intervals never deviate profoundly from the central parameter estimates. This suggests a degree of robustness in our findings, even when faced with greater statistical noise and weaker signals. In essence, while pinpointing the exact magnitude becomes a bit more challenging outside of crisis periods, the general direction and relative importance of these effects remain relatively stable over time.

Figure 4. Lagged RER dynamic regression coefficient estimates, 10-year window

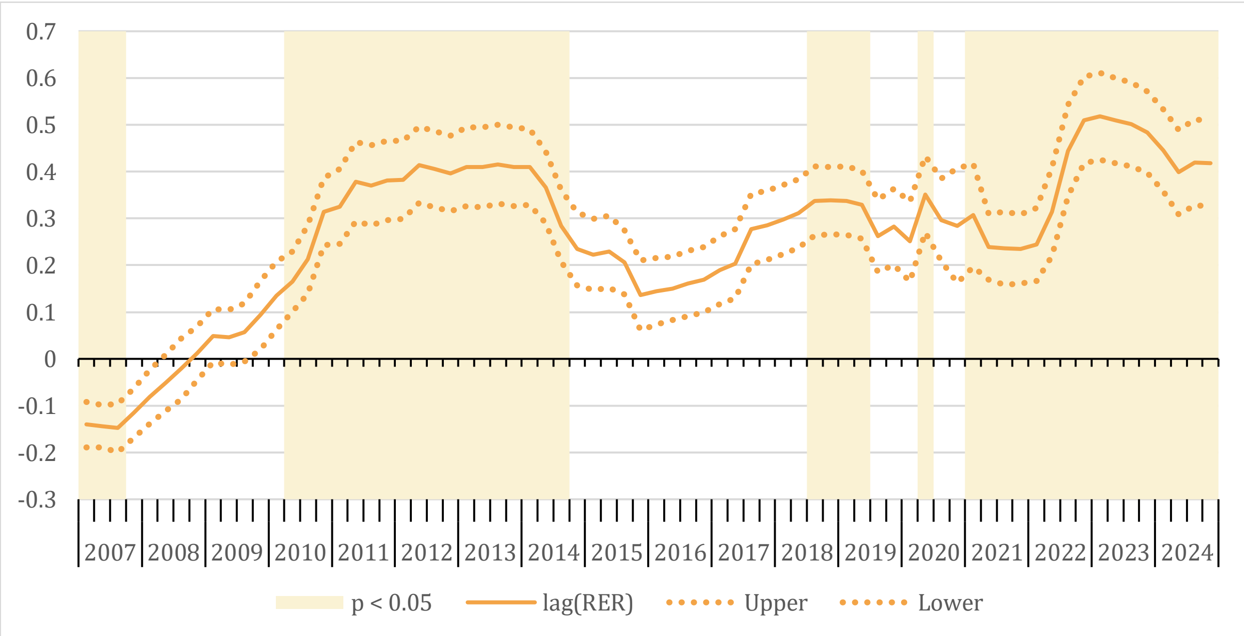


Figure 4 presents the dynamic coefficient estimates for the lagged Real Exchange Rate. Shaded areas represent periods when the estimates' p-value is lower than 0.05. The expected positive effect is observed for the entire duration of the series, with the exception of a number of pre-2008 crisis years when an attenuating effect was present.

The lagged RER has a positive relationship with the BEER and is significant for around half of the estimation period. The coefficient values indicate a decaying effect with varying degrees of persistence. During the Covid pandemic the parameter estimate went was high as 0.51, indicating moderately strong habit-formation or sticky price effects.

During the Global Financial Crisis, a strong mean-reversion mechanism pulled parameter estimates into negative territory leading to rapid corrections in deviations from equilibrium. This effect may have been compounded by overreaction to developments on the foreign exchange market, whereby agents believed that a large appreciation was unsustainable, and aggressively sold back the currency, causing it to depreciate more than warranted by fundamentals.

The confidence bands surrounding the lagged RER dynamic parameter estimates remain consistent across time and are nested tightly around the estimates. When the parameters indicate increased persistence, confidence bands tend to widen slightly, returning to a tighter form as the degree of persistence subsides.

Figure 5. Remittances / GDP dynamic regression coefficient estimates, 10-year window

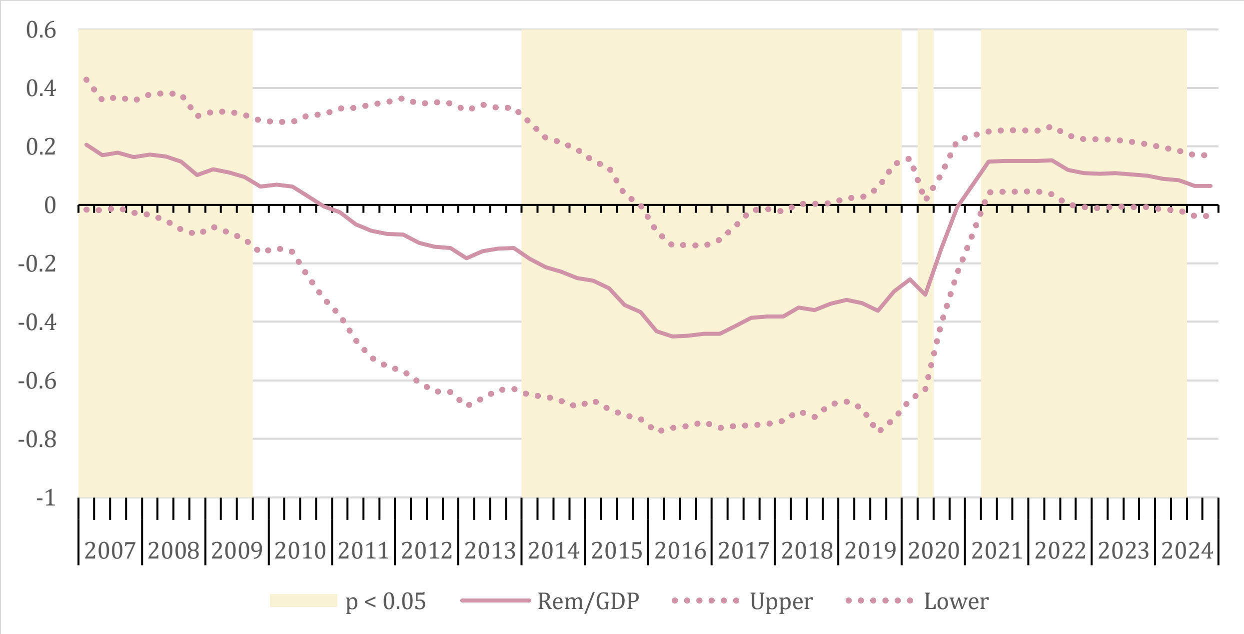


Figure 5 presents the dynamic coefficient estimates for Remittances / GDP. Shaded areas represent periods when the estimates' p-value is lower than 0.05. Remittances stop playing an important role during crises when inflow dynamics change.

Between 2007 and 2009, throughout the Global Financial Crisis (GFC), we observe a positive and statistically significant coefficient on Remittances/GDP. This relationship appears as the period was characterized on one hand by declining Remittances/GDP following a sharp drop in remittance flows, and on the other hand, an appreciating RER due to foreign price growth outpacing domestic inflation.

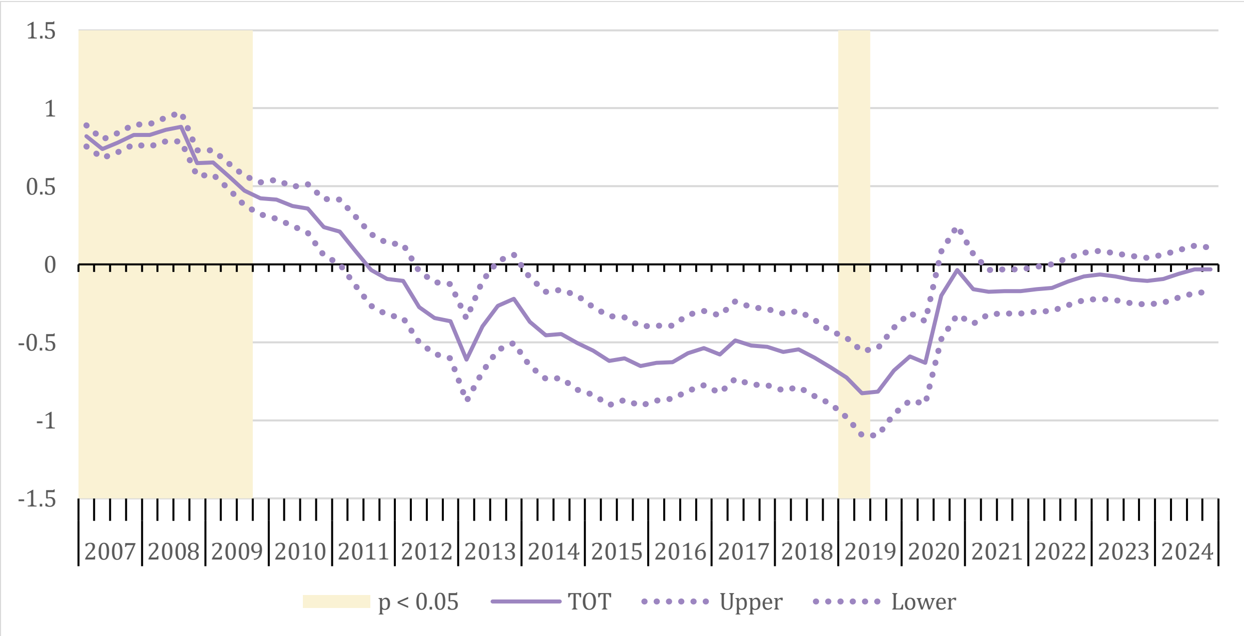
From 2010-2019, the coefficient on Remittances/GDP turns negative and becomes increasingly pronounced, reaching its most negative value in 2016. This aligns with traditional theory: higher remittances increase national income, boosting demand for domestically produced goods and services, thus appreciating the RER. The increasing strength of the effect during 2016 may also be reflective of a period in which remittances dropped and the exchange rate depreciated due to a Banking Fraud episode involving huge capital outflows.

However, this established negative relationship abruptly reverses with the onset of the COVID-19 pandemic in 2020. The coefficient on Remittances/GDP becomes positive again, mirroring the GFC pattern. This shift likely reflects crisis behavior when remittance receivers hoard foreign currency liquidity instead of converting it immediately into domestic currency for consumption.

The estimated coefficients exhibit varying levels of statistical significance and precision over time. Estimates were significant during 2007-2009, indicating robust evidence supporting the positive relationship during the GFC. Significance was lost between 2010 and 2013, potentially due to reduced volatility and a weaker signal amidst more stable economic conditions. From 2014 to 2019, significance returned, reinforcing the negative association observed in this period. The onset of the pandemic in 2020 led to a brief loss of statistical significance as the coefficient rapidly shifted from negative to positive values, reflecting increased uncertainty. From 2021 onwards, estimates became consistently positive and statistically significant.

The confidence bands surrounding these estimates were relatively narrow during crises, indicating greater precision in our estimations. These widened in normal times, reflecting a more diffuse transmission channel.

Figure 6. Terms of Trade dynamic regression coefficient estimates, 10-year window



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The confidence bands surrounding these estimates were relatively narrow during crises, indicating greater precision in our estimations. These widened in normal times, reflecting a more diffuse transmission channel.

Figure 6 *presents the dynamic coefficient estimates for Terms of Trade. Shaded areas represent periods when the estimates' p-value is lower than 0.05. The variable's significance is low across the spectrum of estimated models.*

The Terms of Trade coefficient maintained a positive value throughout the Global Fianncial Crisis period, and was significant, with narrow confidence bands. However, From the end of 2009 onwards, coefficient estimates lost significance, as the relationship switched from positive to negative at the end of 2011. The most negative value was reached in the middle of 2019.

A brief period of significance resurfaced at the beginning of 2019, potentially giving an early signal of the Covid pandemic, with the sign of the coefficient experiencing a new reversal and quickly nearing the null value, without ever becoming positive again.

Post-GFC, the confidence bands associated with coefficient estimates widened, reflecting the loss in significance. They narrowed somewhat after the onset of the Covid pandemic.

Figure 7. Interest Rate Differential dynamic regression coefficient estimates, 10-year window

Figure 7 presents the dynamic coefficient estimates for interest rate differential. Shaded areas represent periods when the estimates' p-value is lower than 0.05. The variable's significance is low across the spectrum of estimated models.

The interest rate differential is significant only during the period preceding the GFC of 2008 and very briefly in 2015, during the Banking Fraud, when the largest systemic institution collapsed. The sign was positive in 2007-2008, while in the fraud episode, negative and at its lowest.

NFA is significant throughout most of the estimation period and its sign is negative, reflecting the dominance of the income and wealth effects. However, during crisis periods such as the GFC and Covid pandemic, the effect weakens and the coefficient estimates become close to null and insignificant. Confidence bands tend to vary more than in the case of other parameter estimates.

Figure 8. Net Foreign Assets dynamic regression coefficient estimates, 10-year window

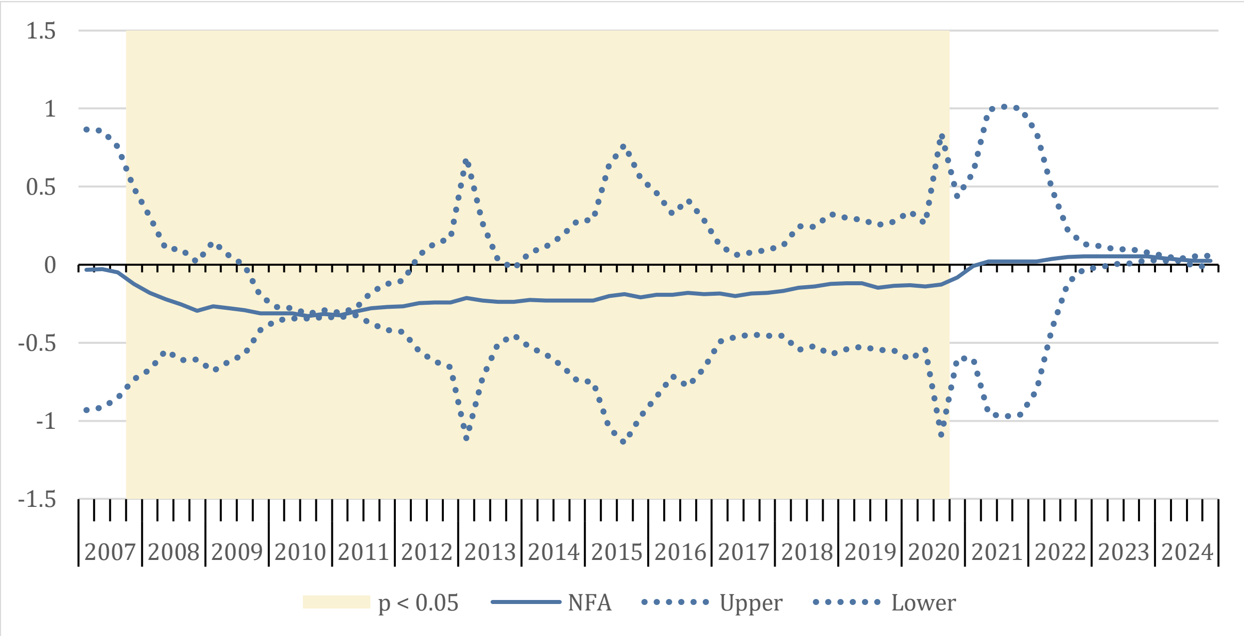

Figure 8 presents the dynamic coefficient estimates for Net Foreign Assets. Shaded areas represent periods when the estimates' p-value is lower than 0.05. The variable's significance manifests cyclicality and persists in periods where the coefficient estimate is negative (corresponding to the expected baseline effect).

Figure 9. Intercept dynamic regression coefficient estimates, 10-year window

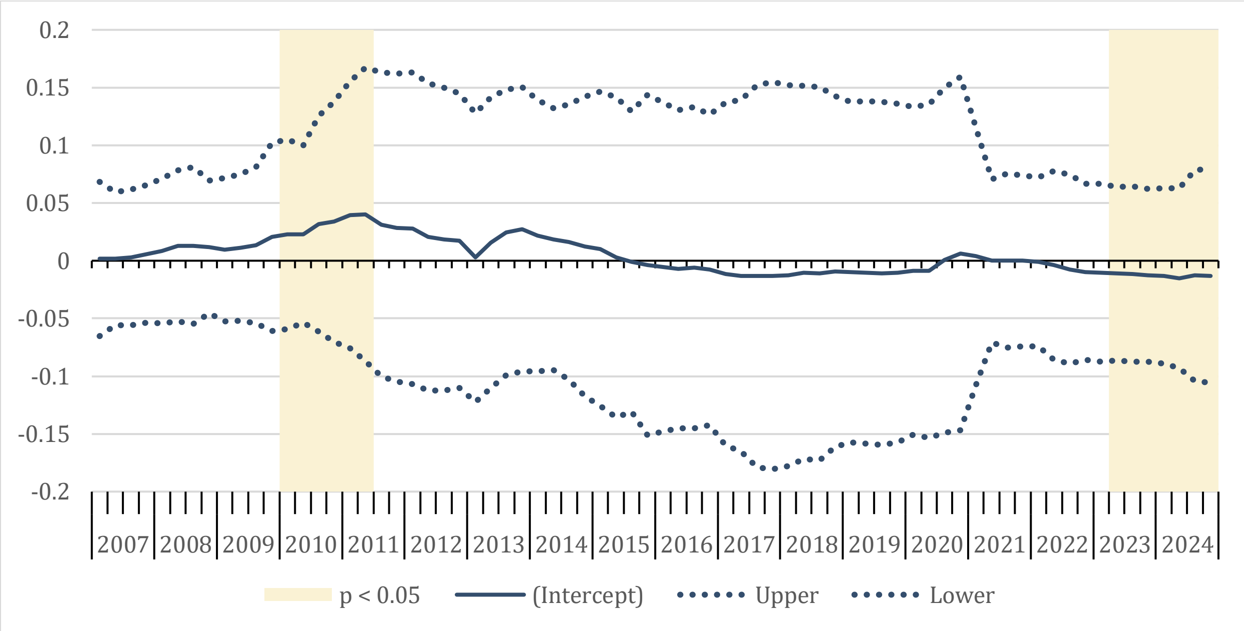

Figure 9 presents the dynamic coefficient estimates for intercept. Shaded areas represent periods when the estimates' p-value is lower than 0.05. The variable becomes significant during post-crisis cool-down periods.

The set of figures depicting the coefficient estimates for the regressors included in the model highlight the importance of the Balassa-Samuelson effect across the entire range of estimated models. The lagged Real Exchange Rate and the remittance indicator also manifest a high degree of significance. The Terms of Trade and interest rate differential are seldom significant, while Net Foreign Assets manifest longer-term dynamics in significance levels. Some of the regressors manifest sign inversions. This is due to either changing degrees of significance (in particular switching from significance to insignificance or vice-versa) or to more complex transmission mechanisms involving several effect channels which, each, dominate at different intervals of time.

Table 5. Coefficient estimate summary for the dynamic 10-year window regression

Parameter	Stability	Significance	Confidence bands	Crisis shift
Balassa-Samuelson Effect	Stable	Significant throughout the entire period	Narrow	- GFC - Covid
Lagged RER	Stable	Significant for large portions of time	Narrow	- GFC
Remittances / GDP	Stable outside of crisis shift periods	Significant for large portions of time	Wide	- GFC - Fraud - Covid
Terms of Trade	Somewhat stable	Occasionally significant	Narrow	- GFC - Covid
Interest Rate Differential	Unstable	Occasionally significant	Narrow	- Fraud - Covid

Net Foreign Assets	Stable	Significant throughout the most of the period	Wide	- GFC - Covid

This table analyzes factors impacting exchange rate movements. The Balassa-Samuelson effect, lagged RER and Net Foreign Assets demonstrate consistent stability and significance, manifesting level shifts during the Global Financial Crisis (GFC) and COVID-19. Remittances/GDP are stable except during crises (GFC, Fraud, Covid), exhibiting wider confidence bands. Terms of Trade show some stability, but limited significance. Interest Rate Differentials are unstable and occasionally significant, but react well to the fraud episode. Overall, most parameter estimates are impacted by external shocks.

Analysis of the dynamic partial R^2 and the relative dynamic partial R^2 allows for a comprehensive analysis of the key drivers explaining the variability in the data. The dynamic nature of the indicators enables studying the evolving ability of individual regressors to capture the dynamics of the RER, but also, the relative contribution of each explanatory variable.

Figure 10. Dynamic Partial R^2, 10-year window

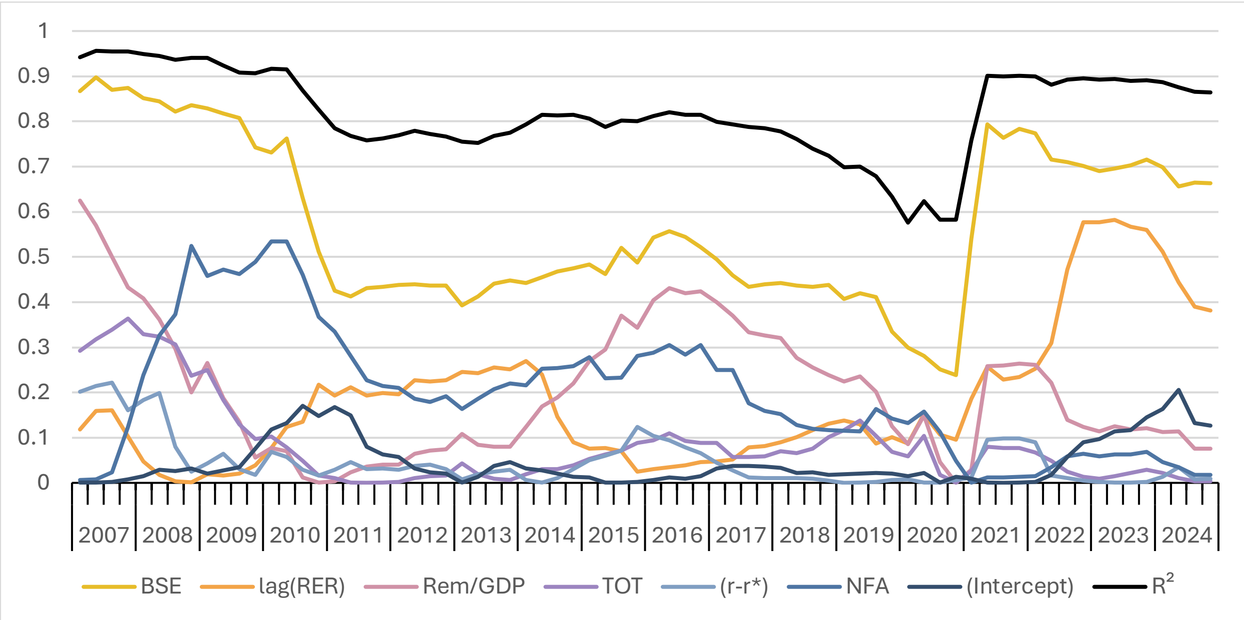

Figure 10 presents the dynamic Partial R^2 estimated over a 10-year window for each of the explanatory variables, as well as the global dynamic R^2.

The dynamic partial R^2 highlights the fact that during economic crises, the Balassa-Samuelson effect is capable of explaining the vast majority of the variability of the RER on its own. This highlights the importance of the regressor in explaining crisis dynamics. The effect of remittances declines after crisis events while the lagged RER benefits from enhanced capacity in explaining the variability in the data within proximity of crisis events.

Figure 11. Relative Dynamic Partial R^2, 10-year window

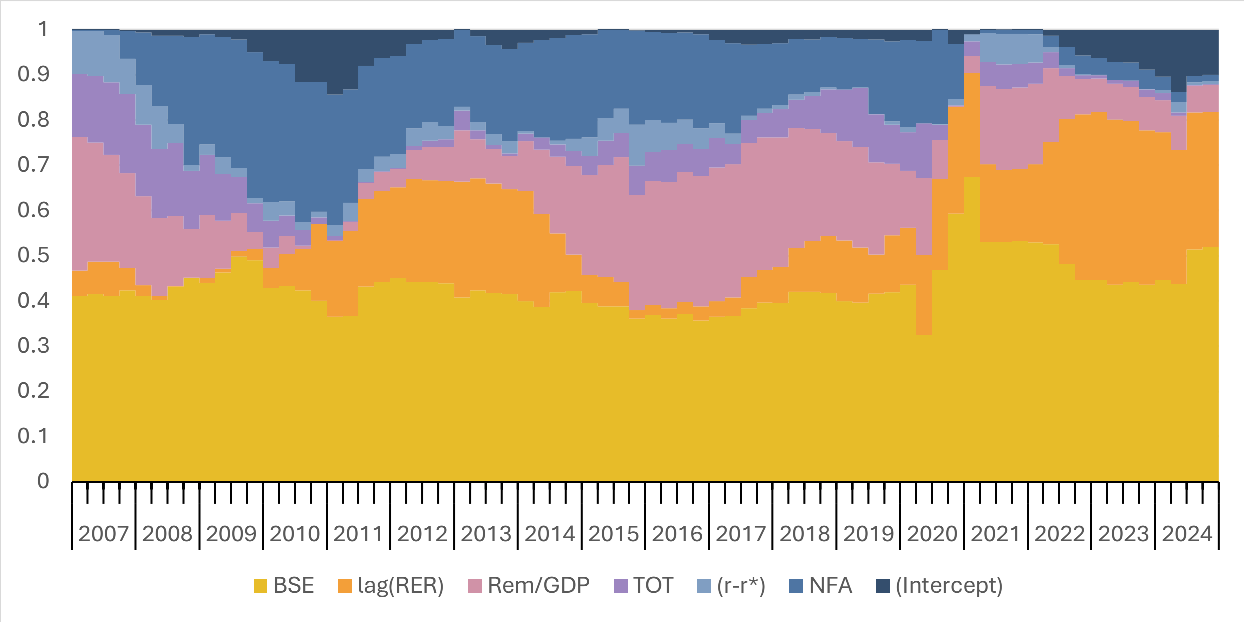

Figure 11 presents the relative contribution of each regressor towards the aggregate explained variability.

The relative dynamic partial R^2 presents the contribution of each variable towards the combined variable contributions. It allows for an easy comparison of key drivers and their temporal evolution.

Around crises, the explanatory power of remittances diminishes as they suffer changes in dynamics or even inversions. As such, in the BEER model they depart from the mix of fundamentals driving the trend dynamics and start contributing to the exogenous factors driving the actual RER away from its behavioral level. Similarly, the Terms of Trade effect diminishes around crisis events and dissipates in periods following turmoil. This comes in contrast to the dynamics manifested by the Balassa-Samuelson effect which increases in the run up to economic and financial crises. The interest rate channel plays a role in periods where monetary policy is active in counteracting inflation. This is the case in 2007-2008, 2015-2016 and the post-pandemic period. Finally, Net Foreign Assets are observed to follow a longer cycle than other indicators.

It is additionally important to note that, following crises, there are periods when the contribution of the intercept increases. This denotes a “cooling off” of the economy, as system dynamics slow down and the importance of fixed (constant) effects increases.

The dynamic regression produces results that are closer to the actual RER growth rate series, closing the gap between the fundamentals-driven calculated series and the dynamics observed in the economy.

Figure 12. Dynamic regression quality of fit, 10-year window

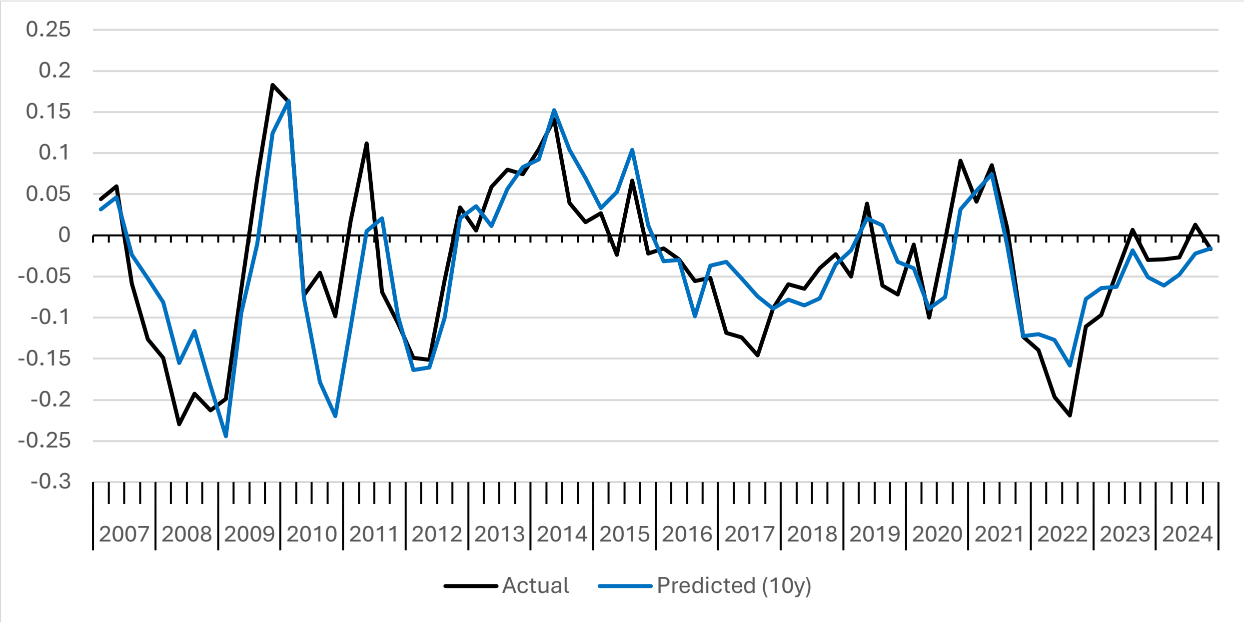

Figure 12 shows the predicted values of the dependent variable which provide a better quality of fit, compared to the regression estimated over the entire data sample.

6.3. Short-run dynamic five-year window regression

Shorter window regressions provide insights into local dynamics and allow for a more nuanced understanding of how relationships between variables change in response to recent developments or shocks.

Shorter rolling windows allow the model to adapt to structural breaks or regime shifts that may occur over time. Economic relationships are not static and they can evolve due to changes in policy, technology, consumer preferences or as a result of permanent shocks. Therefore, dynamic regressions with shorter windows help capture changing patterns by focusing on more recent data.

By using short-term windows, one can detect periods of increased volatility or instability in the relationship between variables that might be obscured in a long-term analysis. This is especially useful for identifying and understanding short-term fluctuations.

Models based on shorter time frames also have the advantage of providing more accurate forecasts by focusing on current economic conditions rather than historical patterns that no longer apply. They are particularly beneficial in rapidly changing environments where recent data is more relevant.

In total, 92 models were estimated over the period from 2002Q1 to 2024Q4 capturing dynamics specific to four crises – remnants of the 1998 crisis, the Great Recession, the Moldovan Banking Fraud and the Covid Pandemic, as well as the interim periods of calm.

As in the case of the 10-year window, a similar set of figures presents the dynamic coefficient estimates for each of the regressors included in the model. The graphs facilitate identification of sign inversions and highlight periods of estimate significance.

Figure 13. Balassa-Samuelson effect dynamic regression coefficient estimates, 5-year window

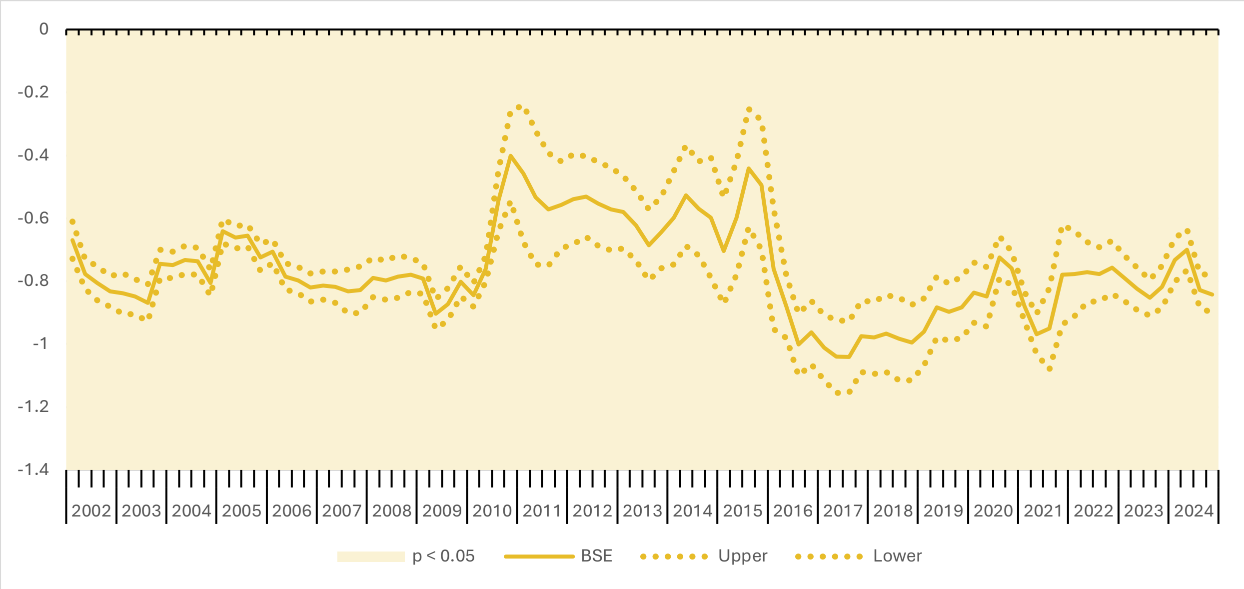

Figure 13 presents the dynamic coefficient estimates for the Balassa-Samuelson effect. Shaded areas represent periods when the estimates' p-value is lower than 0.05. The Balassa-Samuelson effect proves to be highly significant in the vast majority of estimated models and manifests no sign deviations from the expected baseline effect. During the brief periods of insignificance, the magnitude of the effect drops, but is rapidly restored once significance is regained.

Figure 14. Lagged RER dynamic regression coefficient estimates, 5-year window

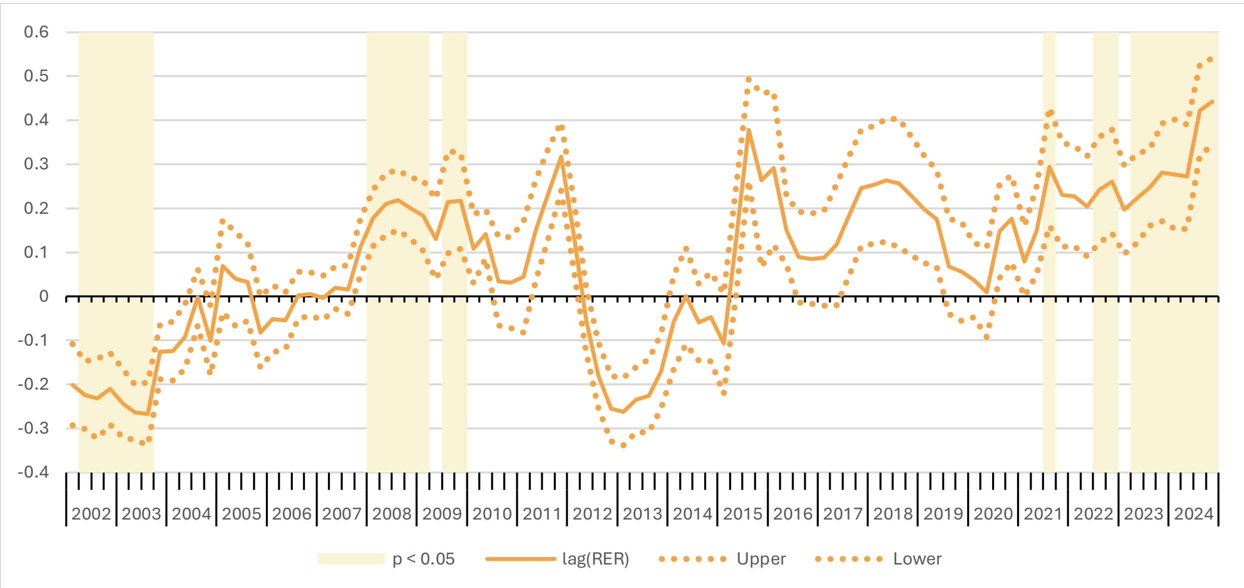

Figure 14 presents the dynamic coefficient estimates for the lagged real exchange rate. Shaded areas represent periods when the estimates' p-value is lower than 0.05. The lagged RER effect is weakly significant on the short run and manifest more frequent sign inversions.

Figure 15. Remittances / GDP dynamic regression coefficient estimates, 5-year window

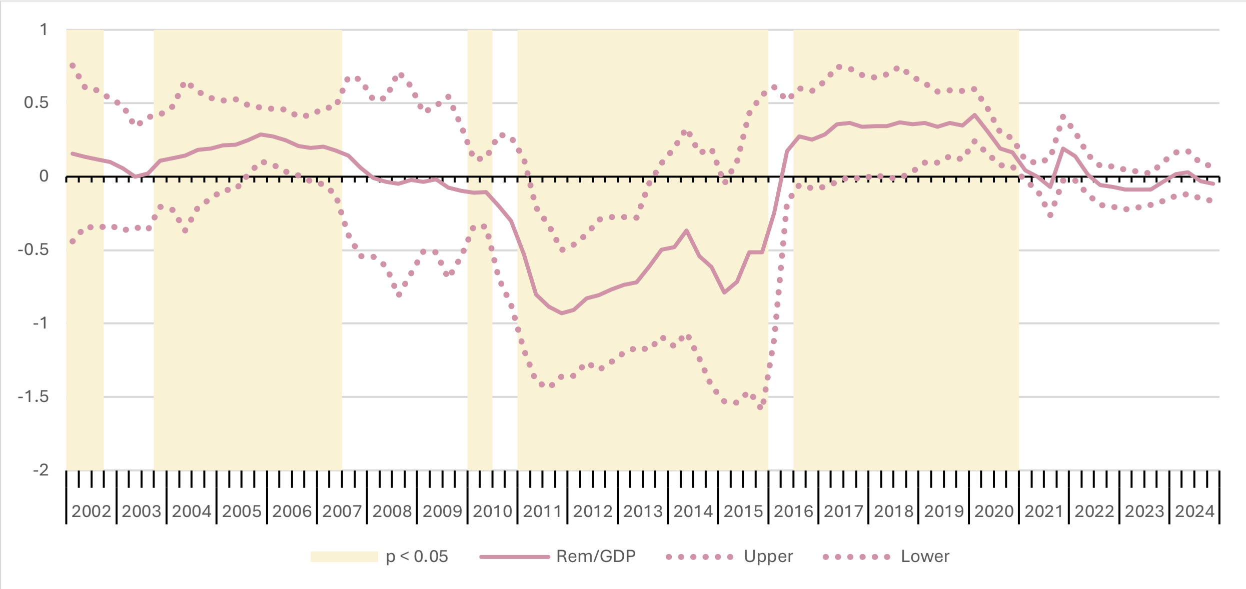

Figure 15 presents the dynamic coefficient estimates for the remittance effect. Shaded areas represent periods when the estimates' p-value is lower than 0.05. Remittances manifest changes in sign and losses in significance in the proximity of crises as financial flows slow down.

Figure 16. Terms of Trade dynamic regression coefficient estimates, 5-year window

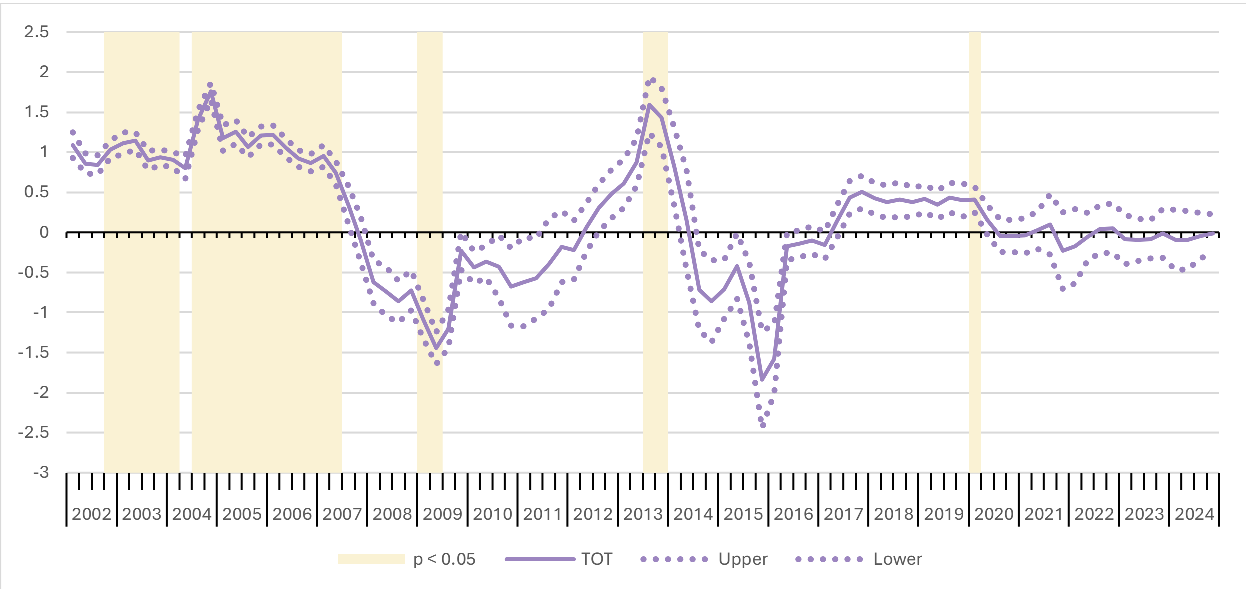

Figure 16 presents the dynamic coefficient estimates for the Terms of Trade effect. Shaded areas represent periods when the estimates' p-value is lower than 0.05. Terms of Trade prove to be weakly significant throughout most of the period and only show intermittent signs of significance.

Figure 17. Interest rate differential dynamic regression coefficient estimates, 5-year window

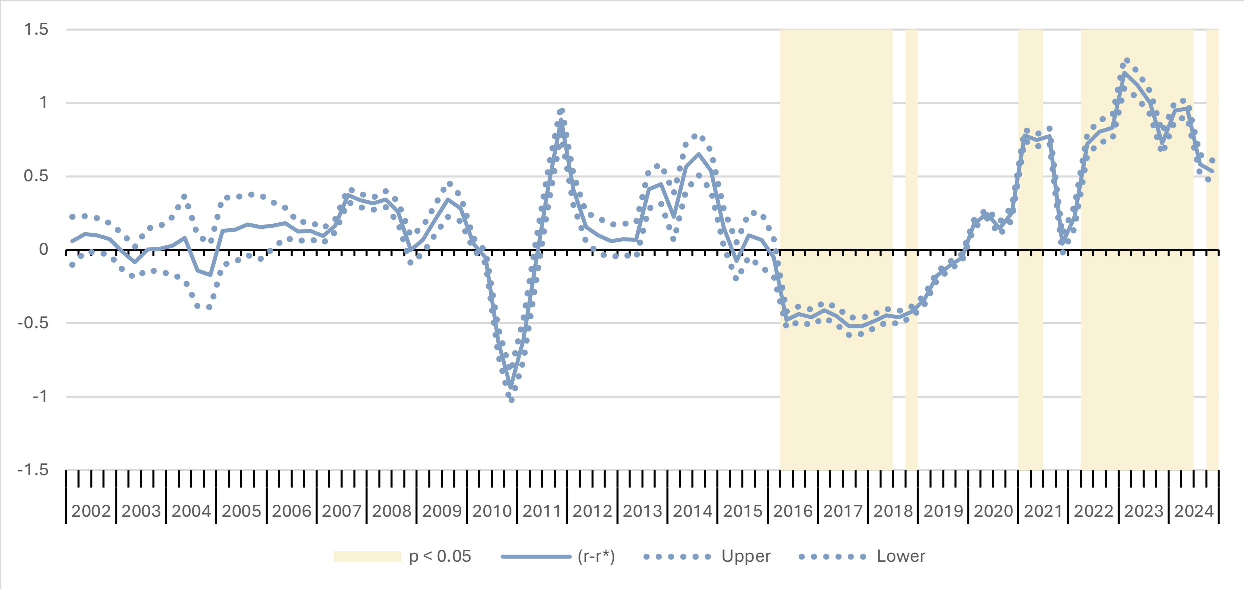

Figure 17 presents the dynamic coefficient estimates for the interest rate differential. Shaded areas represent periods when the estimates' p-value is lower than 0.05. On the short run, dynamics are seldom influenced by the interest rate differential. Positive coefficient signs reflect the fact that the risk premium is not fully reflected in the interest rate, particularly in periods of heightened significance.

Figure 18. Net Foreign Assets dynamic regression coefficient estimates, 5-year window

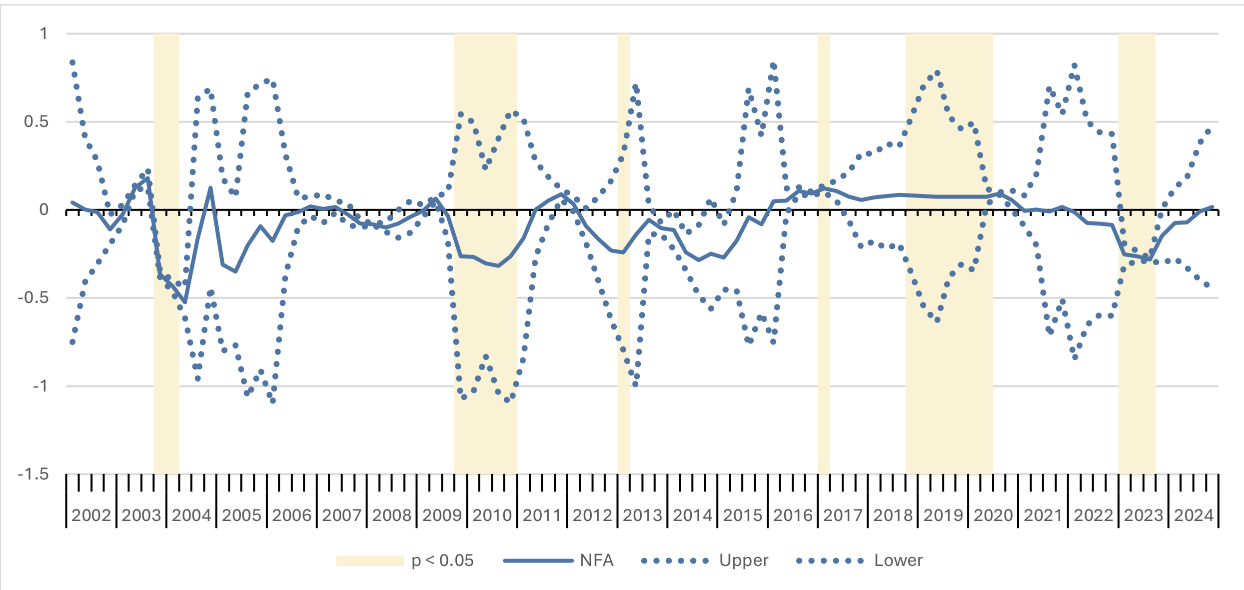

Figure 18 presents the dynamic coefficient estimates for Net Foreign Assets. Shaded areas represent periods when the estimates' p-value is lower than 0.05. NFAs are one of the least significant regressors at all time horizon estimations.

Figure 19. Intercept dynamic regression coefficient estimates, 5-year window

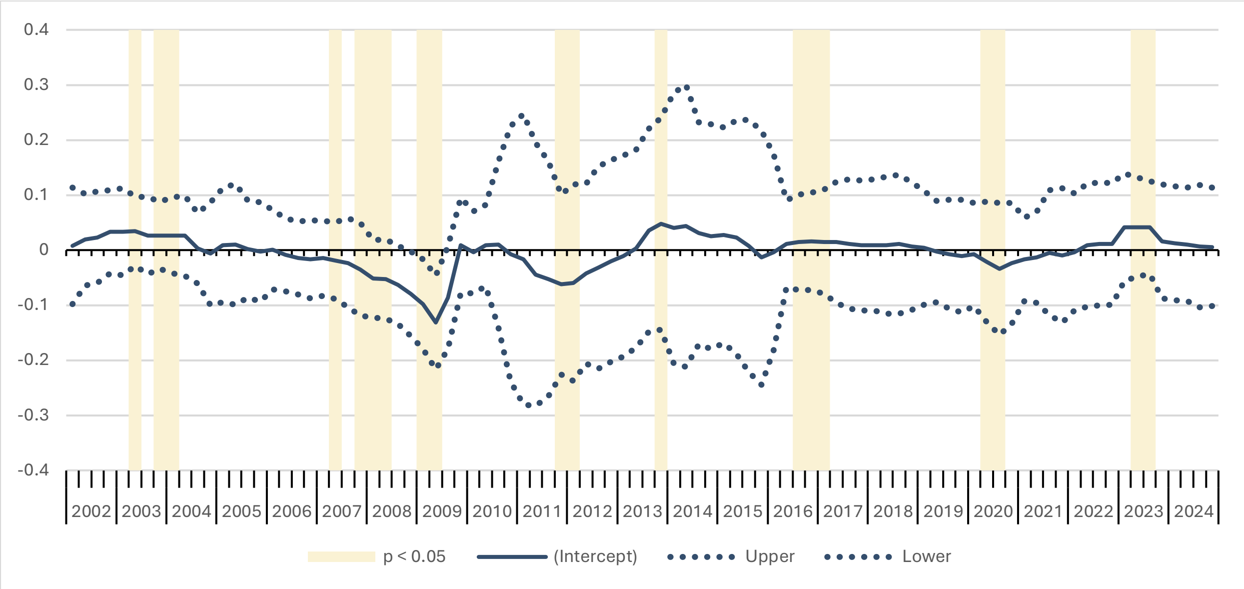

Figure 19 presents the dynamic coefficient estimates for the intercept. Shaded areas represent periods when the estimates' p-value is lower than 0.05. On the short term, the intercept substitutes for variables which lose significance during times of distress and changes in dynamics.

The 5-year window estimates highlight that the Balassa-Samuelson effect is the most potent predictor of short-run dynamics, capable of explaining most of the variability of the model on its own. Other variables complement the BSE, but are rendered less significant by the more complex and less direct channels through which their effect passes.

Figure 20. Dynamic Partial R^2, 5-year window

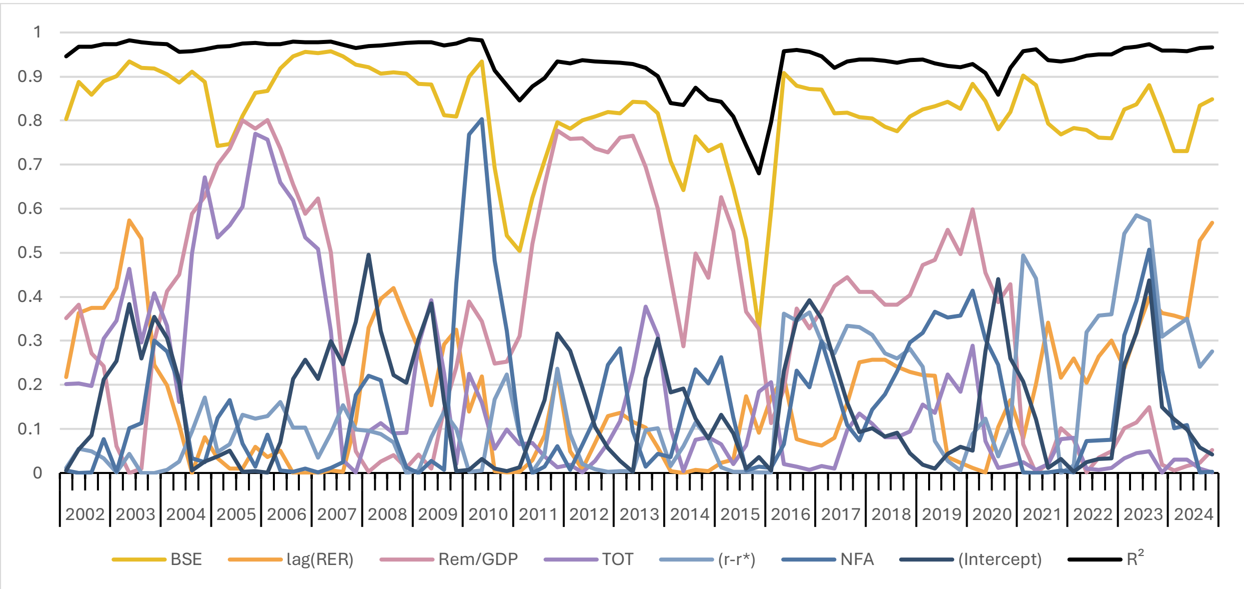

Figure 20 presents the dynamic Partial R^2 estimated over a 5-year window for each of the explanatory variables, as well as the global dynamic R^2.

Figure 21. Relative Dynamic Partial R^2, 5-year window

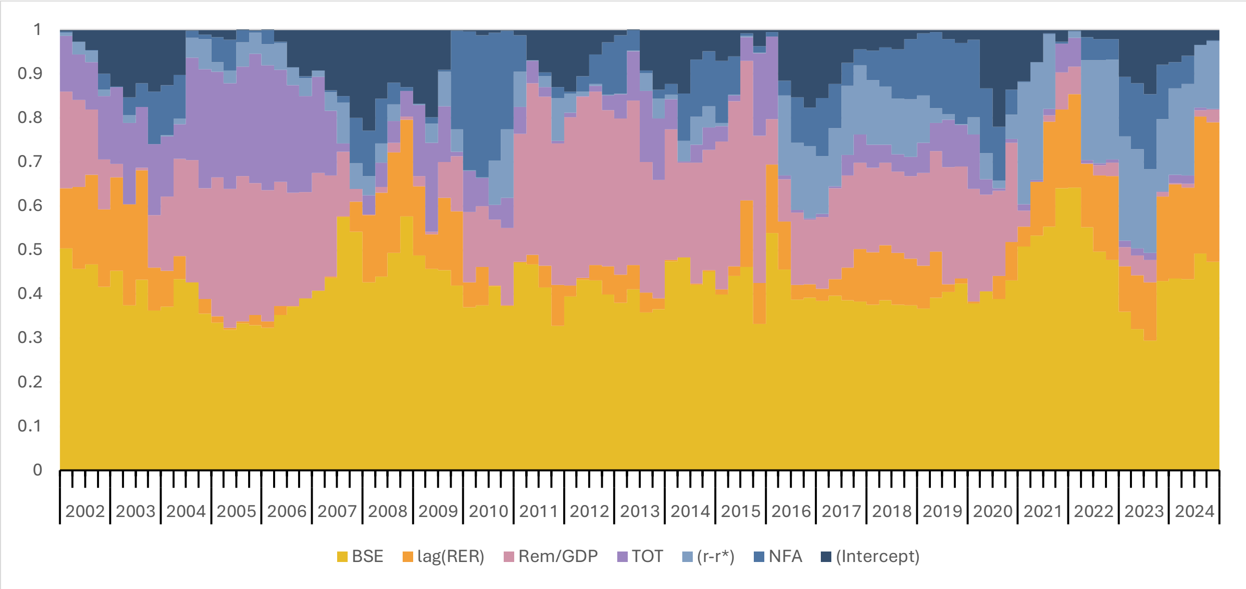

Figure 21 presents the relative contribution of each regressor towards the aggregate explained variability for a 5-year window dynamic regression.

With the shorter 5-year window, the model more rapidly adjusts to the data, as evidenced by the increased volatility of the relative partial R^2. This allows for an overall larger share of the variability to be captured by the model, which is reflected in both the overall as well as the partial R^2 indicators being larger than their 10-year window counterparts.

The Dynamic Partial R^2 confirms the important role played by the Balassa-Samuelson effect which can explain roughly 85% of the variability. Remittances / GDP also come in with increased individual explanatory potency. Around financial crises where monetary policy becomes more active in containing inflation, the interest rate differential also gains explanatory power. Other variables manifest a more transitory effect, commensurate with their dynamic regression estimates and significance levels.

The 5-year model is able to explain most of the variability in the data through fundamentals, however it is less capable of explaining the Banking Fraud period, where exogenous factors unrelated to the country's fundamentals accounted for some of the observed dynamics.

Overall, the fact that parameter estimates vary significantly for several variables, across different windows, both in the case of the 5-year and 10-year rolling estimates, indicates that the underlying relationships are in constant motion and need to be re-evaluated regularly in order to maintain the model's analytical relevance.

Figure 22. Dynamic regression quality of fit, 5-year window

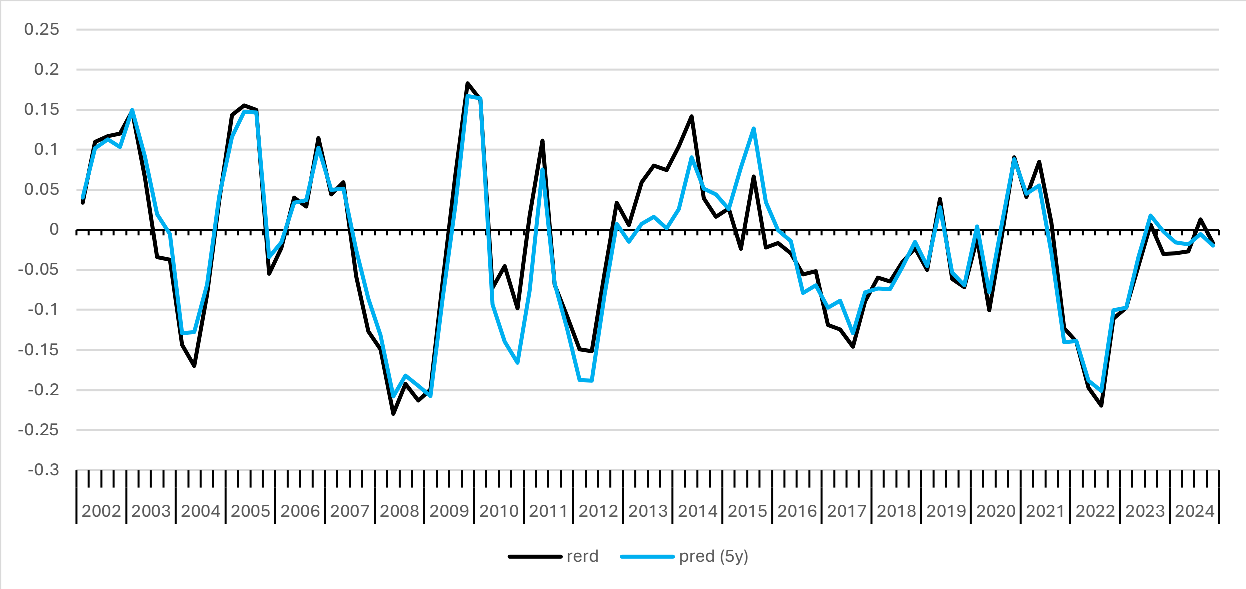

Figure 22 shows the predicted values of the dependent variable which provide a superior quality of fit, compared to the regression estimated over the entire data sample, as well as over a 10-year window.

In the case of the 5-year window, the dynamic regression produces predicted values closer to the original series, eliminating more of the gap between the two. Here, more abrupt exogenous non-fundamentals-related shocks are needed to move estimates away from the actuals.

The shorter-term specification could prove ideal for nowcasting exercises and could be successfully integrated in short-term forecasting exercises due to its high performance, whereas in the case of initiatives focused on modeling longer-term dynamics, longer-window estimates or even estimation on the full sample would be more relevant. Thus, the BEER which, by design, aims to include historical tendencies alongside near-term evolutions is augmented with the dynamic regression and can be adjusted for the scope of the analysis being undertaken.

6.4. The Behavioral Real Exchange Rate

Initially, the BEER is estimated using the full dataset to capture the longest historical dynamics and tendencies in the data. Afterwards, the BEER with smaller 10-year and 5-year windows is computed. This reduces the gap between the actual RER and the fundamentals driven behavioral indicator, but also can lead to diverging results across the differing BEER variants for periods with high RER volatility.

Figure 23. The RER and Behavioral Real Exchange Rate

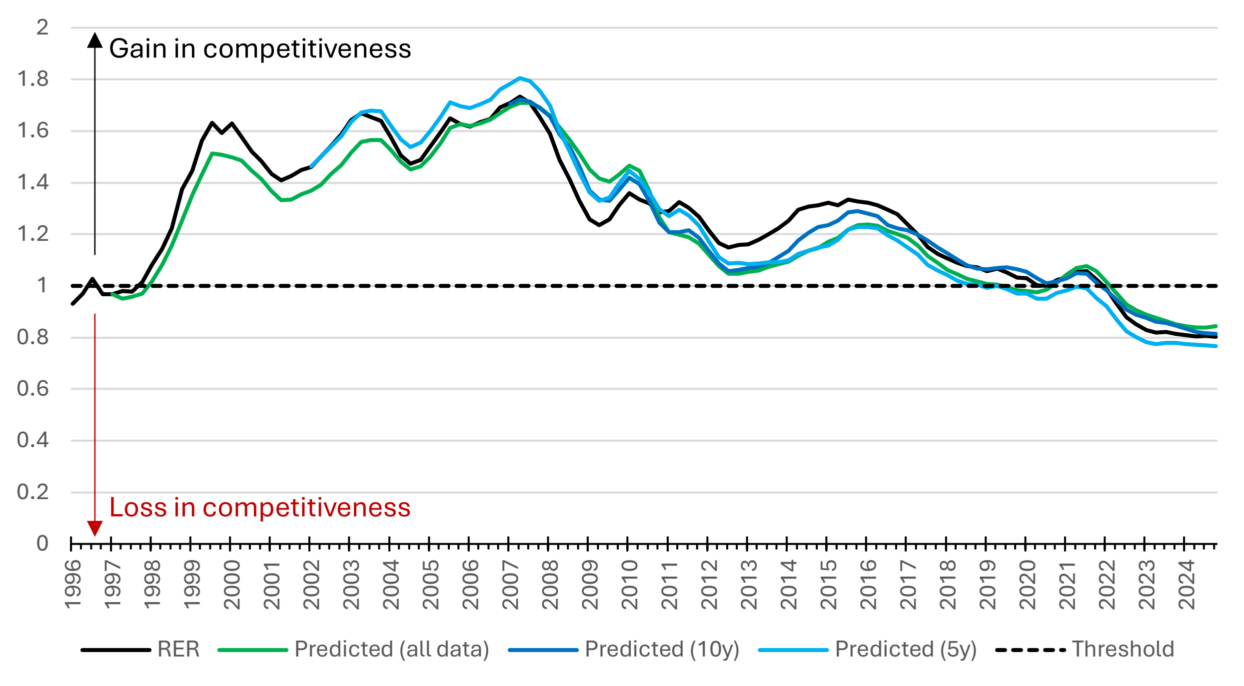

Figure 22 shows the Behavioral Equilibrium Exchange Rate plotted alongside the Real Exchange Rate. The BEER calculated on the entire historical dataset suggests that, based on the fundamentals, the exchange rate was under-appreciated between 1999 and 2004, over-appreciated between 2007 and 2010, again under-appreciated between 2010 and 2020 and is currently over-appreciated since 2022. Outside of the aforementioned periods, the exchange rate was aligned with the fundamentals.

The Behavioral RER tracks relatively closely the movements of the actual RER and broadly reflects the fundamentals and cyclical dynamics of the economy. For instance, after the 1998 crisis, when the domestic exchange rate suffered a significant depreciation, the historical RER estimated on the entire dataset becomes underappreciated when compared to the fundamentals driven Behavioral RER. This tendency continues until the 2008 crisis when an inversion occurs, largely due to inflationary pressures which pushed the RER towards appreciation. The same dynamics were observed during the post-Covid inflationary episode. Finally, the period preceding the unravelling of the Moldovan Banking Fraud of 2014-2015 was characterized by an underappreciated RER, possibly driven by the schemes involving the extraction of foreign currency from the country.

At present, the RER remains overappreciated compared to the value prescribed by the historical fundamentals, suggesting that the currency should depreciate in order for the country to regain competitiveness. Further supporting this argument is the realization that the RER is historically overappreciated, denoting the loss of any competitiveness gains realized since Moldova's independence.

But an overappreciated RER does not automatically mean that the spot rate should immediately depreciate. In fact, in the present case, the depreciation of the exchange rate cannot be considered a solution to the competitiveness problem that Moldova faces, as the fundamentals-driven Behavioral RER is also at a historic low. This points towards lower prices, increased productivity and better terms of trade as more sustainable means of boosting Moldova's competitiveness.

The Dynamic Regression BEER estimated on a 10-year rolling window is positioned closer to the RER, but maintains the same direction as the historical BEER. As the shorter timespan enhances the model's adaptability, it is able to capture more of the variability.

As for the 5-year window counterpart, due to the significantly shorter range of data being considered, the dynamics of the BEER can diverge from the longer-term trend. In fact, based on short-term movements in the data, the real exchange rate is more often viewed as over-appreciated. This reflects the gradual loss of competitiveness that the country has faced. Finally, in terms of distance from the RER, due to the adoption of the shortest window, the 5-year Dynamic Regression BEER positions itself in even closer proximity to the actual series than the 10-year variant.

7. Linkages with macro-financial indicators

Understanding the relationship between macro-financial indicators and the Behavioral Equilibrium Exchange Rate is important for effective policymaking and forecasting in an increasingly interconnected global economy. Traditional exchange rate models often fall short of explaining observed currency movements, largely because they neglect the role of investor psychology and sentiment. The BEER framework attempts to bridge this gap by incorporating behavioral biases into a fundamental equilibrium model.

The BEER framework attempts to ground exchange rates in economic fundamentals. This provides a theoretically sound basis for understanding currency valuation beyond purely speculative movements. By identifying the variables that are most strongly linked to the BEER or BEER gap, and at what lags, we can gain insights into how exchange rates adjust to economic shocks. Analyzing correlations between key macro-financial variables (like inflation, interest rate spreads, risk aversion measures, and capital flows) and deviations from the BEER allows us to identify which factors are driving exchange rate misalignments, assess market expectations and ultimately improve our ability to understand currency behavior and potential financial instability.

Furthermore, rigorously examining these correlations serves as a validation exercise for the BEER model itself. If strong, theoretically-consistent relationships emerge between macro-financial indicators and BEER deviations, it strengthens the argument that behavioral factors are indeed systematically influencing exchange rates, thereby proving the model's practical relevance and explanatory power.

7.1. The BEER and monetary policy: an analysis of interest rate effects

Table 6. Correlations between the BEER and interest rates

Variable	Cor	Wind	Construct	Lag	Cont	1q lag	2q lag	3q lag	4q lag
Interest rates									
10-Year Government Bond Yield	0.99	5Y	BEER Gap	3q lag	-0.94	0.28	0.86	0.99	-0.75
7-Year Government Bond Yield	-0.77	5Y	BEER	1q lag	-0.45	-0.77	-0.56	-0.24	0.01

5-Year Government Bond Yield	-0.68	7Y	BEER	1q lag	-0.64	-0.68	-0.49	-0.1	0.13
3-Year Government Bond Yield	-0.53	10Y	BEER Gap	1q lag	-0.48	-0.53	-0.32	-0.26	-0.11
1-Year Government Bond Yield	-0.44	5Y	BEER Gap	1q lag	-0.44	-0.44	-0.36	-0.19	-0.03
3-Month Government Bond Yield	-0.44	5Y	BEER Gap	1q lag	-0.43	-0.44	-0.37	-0.23	-0.06
Weight of 10-year Gov. Bonds in Total, Primary Market	-0.9	5Y	BEER	2q lag	0.86	-0.63	-0.9	-0.61	-0.78
Policy instruments									
Policy Rate	-0.5	5Y	BEER Gap	1q lag	-0.46	-0.5	-0.46	-0.34	-0.2
Mandatory Reserve Requirement MDL	-0.48	7Y	BEER Gap	2q lag	-0.42	-0.47	-0.48	-0.46	-0.43

This table shows the correlations between various interest rate indicators and the BEER or BEER Gap, estimated at various window lengths.

Analyzing the correlations between the BEER, BEER Gap and interest rates reveals interesting dynamics. The key takeaway is that both the BEER and the BEER Gap are strongly linked to interest rates and policy instruments, suggesting they capture important information about currency valuation beyond traditional equilibrium models.

Interest rates:

- Longer-term government bond yields (10Y, 7Y) exhibit the strongest correlations, both positive and negative, with the BEER Gap – particularly when estimated using a 5-year window. This suggests that long-term interest rate differentials play a key role in determining deviations from the behavioral equilibrium. The 10-year yield has an exceptionally high correlation (0.99) with the BEER gap at a 3 quarter lag, indicating that expectations about future exchange rates embedded in longer-term bonds strongly influence whether the RER is over or under its "fair" value as determined by behavioral factors.
- Shorter-term yields (3Y, 1Y, 3m) also correlate significantly with the BEER Gap, though to a lesser extent than longer-term rates. The consistent negative correlation suggests that increases in these shorter-term rates tend to be associated with a RER that is over-appreciated compared to its equilibrium value. Indeed, the immediate and persistent over-reaction of the RER to interest rate changes indicates that this is a very potent transmission channel which should be carefully monitored and integrated into policy calculations.

- The 7Y and 5Y yields show significant negative correlations with the BEER itself, peaking at a 1 quarter lag. This suggests that these rates are predictive of exchange rate appreciation – higher yields imply an expected strengthening of the currency (lower BEER).
- The weight of 10-year government bonds in total primary market activity shows a strong positive contemporaneous correlation with the BEER, which inverts to negative and reaches its minimum at a 2 quarter lag. This suggests that shifts in investor preference towards longer-term debt, possibly amid signs of increasing risk in the domestic economy, produce an immediate depreciation of the currency, with expectations that it will appreciate in the future (when risk diminishes again), given the higher yield typically associated with longer maturity instruments.

Policy instruments:

- The policy rate shows a moderate negative correlation (-0.5) with the BEER Gap, peaking at a 1 quarter lag. This indicates that tightening monetary policy (increasing the policy rate) is associated with an overvalued RER (lower BEER Gap), consistent with standard economic intuition.
- Mandatory reserve requirements also show a moderate negative correlation (-0.48) with the BEER Gap, peaking at a 2 quarter lag. This suggests that increasing reserve requirements (a contractionary policy that typically occurs in periods of interest rate tightening) is similarly associated with an overvalued RER.

Traditional exchange rate models often assume rational expectations and immediate adjustment to equilibrium. The fact that correlations with the BEER Gap are so strong, particularly with interest rates, suggests that over-shooting behavior may also be present. The advantage of the BEER Gap is that it captures "misalignments" driven by behavioral factors (like investor sentiment or risk aversion) not fully accounted for in standard models.

The lagged correlations highlight the predictive power of both constructs – the BEER and the BEER Gap. For example, the strong correlation between the 10Y yield and the BEER Gap at a 3 quarter lag suggests that long-term interest rate expectations can forecast future exchange rate misalignments. This is an important transmission mechanism for policymakers aiming to stabilize currency values.

The varying window size indicates that different dynamics are captured over different time horizons. Longer windows (7Y, 10Y) seem more relevant for the BEER Gap and medium-term rates (3-year, 5-year), suggesting that the dynamics of short-term bond yields are more closely aligned with a BEER driven by long-run factors. Shorter windows (5Y) appear to be more pertinent when analyzing the BEER itself with longer term or very short-term yields. This nuance is important for understanding the underlying drivers of exchange rate movements.

The correlations with policy instruments (policy rate and reserve requirements) demonstrate that the BEER and BEER Gap can provide valuable insights into the effectiveness of monetary policy. Understanding how these policies impact the gap between the actual RER and its behavioral equilibrium is important for achieving desired currency outcomes.

7.2. The relationship between external sector indicators, liquidity and the BEER

Table 7. Correlations between the BEER, trade and liquidity

Variable	Cor	Wind	Construct	Lag	Cont	1q lag	2q lag	3q lag	4q lag
Trade									
Domestic Trade - Retail	0.85	7Y	BEER Gap	3q lag	-0.79	-0.43	0.15	0.85	0.8
Domestic Trade - Wholesale	0.82	10Y	BEER	3q lag	-0.26	-0.24	0.22	0.82	0.6
Goods Transportation	0.81	7Y	BEER	3q lag	-0.17	0.08	0.59	0.81	0.53
Passenger Transport	-0.51	10Y	BEER Gap	1q lag	-0.09	-0.51	-0.05	0.38	-0.04
Customs Revenues	0.47	10Y	BEER Gap	4q lag	-0.1	0.04	0.43	0.43	0.47
Liquidity and monetary aggregates									
Excess Liquidity	-0.68	3Y	BEER	4q lag	0.06	-0.1	-0.34	-0.58	-0.68
M0 Money Supply to Economy	0.5	10Y	BEER	cont	0.5	0.45	0.32	0.23	0.15

This table shows the correlations between various trade and liquidity indicators, and the BEER or BEER Gap, estimated at various window lengths.

Trade indicators:

- The trade indicators exhibit the highest correlations among the variables captured in the table (ranging from 0.47 to 0.85). This is significant because trade flows are fundamental drivers of exchange rate determination.
- Both retail and wholesale domestic trade show strong positive correlation with the BEER Gap, peaking at a 3-quarter lag. The fact that these correlations peak with a lag suggests that changes in domestic trade influence expectations about future exchange rate misalignment, which are then reflected in the BEER Gap. A widening gap can signal unsustainable trade imbalances and potential for correction.
- Goods transportation correlates strongly with the BEER itself (0.81), while passenger transport correlates with the BEER Gap (-0.51). This suggests that goods transportation reflects long-run equilibrium conditions, captured by a 7Y window for BEER estimation,

whereas passenger transport impacts the exchange rate more rapidly given the 1 quarter lag at which the correlation peaks.

- Customs revenues correlate positively with the BEER Gap, peaking at a 4q lag. This suggests that changes in customs revenue (reflecting import/export activity) can signal future exchange rate misalignment.

Liquidity and monetary aggregates:

- Excess liquidity shows a weak positive correlation with the BEER, which gradually builds up into a strong negative correlation peaking at a 4q lag (-0.68). This is an important finding as excess liquidity often leads to currency depreciation (higher RER). Banks flush with reserves are less likely to need to borrow from each other, pushing interbank lending rates down. Lower interest rates make a country less attractive for foreign investment, reducing demand for its currency. The fact that this relationship is captured by the concurrent correlation with the BEER suggests the framework correctly incorporates monetary conditions into its equilibrium exchange rate calculation. Furthermore, the negative correlation that occurs with later lags is indicative of a confidence effect, whereby current excess liquidity gives investors confidence in the future state of the economy, leading to increased future capital inflows and the currency appreciation that comes with them.
- M0 money supply has a positive correlation with the BEER (0.5), peaking at the contemporaneous value. This indicates that current monetary aggregates are immediately reflected in the estimated long-run equilibrium exchange rate, reinforcing the BEER's relevance for understanding the impact of monetary policy on currency values.

Indicators like domestic wholesale trade and M0 money supply correlate strongly with the BEER using longer windows (10 years). This suggests that these variables are more relevant for determining long-run equilibrium exchange rates. Excess liquidity is best correlated with the BEER using a 3-year window, suggesting its impact is more correlated with medium-term exchange rate fluctuations. The prevalence of lagged correlations (especially at 3q and 4q lags) highlights that many economic indicators don't have an immediate effect on exchange rates but influence them over time through expectations and adjustments. The BEER framework, by allowing for these dynamic relationships, provides a more realistic assessment than static equilibrium models.

Indeed, the diverse set of indicators – trade, liquidity, monetary aggregates – all show significant correlations with either the BEER or the BEER Gap. This demonstrates that the BEER framework captures a broad range of factors influencing exchange rate determination. The lagged relationships and varying window sizes reveal that the Dynamic BEER and BEER Gap don't just reflect static equilibrium, but they incorporate dynamic adjustments and expectations, making them more realistic than simple purchasing power parity (PPP) or interest rate parity models.

The strong correlations with the BEER Gap highlight its usefulness as an indicator of exchange rate misalignment. Policymakers can use this gap to identify potentially unsustainable currency valuations from a trade perspective and intervene if necessary.

7.3. Interactions between the BEER, financial flows and deposit trends

Table 8. Correlations with turnover and deposit indicators

Variable	Cor	Wind	Construct	Lag	Cont	1q lag	2q lag	3q lag	4q lag
Turnover									
Cash Turnover - Consumer Goods Trade	0.54	10Y	BEER	1q lag	0.45	0.54	0.38	0.27	0.15
Cash Receipts from Foreign Currency Sales to Households	0.45	3Y	BEER	3q lag	-0.13	0.09	0.34	0.45	0.33
Cash Turnover - Other Services	0.40	7Y	BEER Gap	3q lag	0.02	0.19	0.30	0.40	0.28
Foreign Exchange Inflows - Outflows	0.39	5Y	BEER Gap	cont	0.39	0.27	0.25	0.19	0.15
Deposits									
FX Deposits Balance – Households	0.68	5Y	BEER	3q lag	0.21	0.46	0.62	0.68	0.59
Dollarization of Sight Deposits	-0.58	5Y	BEER Gap	1q lag	-0.57	-0.58	-0.51	-0.39	-0.30
Foreign Currency Deposits Balance	0.50	5Y	BEER	3q lag	0.20	0.37	0.47	0.50	0.41

This table shows the correlations between turnover and deposit indicators, and the BEER or BEER Gap, estimated at various window lengths.

Turnover:

- Cash Turnover - Consumer Goods Trade shows a strong positive correlation (0.54) with the BEER using a 10Y window and a 1q lag. This suggests that increased turnover in consumer goods trade is associated with future depreciation of the exchange rate. The diminishing correlations at longer lags suggest this relationship weakens over time.
- Cash Receipts from Foreign Currency Sales to Households initially has a negative correlation with the BEER, reflecting the exchange rate appreciation that occurs when foreign currency inflows accelerate. Subsequently, the relationship inverts and culminates with a maximum positive correlation of 0.45 at a 3q lag. This indicates that inflows from foreign currency sales are associated with future depreciation of the exchange rate. This delayed effect underscores the transient effect of foreign currency inflows, also reflected in the short 3Y window that best correlates with the indicator.
- The fact that these turnover indicators correlate with the BEER rather than the BEER Gap suggests that they reflect underlying fundamental drivers of medium to long-run

exchange rate equilibrium. Trade activity and foreign currency inflows contribute towards maintaining a sustainable level for the exchange rate and, therefore, influence its long-term value.

- Net Foreign Exchange Inflows (defined as the difference between Inflows and Outflows) has a moderate positive correlation (0.39) with the BEER Gap at a contemporaneous level using a 5Y window. This suggests that net inflows of foreign exchange are associated with a larger BEER Gap – meaning the RER is more depreciated than its fundamental equilibrium level. This relationship declines relatively rapidly, but does not completely subside within one year. This means that although the fundamentals indicate that the currency should appreciate rapidly as a result of the incoming foreign currency, in reality the appreciation is slower.

Deposits:

- The Foreign Currency Deposits Balance of Households exhibits the strongest correlation of all indicators in the table (0.68) with the BEER, using a 5Y window and a 3q lag. This is significant: higher foreign currency deposits held by households are associated with future depreciation of the exchange rate. This behavior reflects expectations of future domestic currency weakening or a preference for holding assets in a stronger currency.
- Dollarization of Sight Deposits, however, shows a strong negative correlation (-0.58) with the BEER Gap using a 5Y window and a 1q lag. This is an equally important observation: higher dollarization (a larger proportion of deposits held in foreign currency) is associated with a smaller BEER Gap – meaning the RER is more appreciated than its fundamental equilibrium level. This relationship diminishes very gradually in time, indicating that the RER is very slow to catch up to its equilibrium value. This is partially the result of stabilizing measures by the Central Bank, but also due to a re-entry of currency into the monetary circuit as loans.
- The overall Foreign Currency Deposits Balance also correlates positively with the BEER (0.5) using a 5Y window and a 3q lag, similar to the FX Deposits Balance for Households, indicating future depreciation.

The correlations with indicators like trade turnover, FX deposits, and foreign currency sales suggest that the BEER captures underlying economic fundamentals driving long-run exchange rate equilibrium. On the other hand, the BEER Gap provides a valuable diagnostic tool. Indicators like dollarization correlating strongly with the Gap highlight situations where the RER is deviating from its sustainable level, potentially signaling imbalances or risks.

7.4. The co-movement of price levels and cross-border transfers with the BEER

Table 9. Correlations with prices and transfers

Variable	Cor	Wind	Construct	Lag	Cont	1q lag	2q lag	3q lag	4q lag
Prices									
Construction Prices	-0.55	10Y	BEER Gap	cont	-0.55	-0.48	-0.25	-0.06	0.12
Fuel Prices	0.40	10Y	BEER Gap	4q lag	-0.23	-0.01	0.17	0.33	0.40

Transfers

Transfers in RUB	0.70	5Y	BEER Gap	1q lag	0.70	0.70	0.60	0.50	0.37
Transfers in USD	0.47	5Y	BEER	4q lag	0.02	0.16	0.20	0.29	0.47
Transfers in EUR	-0.35	3Y	BEER	3q lag	-0.05	-0.13	-0.24	-0.35	-0.14

This table shows the correlations between turnover and deposit indicators, and the BEER or BEER Gap, estimated at various window lengths.

Construction prices – a long-term equilibrium indicator:

- A strong negative contemporaneous correlation (-0.55) between construction prices and the BEER Gap, estimated with a 10-year window, is particularly noteworthy. This suggests that deviations from the long-run equilibrium (BEER Gap) are strongly linked to changes in construction costs. As construction prices rise, the RER tends to be overvalued relative to its behavioral equilibrium – and vice versa.
- The correlation weakens with shorter lags, becoming positive at 4q lag (0.12). This indicates that changes in construction price levels produce an immediate, transient impact on the long-term (10Y) BEER Gap, which dissipates and reverses over the course of a year.

Fuel prices – delayed impact on equilibrium:

- Fuel prices show an expected negative correlation with the BEER Gap on the short term, however the effect is milder and turns positive with a two-quarter lag. This suggests that changes in fuel prices influence the RER differently over time, pushing it away from its behavioral equilibrium.
- The increasing correlation across lags (from -0.23 at contemporaneous to 0.4 at 4q) indicates a delayed and persistent impact. Higher fuel prices eventually lead to a more depreciated RER relative to the BEER.

Transfers – short-to-medium term drivers of the BEER Gap:

- Transfers in EUR show a negative correlation (-0.35) with the BEER, peaking at 3q lag. This suggests that euro transfers have a delayed effect on the level of the equilibrium exchange rate and push it towards appreciation.
- Transfers in USD initially are uncorrelated with the BEER, but subsequently exhibit an even more delayed, positive correlation (0.47). This means that increased transfers tend to depreciate the BEER.
- A significant portion of USD transfers could be used to finance imports. While this creates demand for the local currency initially (to convert USD), it also increases demand for foreign currencies later when paying suppliers (for instance, for energy imports), potentially offsetting the initial effect and contributing to depreciation in the long run.

The strong correlations between prices and longer windows of the BEER Gap (e.g., construction prices and the 10Y BEER Gap) suggest that price levels determine long-run equilibrium conditions. On the other hand, transfers impact the short-term equilibrium.

7.5. The BEER and fundamental economic factors: revenue, supply and demand

Table 10. Correlations with supply, demand and revenue indicators

Variable	Cor	Wind	Construct	Lag	Cont	1q lag	2q lag	3q lag	4q lag
Production									
Industrial Production – Industry	0.52	3Y	BEER	1q lag	0.26	0.52	0.51	0.3	0.16
Consumption									
Share of New Loans in Financing Consumption	0.51	10Y	BEER Gap	1q lag	0.37	0.51	0.5	0.26	0.09
Revenue and wage									
Disposable Income of the Population	0.5	10Y	BEER Gap	2q lag	0.31	0.45	0.5	0.45	0.17
Average Number of Employees	0.48	10Y	BEER Gap	3q lag	-0.06	-0.07	0.32	0.48	0.27
Real Wage – Real Sector	0.47	10Y	BEER Gap	1q lag	0.36	0.47	0.43	0.22	-0.02
Payroll Fund – Real Terms	0.43	10Y	BEER Gap	2q lag	0.27	0.38	0.43	0.28	0.04

This table shows the correlations between production, consumption, revenue and wage indicators, and the BEER or BEER Gap, estimated at various window lengths.

A significant observation is that most indicators in this group exhibit their strongest correlation with the BEER Gap rather than the BEER itself. This suggests that deviations from the fundamental equilibrium (captured by the BEER) are more readily explained by changes in economic variables than the absolute level of the equilibrium rate. This is significant because it implies that understanding why a currency deviates from its "fair" value (the BEER Gap) is easier to quantify, and both micro- and macroeconomic indicators help explain these deviations.

Supply and demand factors:

- The fact that industrial production correlates most strongly with the *BEER* itself (rather than the gap) and at a short lag suggests it's a key driver of the long-run equilibrium exchange rate. Changes in productive capacity directly affect trade flows and relative prices, influencing where the BEER settles. Increased industrial production often goes hand-in-hand with technological advancements and efficiency improvements – leading to higher productivity in the domestic manufacturing sector. The increase in productivity lowers the cost of producing goods domestically, which leads to lower domestic price levels (or slower price increases) relative to foreign prices. As a consequence, the RER depreciates, making domestic goods more competitive. This is a key long-run benefit of increased industrial production – it can improve export competitiveness without necessarily relying on nominal exchange rate depreciation.

- Industrial production has its strongest correlation with the BEER at a 1-quarter lag. This suggests that changes in industrial output quickly influence expectations about the equilibrium exchange rate, potentially through their impact on trade balances or relative price levels.
- Consumption, as measured by the "share of new loans in financing consumption" has a strong positive correlation with the BEER Gap which peaks with a 1 quarter lag. This is indicative of a rapid effect which interferes with the equilibrium exchange rate. Increased consumption makes the RER increasingly under-appreciated compared to its fundamental value.

Revenue indicators:

- Disposable Income, Average Employees, Real Wage and Payroll Fund show increasing correlations with the BEER Gap at lags of 2-3 quarters. This suggests that changes in these fundamental variables take time to influence expectations and ultimately impact the exchange rate through its deviation from equilibrium. For example, a rise in disposable income might not immediately lead to currency appreciation but will do so after several quarters as consumption patterns adjust and capital flows respond.

The table consistently shows 10-year windows being associated with the highest correlations for most variables linked to the BEER Gap, while Industrial Production has a correlation maximized using a 3-year window against the BEER. This signifies that long-term economic fundamentals are more strongly related to deviations from equilibrium (BEER Gap). Indeed, factors influencing whether a currency is over- or undervalued tend to be persistent and unfold over longer time horizons. The shorter window for Industrial Production suggests that it has an impact on the short-term equilibrium rate itself, rather than deviations from long-term fundamentals.

In terms of the "speed of impact", supply and demand factors manifest maximum correlation with the BEER or BEER Gap with a one quarter delay, whereas revenue variables have correlations that peak with a 2 or 3-quarter lag.

7.6. Assessing the interplay between the BEER, the REER and credit conditions

Table 11. Correlations with lending indicators and the REER

Variable	Cor	Wind	Construct	Lag	Cont	1q lag	2q lag	3q lag	4q lag
Lending and Indebtedness									
Foreign Currency Loan Balance – Households	-0.44	7Y	BEER	4q lag	-0.25	-0.31	-0.36	-0.4	-0.44
MDL (Moldovan Leu) Loan Balance – Corporates	0.43	7Y	BEER Gap	3q lag	0.28	0.36	0.41	0.43	0.4

Degree of Indebtedness of the Economy	0.4	3Y	BEER Gap	2q lag	0.38	0.38	0.4	0.39	0.39
USD Foreign Currency Demand on the Economy	-0.4	5Y	BEER	3q lag	-0.34	-0.37	-0.39	-0.4	-0.39
Other exchange rate measures									
REER	-0.32	5Y	BEER	1q lag	-0.3	-0.32	-0.32	-0.32	-0.32

This table shows the correlations between lending and indebtedness indicators and the BEER, as well as BEER-REER interactions.

Across all indicators, one can observe non-trivial correlation coefficients (ranging from -0.44 to 0.43). This indicates that these economic factors systematically relate to either the BEER or the deviation of the RER from its equilibrium level (BEER Gap).

Many of the highest correlations are found with lagged values of the BEER/BEER Gap. This suggests that the indicators aren't necessarily related to the current exchange rate but rather interact with it in the future. This aligns well with the behavioral economics underpinning the BEER, which posit that exchange rates are driven by expectations and slowly adjusting behavior.

Lending and indebtedness:

- The Foreign Currency Loan Balance to Households (-0.44 correlation with the BEER at 7Y window, 4q lag): manifests the strongest negative correlation among lending indicators. A higher balance of foreign currency loans held by households likely puts upward pressure on domestic prices (including, for instance, housing prices). This leads to an appreciation of the RER. The 7-year window and 4-quarter lag needed for the correlation to peak suggest this effect unfolds over a longer period, reflecting how increased household debt gradually feeds through into prices and influences future exchange rates.
- A higher Balance of MDL Loans to Corporations (0.43 correlation at 7Y window, 3q lag) suggests greater domestic investment and potentially lower prices, leading to an under-appreciated RER compared to the behavioral equilibrium. The longer window again points to a gradual effect with a correlation that peaks in the third quarter and then begins to subside.
- Higher overall indebtedness (0.4 correlation at 3Y window, 2q lag) produces a rapid and persistence effect on the BEER Gap. Higher debt continues to drive the economy and fuel the same transmission mechanism associated with the national currency loan balance, but increased indebtedness also increases risk aversion and capital outflows (or a slowdown in inflows), inducing a sustained linkage the BEER Gap.

REER and BEER – misalignment:

- The moderate negative correlation between the actual Real Exchange Rate (REER) and the BEER is expected when there are prolonged deviations from the BEER, as evidenced by the high correlations observed with the BEER Gap across all micro- and macroeconomic indicator groups. The difference between the REER and BEER is precisely the impact of the behavioral factors included in the BEER model, which attempts to quantify how much exchange rates deviate from PPP because of things like investor sentiment, risk aversion or habits.

8. Conclusion

This paper introduced the Dynamic Behavioral Equilibrium Exchange Rate model which makes it possible to adjust the time frame of a BEER model to suit the analytical horizon of the policymaker. This enables shorter-run equilibrium dynamics to be investigated and produced interesting results for Moldova. While long-run tendencies suggested that Moldova's currency underwent cycles of over- and under-appreciation, shorter-term dynamics revealed that the currency was consistently over-appreciated.

The BEER model itself was enhanced to include an additional regressor of particular importance to small, open economies such as Moldova where a large share of the population works abroad – the Remittances / GDP indicator. With an indicator mix containing the traditional BEER variables and the new addition and a relatively long time series, it was possible to achieve significantly higher R^2 results than previous estimations of models both from within this class, as well as from other methodologies.

Furthermore, the paper introduced two new performance metrics – the Dynamic Partial R^2 and the Relative Dynamic Partial R^2 which quantify the contribution of each individual variable to the overall explanatory power of the model and allow for an identification of key drivers and temporal shifts in their structure. The Partial R^2 indicator which was also calculated for the dynamic regressions provides a metric quantifying the performance of the 10-year and 5-year window estimations, which achieve even closer fits than the full series BEER.

The innovations presented in this paper allow for targeted investigations of the transmission mechanisms at play within an economy and contribute to a better understanding and identification of the dominant channels of effects at any given time within an economy. They also allow for a detection of turning points, where the tendencies and relationships between variables change. This is particularly useful for the detection of crisis episodes and their impact on the interactions between the macro-financial landscape and the exchange rate.

9. References

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