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External Debt-Driven Unemployment, Exchange Rate Volatility, And Interest Rates: Hysteresis Effect Evidence from the Burundian Economy

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Abstract

This study examines the determinants of unemployment in Burundi through a vector error correction model (VECM) incorporating the unemployment rate, exchange rate volatility, lending interest rate, their interaction term, and the stock of external debt over the period 1991-2025. The results reveal that external debt is the dominant structural determinant of long-term unemployment (t = -8.217), with a speed of adjustment significantly lower than that of the debt (-0.020 < 2.298), generating a hysteresis effect confirmed by the historical episodes of 2004, 2009, and 2015. Moreover, the analysis of marginal effects shows that the impact of exchange rate volatility on unemployment is not fixed but is conditioned by the prevailing interest rate regime, shifting from a positive and significant effect at low rates to a negative effect beyond an estimated critical threshold of 10.02%. These results highlight a dual hysteresis dynamic— driven by external debt and modulated by the exchange rate-interest rate interaction—and call for strengthened coordination between debt management, exchange rate policy, and monetary policy to sustainably mitigate unemployment in the Burundian economy.

1. Introduction

Small open African economies are overall dependent on importation of intermediate goods, capital goods, and petroleum products, and they have restricted and high-cost access to world financial markets (IMF, 2023). These dual limitations make these economies especially fragile to external shocks, such as commodity price changes, monetary tightening in the advanced economies, or fluctuations in capital flows. Burundi is a good case in point. The country is a low-productive, undiversified economy with a high reliance on public development aid, and it transmits external shocks to the real economy in a short time. World Bank statistics indicate that over 60% of Burundi's imports are intermediate goods and fuel, which directly affects the cost of production and households' purchasing power when the Burundian franc depreciates (World Bank, 2024). First, despite moderate average economic growth, the youth unemployment rate is structurally high, estimated by the International Labour Organisation at 13.6%. Second, the Burundian franc (BIF) depreciated by more than 38% against the US dollar over the same period, with episodes of high volatility linked to balance of payments tensions and foreign exchange reserves (BRB, 2023). Third, the average lending rate of commercial banks remained abnormally rigid, fluctuating between 11% and 14%, even as the Central Bank's (BRB) policy rate underwent several adjustments. This downward rigidity in the cost of credit suggests a disconnect between monetary policy instruments and the actual financing conditions of the economy. The concurrence of these three trends necessitates an integrated analysis of transmission channels.

The theoretical literature offers three main channels for explaining the relationship between exchange rate volatility and unemployment. The first channel, derived from the Mundell-Fleming model with nominal rigidities, posits that an unexpected depreciation of the exchange rate increases the cost of imported inputs and worsens the financial situation of firms heavily indebted in foreign currency, leading to reduced output and layoffs in the short term (Obstfeld & Rogoff, 1995). The second channel, inspired by the theory of critical elasticities, suggests that in the medium term, a competitive depreciation can stimulate exports and import substitution, resulting in job creation if the Marshall-Lerner condition is met (Aguirre & Calderón, 2005). The third channel is that of the uncovered interest rate parity (UIP) hypothesis, according to which, in the presence of expectations and in the absence of a risk premium, the interest rate differential between two countries should exactly offset the expected depreciation of the exchange rate (Meredith & Chinn, 1998).

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In short, this hypothesis states that the interest rate predicts future fluctuations in the exchange rate. This hypothesis is also widely discussed in international finance literature, although it is controversial (Chinn & Meredith, 2005; Chinn & Zhang, 2015; Engel, 1996; Engel, 2016 ; Engel et al., 2022). For an economy like Burundi, where the productive structure is undiversified and export capacity is limited by supply constraints, the first and third channels are likely to dominate the second competitiveness effect.

Empirical evidence on the relationship between exchange rate volatility and unemployment remains ambiguous, particularly for sub-Saharan African countries. Bahmani-Oskooee & Gelan (2018), using panel data for 12 African countries over the period 1980–2015, found that exchange rate volatility has a significant negative effect on exports and thus indirectly on employment. Aguirre & Calderón (2005), meanwhile, show that real exchange rate misalignment has a robust negative effect on economic growth in developing countries, resulting in job losses. However, the magnitude and even the sign of this effect depend heavily on the structure and composition of imports. The lack of specific empirical studies in Burundi using recent data warrants further analysis, as the country's heavy reliance on intermediate goods imports could amplify the negative effect of exchange rate volatility on employment.

The second relationship concerns the impact of interest rates on unemployment. According to the New Keynesian Synthesis (Clarida et al., 1999), interest rates influence economic activity. When the interest rate is increased, people face a higher cost of borrowing money, leading to reduced investments in the private sector and reduced consumption of products by households. This leads to an increase in the unemployment rate within those developing countries. However, such a scenario only happens when banks adjust their lending rates as quickly as the central bank adjusts the policy rate and when businesses have access to alternative sources of financing. Such conditions are rarely present in low-income countries with underdeveloped financial systems. In smaller African economies, for instance, interest lending interest rate tends to possess an exogenous nature with respect to the internal macroeconomic state of the country. As Mishra et al. (2010) show, the monetary transmission mechanism in the case of poor countries is ineffective because of weak banking competition, the prevalence of the informal sector, and dollarization. In this case, the main factors that influence the behavior of the lending rate are the risk premium, international interest rates, and liquidity problems in the banking system, but not the central bank policy rate. According to the IMF (2023), the pass-through of the policy rate to the lending rate in sub-Saharan Africa is incomplete and lasts, on average, more than six quarters. As for Burundi, this is evidenced by the BRB's annual report (2023).

The third relationship, closely related to the second, concerns the link between exchange rate volatility and lending interest rates. The uncovered interest rate parity (UIP) condition implies that any increase in exchange rate volatility must be offset by a higher risk premium, resulting in higher interest rates to attract capital and protect lenders. In partially dollarized economies, this mechanism is reinforced by the "fear-of-float" phenomenon described by Calvo & Reinhart (1999). Banks, anticipating depreciation, increase their margins on local currency loans and ration foreign currency lending. Reinhart et al. (2003) show that in countries with a history of monetary instability, exchange rate risk is structurally built into the price of credit and has a lasting impact on the supply of loans.

The Burundian banking system has several characteristics that reinforce the link between exchange rates and interest rates. First, the shallow depth of the interbank market forces banks to refinance externally at rates indexed to the Secured Overnight Financing Rate (SOFR). Second, the partial dollarization of deposits and loans directly exposes bank balance sheets to exchange rate risk (BRB, 2023). Third, the concentration of the banking sector limits competition and allows banks to quickly pass on exchange rate shocks to their customers through spread adjustments. As a result, episodes of sharp depreciation of the Burundian franc (BIF) are almost always accompanied by a tightening of credit conditions, which reinforces the procyclical nature of the cost of capital and limits the effectiveness of monetary policy. This cannot happen without affecting the labor market.

Beyond the aforementioned bilateral relationships, the main contribution of this paper is to analyze the impact of the exchange rate volatility and the lending interest rate interaction on Burundian unemployment rate. The traditional theory suggests a three-stage mechanism. An external shock, such as monetary tightening by a foreign central bank such as the Federal Reserve or a rise in oil prices, first causes increased exchange rate volatility. This volatility increases the risk premium and makes lending rates more rigid and exogenous, as banks prioritize preserving their margins and hedging risk over supporting credit to the real economy (Calvo & Reinhart, 1999). Finally, the combination of a volatile exchange rate and expensive, rigid credit reduces private investment, compresses aggregate demand, and generates structural unemployment that conventional monetary policy instruments cannot stabilize (Berg et al., 2006). However, the effective effect of the exchange rate volatility on labor market depends on the behavior of the Central Bank with respect to the level of the lending interest rate. Hence, this external-driven transmission channel of the interaction between exchange rate volatility and lending interest rate on unemployment is analyzed for Burundi.

1.1 Gaps in the literature and justification for the study

Notwithstanding the crucial role that the transmission channel driven by the externals plays in theory, we have found little research devoted to its estimation on the empirical level in the case of Burundi. Although the 2023 International Monetary Found report and the 2024 World Bank report provide an analysis of the situation, they do not estimate any structural model and thus cannot identify the dynamics involved. In those academic articles where there is some research on the transmission channel, either inflation or economic growth was considered without taking into account unemployment, exchange rate volatility, and the interest rate framework. Moreover, the hypothesis about the interaction between exchange rate volatility and the lending interest rate is novel in the case of Burundi.

1.2 Objectives and methodology

The primary goal of this research is the estimation of the dynamics of the impacts of exchange rate volatility and interest rate exogeneity in Burundi over the period 1991-2025. For this purpose, this paper reviews the existing theoretical and empirical literature, then, using a Vector Error Correction Model (VECM) depending on the properties of the data, it considers both short-term and long-term relationships among the studied variables. The estimating methodology involves such tools as Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root tests, the Johansen cointegration test, and marginal effect analyzis. Hence, this paper contributes to scientific knowledge in two ways. Firstly, it is the first empirical estimation of the interaction between exchange rate volatility and interest rate in Burundi. Secondly, it uses VECM and some algebra to depict and analyze the significance of the marginal effect of exchange rate volatilty on unemployment in Burundi. Overall, this paper fills an important gap in the literature on low-income countries and has implications for the monetary and employment policy.

2 Theoretical and Empirical Literature Review

2.1 Review of Concepts and Theoretical Review

Unemployment and external-driven framework

Unemployment is a state where people of working age lack employment, are ready for work, and are seeking work opportunities. Unemployment is mainly structural in low-income countries such as Burundi, being associated with large informal economy. According to the "Externally-driven" unemployment assumption, in these types of economies unemployment cannot be explained only with internal factors of labor supply and demand but rather can be highly affected by external shocks conveyed through foreign trade and international financial conditions. The Externally driven theory is highly applicable in the case of Burundi, where more than 60% of its imports are intermediate goods (World Bank, 2024).

Exchange rate volatility and transmission channels

Exchange rate volatility refers to the degree of fluctuation in currency values over time, caused by changes in market conditions and currency demand (Naib & Guati, 2022). Theoretically, the literature identifies two opposing channels. The "cost channel", derived from the Mundell-Fleming model with nominal rigidities, stipulates that depreciation increases the cost of imported inputs, compresses firm margins, and destroys jobs in the short term (Obstfeld & Rogoff, 1995). The "competitiveness channel", derived from the theory of critical elasticities, postulates that in the medium term, depreciation makes exports more competitive and stimulates employment in tradable sectors if the Marshall-Lerner condition is met (Aguirre & Calderón , 2005). For an economy like Burundi, characterized by a small export base and a high dependence on imports, the cost channel is a priori dominant.

The lending interest rate and the concept of exogeneity

The interest rate on loans represents the price of borrowing from the banks. Under the theory of the New Keynesian Synthesis, the interest rate represents the major channel through which monetary policy influences the real sector (Clarida et al., 1999). An increase in the interest rate will raise the cost of capital, reduce investment, and cut consumer spending, resulting in a fall in aggregate demand and an increase in unemployment. Exogeneity means that the lending interest rate in the country is not mostly influenced by domestic fundamentals but rather by external variables, such as the interest rates set by the central bank in advanced economies, country risk premiums, and international financing costs (Mishra et al., 2010).

The External-Driven Transmission Channel: Interaction Theory

The interaction theory stipulates that exchange rate volatility and interest rate can interact through a single external transmission channel. An external shock, such as monetary tightening by the Fed or a rise in oil prices, initially generates increased exchange rate volatility. This volatility increases uncertainty and the risk premium. Commercial banks, to protect themselves, increase their margins and ration credit, making lending rates more rigid and exogenous (Calvo & Reinhart, 1999). Finally, the combination of a volatile exchange rate and expensive credit reduces private investment and aggregate demand, resulting in a structural increase in unemployment (Berg et al., 2006). This mechanism is reinforced in partially dollarized economies where exchange rate risk is directly integrated into the price of credit (Reinhart et al., 2003). Furthermore, the assumption of the uncovered interest rate parity (UIP) comes into play and implies that any increase in exchange rate volatility must be offset by a higher risk premium, resulting in higher interest rates to attract capital and protect lenders. In partially dollarized economies, this mechanism is reinforced by the "fear-of-float" phenomenon described by Calvo & Reinhart (1999). Banks, anticipating depreciation, increase their margins on local-currency loans and ration-foreign currency lending. Reinhart et al. (2003) show that in countries with a history of monetary instability, exchange rate risk is structurally built into the price of credit and has a lasting impact on the supply of loans.

2.2 Review of the Empirical Literature

This empirical literature is organized according to the direction of effects found in the paired relationships of the variables of interest in this study.

Relationship between exchange rate volatility and unemployment

Several empirical studies find a significant positive effect of exchange rate volatility on unemployment. For example, Bahmani-Oskooee & Gelan (2018), using the ARDL method on a panel of 12 African countries from 1980 to 2015, show that exchange rate volatility significantly reduces exports and manufacturing job growth. The channel is uncertainty: firms postpone their investment and hiring decisions. Aguirre & Calderón (2005), in a study of 60 developing countries, find that real exchange rate misalignment reduces GDP growth by 1 to 2 percentage points, resulting in job losses. Belke & Gros (2001) show that, for EU countries, exchange rate volatility increased unemployment by 0.5 percentage points in exposed sectors. For East Africa, Ndung'u (1999) finds that in Kenya, episodes of sharp depreciation coincided with a rise in urban unemployment due to the increased cost of imported inputs. Nonetheless, a second strand of thinking finds a negative relationship between exchange rate volatility and unemployment. For instance, Rodrik (2008) found that for 184 countries, real undervalued exchange rates lead to an increased share of GDP by the industrial sector and hence employment. In Brazil, Gala & Lucinda (2006) found that the 1999 depreciation helped in reducing unemployment through manufactured exports. As for Africa, the World Bank (2024) found that depreciation led to higher agricultural employment in countries exporting cocoa and coffee such as Côte d'Ivoire. Nonetheless, there is a third body of research that finds no significant relationship at all. For instance, Arize et al. (2000), for 13 developing countries, found that controlling for growth had no significant effect on unemployment.

Relationship between lending interest rates and unemployment

It is theoretically evident that there is a positive relationship between the interest rate and unemployment levels. According to Clarida et al. (1999), the interest rate channel works effectively to stabilize unemployment through the DSGE model. In terms of evidence from empirical studies, Mishra et al. (2010) show that a 1% increase in the lending rate reduces private sector credit growth by 3 percentage points and increases unemployment with a two-quarter lag in 29 low-income countries. The IMF (2023), through its Regional Economic Outlook, explains that the interest rate increase of 2022-2023, aimed at reducing inflation, cost 0.8 percentage points of employment growth in sub-Saharan Africa. Christiano et al. (2005) have confirmed in the US that the interest rate shock is the main source of short-term changes in the unemployment level. However, there are some studies that have shown an inverse or no relation between interest rates and unemployment rates in developing countries. According to Mishra et al. (2010), in 40% of their sample, there is no impact of lending rate on investment due to prevalence of informal sectors. Similarly, Bleaney & Greenaway (2001) argue that for African countries, monetary policy does not influence the real unemployment rate because of structural rigidities. IMF (2023) stresses that when there is structural unemployment, reduction in interest rates will not lead to creation of employment opportunities. On the other hand, Bernanke & Gertler (1995) show that the credit channel is weak when the financial system is shallow.

Relationship between exchange rate volatility and lending interest rates

The positive link between exchange rate volatility and interest rates is supported by several studies. Frenkel & Razin (1986) theoretically demonstrate that exchange rate volatility increases the risk premium. Calvo & Reinhart (1999), in a study of 39 emerging countries, found that countries with high exchange rate volatility have real interest rates 3 percentage points higher. Hausmann et al. (2001) show that dollarization forces banks to pass on exchange rate risk to the cost of credit. For Africa, Aizenman et al. (2015) show that countries with a flexible exchange rate regime have more volatile interest rates because markets demand a higher risk premium. Few studies find a negative correlation between exchange rate volatility and interest rates. Among these few studies is Edwards (1996), who shows that to maintain a fixed exchange rate, the central bank can lower rates and inject liquidity, which temporarily reduces the lending rate despite volatility. On the other hand, Reinhart et al. (2003) show that in highly dollarized countries, the interest rate depends more on expected inflation than on exchange rate volatility.

2.3 Research Questions and Hypotheses

The previous are the major findings of the literature review. First, there are many studies supporting the External-Driven hypothesis in relation to significant positive effects. Second, there are some studies providing a different point of view about the issue, suggesting negative effects in relation to competitiveness. Third, there are other studies suggesting that the effect is neutral because of structural rigidities. In the case of Burundi, the absence of studies covering simultaneously the exchange rate volatility, interest rate, and their interaction on unemployment is a major gap. This study is supposed to answer the following research questions, based on theoretical and empirical analysis:

- Question 1: Does exchange rate volatility have an increasing effect on the unemployment rate in Burundi?
- Question 2: Is the external-driven unemployment hypothesis valid in the Burundian economy?
- Question 3: What effect does the interrelationship between exchange rate volatility and interest rates have on unemployment dynamics in Burundi?
- Question 4: Is the effect of exchange rate volatility on unemployment conditional on the interest rate regime in force in Burundi?

In order to respond to these research questions, the following hypotheses are formulated:

- Hypothesis 1: Exchange rate volatility has an increasing and significant effect on the unemployment rate in Burundi.
- Hypothesis 2: The external-driven unemployment hypothesis is valid in the Burundian economy.
- Hypothesis 3: The interaction between exchange rate volatility and interest rates increases unemployment in Burundi.
- Hypothesis 4: The effect of exchange rate volatility on unemployment is conditional on the interest rate regime in force in Burundi.

3 Variables, data, and model specification

In this article, we use a three-principal-variable model: UR, the unemployment rate (unemployment as a percentage of the total labor force, modeled ILO estimates); IR, the lending interest rate; and ERV, the exchange rate volatility (calculated using official USD/BIF exchange rate data from 1991 to 2025). Exchange rate volatility was calculated using the return and standard deviation method, as the standard deviation is the most commonly used measure of volatility. It expresses the dispersion of values around the mean. This approach allows to track the evolution of annual exchange rate volatility over time, capturing periods of high instability. This computation is based on the following formula for logarithmic returns, r_t:

$$r_t = \ln\left(\frac{Exch_t}{Exch_{t-1}}\right) \tag{1}$$

Volatility, which is the standard deviation of log returns, is calculated using the formula:

$$\sigma_t = \sqrt{\frac{1}{2}\sum_{i=0}^{N}(r_{t-i} - \bar{r})^2} \tag{2}$$

However, a fourth foreign variable, EDS, external debt stocks (measured as a percentage of GNI), is added to better control for the externally driven unemployment hypothesis. The data used in this article are drawn from the World Bank's World Development Indicators database. The study period spans from 1991 to 2025 and was dictated by data availability. Therefore, the basic specified model is as follows:

$$UR_t = (ERV_t, IR_t, EDS_t) \tag{3}$$

As first step, before we look at the characteristics of our time series, we need to consider three years that changed things in the Burundian economy: 2004, 2009, and 2015. In Burundi's political history, 2004 is a pivotal year, marking the transition from the war period of 1993-2003 to a post-war era. 2009 represents the completion of multilateral debt relief under the Heavily Indebted Poor Countries Initiative (HIPC), which saw the debt amount decrease from 154% of GDP in 2008 (before the completion point in 2009) to 48 % in 2010 (Juana & Wolpe, 2006). As for 2015, it is the year in which Burundi was shaken by a new wave of political crisis. Threfore, we added three variables, D2004, D2009, and D2015, to account for these changes. Thus, the previous specification becomes:

$$UR_t = (ERV_t, IR_t, EDS_t, D2004, D2009, D2015) \tag{4}$$

4 Results presentation and conclusion

4.1 Estimation results

We begin by studying stationarity to determine the order of integration of the series. Two commonly used tests, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, are used. The results of these tests are given in Tables 1 and 2 below.

Analysis of stationarity and order of integration of series

Table 1. Results of the ADF Unit Root Test

Model		ADF-Statistics			
	At level				
Variables		UR	ERV	IR	EDS
With Constant	t-Statistic	-0.87097	-2.191622	-0.856175	-0.843877
	Prob.	0.7850	0.2129	0.7897	0.7936
	Significant	No	No	No	No
With Constant & Trend	t-Statistic	-2.594217	-2.188087	-1.864936	-1.865576
	Prob.	0.2851	0.4802	0.6504	0.6501
	Significant	No	No	No	No
Without Constant &Trend	t-Statistic	-1.394707	-0.925297	-0.479494	-0.749923
	Prob.	0.1486	0.3084	0.5006	0.3841
	Significant	No	No	No	No
	At first-difference				
With Constant	t-Statistic	-3.656981***	-3.401096**	-4.874710***	-4.473472***
	Prob.	0.0097	0.0181	0.0004	0.0012
	Significant	Yes	Yes	Yes	Yes
With Constant & Trend	t-Statistic	-3.582471**	-3.330861*	-5.172307***	-4.387314***
	Prob.	0.0470	0.0786	0.0010	0.0074
	Significant	Yes	Yes	Yes	Yes
Without Constant &Trend	t-Statistic	-3.466727***	-3.429137***	-4.916914***	-4.516422***
	Prob.	0.0011	0.0012	0.0000	0.0000
		Yes	Yes	Yes	Yes

Note (*): ***, ** and * denote significant at 1%; 5% and 10% levels, respectively. No: Not stationary; Yes: Stationary.
*Mackinon (1996) one sided P-Value.
Source: Authors'computation using Eviews 14.

From Table 1 above, in level, for the three specifications tested (with constant; with constant and trend; without constant or trend), none of the four variables (UR, ERV, IR, EDS) rejects the null hypothesis of existence of a unit root in the ADF. All probabilities are well above the 5% (and even 10%) threshold, meaning that H0 (presence of a unit root) cannot be rejected for any of the four series level analysis. However, in first-difference analysis, the rejection of H0 is clear and generalized across all three specifications. All ADF statistics in first-difference analysis reject H0 at the 5% threshold at a minimum (ERV with trend is significant only at the 10% threshold, a borderline case but consistent with the rest of the table).

Table 2. Results of the Phillips-Perron Unit Root Test

Model		PP-Statistics			
	At level				
Variables		UR	ERV	IR	EDS
With Constant	t-Statistic	-0.395316	-1.896041	-1.111889	-0.965386
	Prob.	0.8990	0.3302	0.6997	0.7543
	Significant	No	No	No	No
With Constant & Trend	t-Statistic	-1.767502	-1.989174	-1.864936	-2.0040024
	Prob.	0.6982	0.5862	0.6504	0.5784
	Significant	No	No	No	No
Without Constant &Trend	t-Statistic	-1.938781	-0.590386	-0.473510	-0.779634
	Prob.	0.0513*	0.4542	0.5030	0.3710
	Significant	Yes	No	No	No
	At first-difference				
With Constant	t-Statistic	-3.459840**	-3.393513**	-4.874710***	-4.388485***
	Prob.	0.0158	0.0185	0.0004	0.0015
	Significant	Yes	Yes	Yes	Yes
With Constant & Trend	t-Statistic	-3.370867*	-3.3113779*	-5.160324***	-4.291722***
	Prob.	0.0728	0.0820	0.0011	0.0093
	Significant	Yes	Yes	Yes	Yes
Without Constant &Trend	t-Statistic	-3.398274***	-3.417835***	-4.917422***	-4.459254***
	Prob.	0.0013	0.0012	0.0000	0.0001
		Yes	Yes	Yes	Yes

Note (*): ***, ** and * denote significant at 1%; 5% and 10% levels, respectively. No: Not stationary; Yes: Stationary.
*Mackinon (1996) one sided P-Value.
Source: Authors'computation using Eviews 14.

From Table 2, at level, the findings are identical in both the "with constant" and "with constant and trend" specifications: no rejection of H0 (the p-value is in between 0.33 and 0.90). The only exception appears in the "without constant or trend" specification, where UR shows p-value = 0.0513, just barely significant at the 10% level—a marginal and isolated result. In terms of first differences, the PP test fully confirms the conclusions of the ADF test: rejection of H0 for all four variables in the three specifications, at significance levels between 1% and 10%.

The two tests, although based on different corrections for autocorrelation and heteroscedasticity of the residuals (parametric correction by adding lagged differenced terms for the ADF; nonparametric Newey-West correction for the PP), lead to the same qualitative conclusion for all four series. This convergence strengthens the robustness of the diagnosis—a result specific to a single test would have been more fragile. The marginal PP result for UR (p-value = 0.0513 in the "no constants or trends" category) does not invalidate the overall conclusion, for two scientific reasons: (i) the threshold is crossed only at the 10% level, not at the conventional 5% level; (ii) the "no constants or trends" specification imposes a zero mean under H0, a restriction rarely justifiable economically for a macro-financial series—it is generally only used as an auxiliary/robustness test, not as the reference specification for the decision. The ADF test on the same series and specification does not reject H0 (p-value = 0.1486), confirming the isolated nature of this anomaly. Consequently, all series are non-stationary in level but stationary after a single differencing, in both tests and in almost all specifications. Thus, the four variables UR, ERV, IR, and EDS are each integrated of order 1, I(1)—non-stationary in level, stationary in first difference. Formally: UR ~ I(1), ERV ~ I(1), IR ~ I(1) and therefore ERVIR= ERV×IR ~ I(1) by product of two I(1) processes. No variable is I(0) in level, none is I(2).

Lag length determination

Table 3. Lag order selection

Lag	LogL	LR	FPE	AIC	SC	HQ
System 1 without the interaction term						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-124.2144	NA	0.057909	8.497840	9.2234420	8.741976
1	-59.67891	97.78099*	0.003164*	5.556298	7.007457*	6.044569*
2	-42.67220	21.64492	0.003290	5.495285*	7.672023	6.227691
System 2 with the interaction term						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-90.70249	NA	0.000568	6.709242	7.616216	7.014411
1	-1.428028	129.8538*	1.23e-05*	2.81820*	4.854512*	3.500451*
2	18.64075	23.10950	2.06e-05	3.112682	6.287092	4.180774

* Indicates lag order selected by the criterion. LR is the likelihood ratio, FPE is Final prediction error, AIC is Akaike information Criterion, SC is Schwarz information criterion, and HQ is the Hannan-Quinn information criterion.
Source: Authors'computation using Eviews 14.

According to the results in Table 3, 4 out of 5 criteria converge toward Lag = 1 for the system without the interaction tem (upper panel of Table 3). Only the AIC designates Lag = 2, and the difference is extremely small (5.495285 against 5.556298, a difference of only 0.061). The discrepancy between the AIC and the other four criteria is not insignificant—it corresponds to a well-documented phenomenon in the econometric literature:

The AIC is an asymptotically inefficient criterion: it does not sufficiently penalize the addition of parameters and tends, in small samples, to systematically select excessively high lag orders (over-parameterization), because its penalty term (2k) grows more slowly than that of the SC (k·ln(T)) as T decreases. With only 33 observations here, this over-selection bias of the AIC is particularly concerning.

The SC (Schwarz) and the HQ are asymptotically consistent: they identify the true order with a probability approaching 1 as T increases, and are considered more reliable than the AIC precisely in small samples like this one. The sequential LR also confirms Lag 1: the change from 0 to 1 delay is highly significant (LR = 97.78, much greater than the critical value of χ^2), whereas the change from 1 to 2 delays (LR = 21.64, not marked as significant by EViews) does not provide a statistically sufficient improvement to justify an additional parameter.

However, after selecting this optimal lag number of 1 based on most criteria, we performed the LM autocorrelation test on the VECM residuals. This test demonstrates that at the chosen lag value there is autocorrelation problem. The result showed autocorrelation at lag 1. Therefore, we selected lag 2, as proposed by the AIC criterion, and the test showed no autocorrelation at this lag.

Johansen Cointegration test and Determining the number of cointegration relationships

Previously performed ADF and Phillips-Perron unit root tests established that the five variables in the system—the unemployment rate (UR), exchange rate volatility (ERV), the lending interest rate (IR), the external debt stock (EDS), and the interaction term ERVIR—are all integrated of order 1, I(1). This shared property is a necessary prerequisite for testing for possible cointegrating relationships between these series, that is, stationary linear combinations that might reveal the existence of one or more long-term equilibrium relationships between them despite their individual non-stationarity (Engle & Granger, 1987).

In a multivariate framework with more than two variables, the Johansen method (Johansen, 1987, 1989) is preferred to the bivariate approach of Engle and Granger because it allows not only testing for the existence of cointegration within an n-dimensional system but also simultaneously estimating and determining the exact number of cointegrating relationships (the rank r of the impact matrix Π) via a maximum likelihood procedure applied to a vector error correction model (VECM). This procedure relies on two complementary statistics—the trace test and the maximum-eigenvalue test—the results of which will be presented and discussed in this section.

The estimation is conducted with an optimal lag of p = 2 (determined in the previous step by AIC) and under the deterministic hypothesis retained (Case 3 of the Johansen–Hendry–Juselius typology), including a constant in the cointegration relationship as well as in the short-term dynamics, and taking into account the structural breaks identified (2004, 2009, 2015) by means of exogenous dummy variables. Thus, the results of the Johansen cointegration test for the system without and with the ERVIR interaction term are presented in Tables 4 and 5, for Trace and Max-eigenvalue statistics, respectively.

Table 4. Cointegration Trace test on system without and with interaction term

System 1 without the interaction term				
Endogenous variables: UR ERV IR EDS				
Exogenous variables (short-run only): D2004 D2009 D2015				
Lags interval (in first differences): 1 to 1				
Null hypothesis: No cointegrating relationship				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. Of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.** Critical Value
None*	0.724140	67.65955	47.85613	0.0003
At most 1	0.346328	25.16013	29.79707	0.1558
At most 2	0.262979	11.13.17	15.49471	0.2036
At most 3	0.031627	1.060568	3.841465	0.3031
System 2 with the interaction term				
Endogenous variables : UR ERV IR EDS ERVIR				
Exogenous variables (short-run only): D2004 D2009 D2015				
Lags interval (in first differences): 1 to 1				
Null hypothesis: No cointegrating relationship				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. Of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob. ** Critical Value
None*	0.806884	90.45838	69.81889	0.0005
At most 1	0.379902	36.19111	47.85613	0.3869
At most 2	0.310493	20.42114	29.79707	0.3947
At most 3	0.191009	8.152477	15.49471	0.4492
At most 4	0.034469	1.157532	3.841465	0.2820

Trace test indicates 1 cointegrating equation(s) at 0.05 level. *: denotes rejection of the hypothesis at the 0.05 level. **: denotes Mackinnon-Haug-Michelis (1999) p-values.
Source: Authors'computation using Eviews 14.

Table 5. Cointegration Max-Eigenvalue test on system without and with interaction term

System 1 without the interaction term				
Endogenous variables: UR ERV IR EDS				
Exogenous variables (short-run only): D2004 D2009 D2015				
Lags interval (in first differences): 1 to 1				
Null hypothesis: No cointegrating relationship				
Unrestricted Cointegration Rank Test (Max-eigen value)				
Hypothesized No. Of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.** Critical Value
None*	0.724140	42.49942	27.58434	0.0003
At most 1	0.346328	14.02996	21.13162	0.3626
At most 2	0.262979	10.06960	14.26460	0.2074
At most 3	0.031627	1.060568	3.841465	0.3031
System 2 with the interaction term				
Endogenous variables : UR ERV IR ERVIR EDS				
Exogenous variables (short-run only): D2004 D2009 D2015				
Lags interval (in first differences): 1 to 1				
Null hypothesis: No cointegrating relationship				
Unrestricted Cointegration Rank Test (Max-eigen value)				
None*	0.806884	54.26727	33.87687	0.0001
At most 1	0.379902	15.76997	27.58434	0.6852
At most 2	0.310493	12.26867	21.13162	0.5214
At most 3	0.191009	6.994945	14.26460	0.4898
At most 4	0.034469	1.157532	3.841465	0.2820

Max-eigenvalue test indicates 1 cointegrating equation(s) at 0.05 level. *: denotes rejection of the hypothesis at the 0.05 level. **: denotes Mackinnon-Haug-Michelis (1999) p-values.
Source: Authors'computation using Eviews 14.

Johansen's cointegration test was applied to two systems, with the number of lags p = 2 retained based on the AIC and the LM test of residual autocorrelation. The first system, composed of the unemployment rate (UR), exchange rate volatility (ERV), the lending interest rate (IR), and the external debt stock (EDS), reveals the existence of a unique cointegrating relationship (Trace statistic = 67.660, p-value = 0.0003; maximum eigenvalue statistic = 42.499, p-value = 0.0003). The second system, augmented by the interaction term ERVIR = ERV × IR, capturing the combined effect of exchange rate volatility and the cost of credit, confirms this result with an even clearer rejection of the hypothesis of no cointegration (Trace statistic = 90.458, p-value = 0.0005; maximum eigenvalue statistic = 54.267, p-value = 0.0001), while maintaining the rank r = 1. This convergence of the two systems attests to the robustness of the long-term relationship identified in the model specification and justifies the estimation of a vector error correction model (VECM) with a single cointegrating vector for each of the two systems. To this end, taking into account this cointegration relationship r = 1 and optimal lag p = 2, the Johansen procedure is based on the general representations of the two vector error correction models (VECM) below.

$$\text{System 1: } \Delta Y_t = \alpha\beta' Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \Phi D_t + \varepsilon_t \quad (5)$$

$$\text{System 2: } \Delta Y_t^* = \alpha^* \beta^{*\prime} Y_{t-1}^* + \Gamma_1^* Y_{t-1}^* + \Phi^* D_t + \varepsilon_t^* \quad (6)$$

With $Y_t = (UR_t, ERV_t, IR_t, EDS_t)'$, β and α of size (4×1) because r = 1.

And $Y_t^* = (UR_t, ERV_t, IR_t, ERVIR_t, EDS_t)^{*\prime}$, $\beta^*$and α^* of size (5×1) because r = 1.

Their expanded VECM forms can be written as follows.

System 1 with $EC_{t-1} = UR_{t-1} + \beta_{ERV}ERV_{t-1} + \beta_{IR}IR_{t-1} + \beta_{EDS}EDS_{t-1}$ gives the system below (7) :

$$\Delta UR_t = \alpha_{UR}EC_{t-1} + \gamma_{11}\Delta UR_{t-1} + \gamma_{12}\Delta ERV_{t-1} + \gamma_{13}\Delta IR_{t-1} + \gamma_{14}\Delta EDS_{t-1} + \varphi_{10} + \varphi_{11}D2004_t + \varphi_{12}D2009_t + \varphi_{13}D2015_t + \varepsilon_{1t}$$

$$\Delta ERV_t = \alpha_{ERV}EC_{t-1} + \gamma_{21}\Delta UR_{t-1} + \gamma_{22}\Delta ERV_{t-1} + \gamma_{23}\Delta IR_{t-1} + \gamma_{24}\Delta EDS_{t-1} + \varphi_{20} + \varphi_{21}D2004_t + \varphi_{22}D2009_t + \varphi_{23}D2015_t + \varepsilon_{2t}$$

$$\Delta IR_t = \alpha_{IR}EC_{t-1} + \gamma_{31}\Delta UR_{t-1} + \gamma_{32}\Delta ERV_{t-1} + \gamma_{33}\Delta IR_{t-1} + \gamma_{34}\Delta EDS_{t-1} + \varphi_{30} + \varphi_{31}D2004_t + \varphi_{32}D2009_t + \varphi_{33}D2015_t + \varepsilon_{3t}$$

$$\Delta EDS_t = \alpha_{EDS}EC_{t-1} + \gamma_{41}\Delta UR_{t-1} + \gamma_{42}\Delta ERV_{t-1} + \gamma_{43}\Delta IR_{t-1} + \gamma_{44}\Delta EDS_{t-1} + \varphi_{40} + \varphi_{41}D2004_t + \varphi_{42}D2009_t + \varphi_{43}D2015_t + \varepsilon_{4t} \quad (7)$$

System 2 with $EC_{t-1} = UR_{t-1} + \beta_{ERV}ERV_{t-1} + \beta_{IR}IR_{t-1} + \beta_{ERVIR}ERVIR_{t-1} + \beta_{EDS}EDS_{t-1}$ gives the system below (8).

$$\Delta UR_t = \alpha_{UR}EC_{t-1} + \gamma_{11}\Delta UR_{t-1} + \gamma_{12}\Delta ERV_{t-1} + \gamma_{13}\Delta IR_{t-1} + \gamma_{14}\Delta ERVIR_{t-1} + \gamma_{15}\Delta EDS_{t-1} + \varphi_{10} + \varphi_{11}D2004_t + \varphi_{12}D2009_t + \varphi_{13}D2015_t + \varepsilon_{1t}$$

$$\Delta ERV_t = \alpha_{ERV}EC_{t-1} + \gamma_{21}\Delta UR_{t-1} + \gamma_{22}\Delta ERV_{t-1} + \gamma_{23}\Delta IR_{t-1} + \gamma_{24}ERVIR_{t-1} + \gamma_{25}\Delta EDS_{t-1} + \varphi_{20} + \varphi_{21}D2004_t + \varphi_{22}D2009_t + \varphi_{23}D2015_t + \varepsilon_{2t}$$

$$\Delta IR_t = \alpha_{IR}EC_{t-1} + \gamma_{31}\Delta UR_{t-1} + \gamma_{32}\Delta ERV_{t-1} + \gamma_{33}\Delta IR_{t-1} + \gamma_{34}ERVIR_{t-1} + \gamma_{35}\Delta EDS_{t-1} + \varphi_{30} + \varphi_{31}D2004_t + \varphi_{32}D2009_t + \varphi_{33}D2015_t + \varepsilon_{3t} \quad (8)$$

$$\Delta ERVIR_t = \alpha_{ERVIR}EC_{t-1} + \gamma_{41}\Delta UR_{t-1} + \gamma_{42}\Delta ERV_{t-1} + \gamma_{43}\Delta IR_{t-1} + \gamma_{44}ERVIR_{t-1} + \gamma_{45}\Delta EDS_{t-1} + \varphi_{40} + \varphi_{41}D2004_t + \varphi_{42}D2009_t + \varphi_{43}D2015_t + \varepsilon_{4t}$$

$$\Delta EDS_t = \alpha_{EDS}EC_{t-1} + \gamma_{51}\Delta UR_{t-1} + \gamma_{52}\Delta ERV_{t-1} + \gamma_{53}\Delta IR_{t-1} + \gamma_{54}ERVIR_{t-1} + \gamma_{55}\Delta EDS_{t-1} + \varphi_{50} + \varphi_{51}D2004_t + \varphi_{52}D2009_t + \varphi_{53}D2015_t + \varepsilon_{5t}$$

We then estimated the vector error correction model (VECM) (7) with two lags (p = 2) and one cointegration rank (r = 1), in accordance with the results of the Johansen test previously established. The system comprises four endogenous variables—the unemployment rate (UR), exchange rate volatility (ERV), the lending interest rate (IR), and the external debt stock (EDS)—and incorporates three dummy exogenous variables capturing the structural breaks of 2004, 2009, and 2015. The results of this system are given in Table 6 below.

Table 6. Estimation results of the VECM without the interaction term

	The cointegration equation			
Cointegration Eq :	CointEq1			
UR (-1)	1.000000			
ERV (-1)	7.372732 (2.81646) [2.61773]			
IR (-1)	0.043218 (0.13432) [0.32176]			
EDS (-1)	-0.061896 (0.00779) [-7.94923]			
C	1.411187			
	The error correction coefficients			
Error Correction :	D(UR)	D(ERV)	D(IR)	D(EDS)
CointEq1	-0.120017 (0.03027) [-3.96500]	0.006209 (0.00581) [1.06909]	0.345111 (0.21682) [1.59166]	10.75645 (2.22395) [4.83665]
D(UR(-1))	0.476693 (0.14410) [3.30796]	-0.043865 (0.02765) [-1.58645]	1.037930 (1.03226) [1.00550]	10.82951 (10.5878) [1.02283]
D(ERV(-1))	0.021936 (1.00938) [0.02173]	0.309303 (0.19363) [1.59704]	-3.445733 (7.23040) [-0.47656]	-99.23998 (74.1616) [-1.33816]
D(IR(-1))	0.007358 (0.02802) [0.26263]	-0.001478 (0.00538) [-0.27496]	-0.101254 (0.20068) [-0.50454]	1.000455 (2.05840) [0.48603]

D(EDS(-1))	-0.003473	-9.13E-06	0.016218	0.156082
	(0.00176)	(0.00034)	(0.01259)	(0.12911)
	[-1.97655]	[-0.02708]	[1.28849]	[1.20894]
C	-0.171496	0.015228	0.967873	24.01497
	(0.06811)	(0.01307)	(0.48786)	(5.00397)
	[-2.51806]	[1.16531]	[1.98390]	[7.79919]
D2004	-0.371504	-0.014233	-0.309746	-14.95225
	(0.09760)	(0.01873)	(0.69912)	(7.17084)
	[-3.80644]	[-0.76002]	[-0.44305]	[-2.08515]
D2009	0.384264	-0.034918	-1.785377	-47.35526
	(0.12870)	(0.02469)	(0.92191)	(9.45593)
	[2.98574]	[-1.41403]	[-1.93661]	[-5.00800]
D2015	0.347384	-0.007634	-1.762667	-29.92335
	(0.12044)	(0.02311)	(0.86272)	(8.84884)
	[2.88436]	[-0.33034]	[-2.04315]	[-3.38161]
R-squared	0.622569	0.355710	0.308256	0.709385
Adj.R-squared	0.496759	0.140947	0.077675	0.612514
F-statistic	4.948478	1.656292	1.336865	7.322951
Log-likelihood	23.78809	78.26838	-41.18766	-118.0101
Akaike AIC	-0.896248	-4.198084	3.041676	7.697581
Schwarz SC	-0.488109	-3.789945	3.449815	8.105719
Log-likelihood		-55.25226		
Akaike information criterion		5.772864		
Schwarz criterion		7.586813		
Number of coefficients		40		

Source: Authors'computation using Eviews 14.

The cointegration relationship reveals that the external debt stock (expressed by its coefficient with a t-statistic of -7.949) and exchange rate volatility (expressed by its coefficient with a t-statistic of 2.618) each maintain a statistically significant long-term relationship with the unemployment rate, while the lending interest rate does not contribute significantly to this relationship (expressed by its coefficient with a t-statistic of 0.322). The results show that the error correction mechanism (ECT) is driven primarily by unemployment itself (expressed by its coefficient with t = 3.965) and external debt (coefficient with t = 4.837). The latter exhibits the fastest adjustment speed in the system, while exchange rate volatility (coefficient with t = 1.069) and interest rate (coefficient with t = 1.592) do not react significantly to deviations from the long-term equilibrium.

In terms of short-term dynamics, the equations relating to unemployment (Adj. Rsquared = 0.497 and statistic F = 4.948) and external debt (Adj. Rsquared = 0.613 and statistic F = 7.323) are overall significant and well fitted, while those relating to exchange rate volatility (Adj. Rsquared = 0.141 and statistic F = 1.656) and interest rate (Adj. Rsquared = 0.078 and statistic F = 1.337) are not. The three structural breaks have significant and consistent effects on unemployment and external debt — negative for 2004 and positive for 2009 and 2015 on unemployment: negative for all three breaks on external debt — but do not significantly affect exchange rate volatility or, with the exception of 2015, the lending interest rate. These results reveal an asymmetrical architecture of the system: unemployment and external debt are the core of the cointegration mechanism, while the lending interest rate appears largely disconnected from the domestic dynamics captured by the model, and exchange rate volatility operates only through a long-term channel, without significant short-term relays. However, at this stage, these results cannot be interpreted without estimating the VECM with the interaction term and choosing which of the two VECMs is appropriate. This VECM is estimated, and its results are presented in Table 7 below.

Table 7. Results of the VECM estimation with the interaction term

The cointegration equation					
Cointegration Eq :	**CointEq1**				
UR (-1)	1.000000				
ERV (-1)	-80.19807				
	(92.3028)				
	[-0.86886]				
IR (-1)	-0.842797				
	(0.79387)				
	[-1.06162)				
ERVIR (-1)	8.003648				
	(6.15225)				
	[1.30093]				
EDS (-1)	-2.280038				
	(0.03408)				
	[-8.21705]				
C	28.73765				
The error correction coefficients					
Error Correction :	D(UR)	D(ERV)	D(IR)	D(ERVIR)	D(EDS)
CointEq1	-0.019733	0.001696	0.082028	0.037523	2.297653
	(0.00642)	(0.00125)	(0.04732)	(0.01796)	(0.46486)
	[-3.07394]	[1.36209]	[1.73358]	[2.08947]	[4.94268]
D(UR(-1))	0.330408	-0.055710	0.972867	-0.862512	13.65075
	(0.15003)	(0.02911)	(1.10559)	(0.41972)	(10.8647)
	[2.20222]	[-1.91379]	[0.87971]	[-2.05499]	[1.25643]
D(ERV(-1))	010.14524	1.679149	7.319974	27.12978	-155.9305

	(5.64876)	(1.09598)	(41.6368)	(15.8022)	(409.056)
	[1.79601]	[1.53210]	[0.17581]	[1.71683]	[-0.38120]
D(IR(-1))	0.051635	0.005202	-0.040825	0.067737	1.038190
	(0.03800)	(0.00737)	(0.28008)	(0.10630)	(2.75158)
	[1.35891]	[0.70557]	[-0.14576]	[0.63724]	[0.37731]
D(ERVIR(-1))	-0.783784	-0.101474	-0.748570	-1.683756	6.212113
	(0.41728)	(0.08096)	(3.07574)	(1.16732)	(30.2172)
	[-1.87833]	[-1.25338]	[-0.24338]	[-1.44241]	[0.20558]
D(EDS(-1))	-0.003395	-0.000128	0.014151	-0.002165	0.109245
	(0.00172)	(0.00033)	(0.01266)	(0.00480)	(0.12435)
	[-1.97691]	[-0.38314]	[1.11807]	[-0.45074]	[0.87854]
C	-0.129554	0.028297	1.279022	0.614665	29.36296
	(0.08902)	(0.01727)	(0.65619)	(0.24904)	(6.44661)
	[-1.45529]	[1.63828]	[1.98390]	[2.46814]	[4.55479]
D2004	-0.572132	-0.033380	-0.310098	-0.620805	-9.326296
	(0.13074)	(0.02537)	(0.96371)	(0.36575)	(9.46788)
	[-4.37596]	[-1.31588]	[-0.32177]	[-1.69733]	[-0.98505]
D2009	0.315187	-0.056344	-2.350908	-1.192195	-57.24427
	(0.16413)	(0.03184)	(1.20978)	(0.45914)	(11.8854)
	[1.92037]	[-1.76936]	[-1.94325]	[-2.59656]	[-4.81636]
D2015	0.348211	-0.033789	-2.548172	-0.954787	-46.48613
	(0.16998)	(0.03298)	(1.25291)	(0.47551)	(12.3091)
	[2.04855]	[-1.02454]	[-2.03380]	[-2.00791]	[-3.77656]
R-squared	0.652774	0.393930	0.326169	0.447517	0.740283
Adj.R-squared	0.516902	0.156773	0.062496	0.231328	0.638655
F-statistic	4.804356	1.661049	1.237021	2.070026	7.284227
Log-likelihood	25.16435	79.27741	-40.75476	-8.783284	-116.1554
Akaike AIC	-0.919052	-4.198631	3.076046	1.138381	7.645780
Schwarz SC	-0.465565	-3.745144	3.529533	1.591868	8.099267
Log-likelihood		0.545190			
Akaike information criterion		3.300292			
Schwarz criterion		5.794471			
Number of coefficients		55			

Source: Authors'computation using Eviews 14.

According to the results presented in Table 7, the introduction of the ERVIR interaction term into the VECM system, increasing the number of endogenous variables from four to five, substantially modifies the results'structure without altering the already established cointegration rank of r = 1. In terms of overall performance, this enhanced specification significantly improves the system's fit: the log-likelihood decreases from -55.252 to 0.545, the AIC from 5.773 to 3.300, and the Schwarz criterion from 7.587 to 5.794, despite the addition of fifteen extra parameters.

In the long-term relationship, only the stock of external debt remains significant (its coefficient has a t-statistic of -8.217, compared to -7.949 in the first system), confirming the stability of this central result under the chosen specification. However, a major change appears about exchange rate volatility: significant in isolation within the first system (with a coefficient whose t-statistic is 2.618), it loses all significance when associated with the interest rate and their interaction term (whose coefficient has a t-statistic of -0.869). The long-term coefficient of the interaction term ERVIR is statistically insignificant (its coefficient has a t-statistic of 1.301), and the interest rate is also not significant (its coefficient has a t-statistic of -1.062). This simultaneous loss of individual significance of the variables associated with the exchange-interest rates channel constitutes a typical verification of a quasi-multicollinearity problem, with ERV, IR, and their interaction term sharing a common information component.

In terms of short-term dynamics, the system confirms the stability of the external debt channel (adjustment coefficient and effects of the 2009 and 2015 breaks are almost identical to those of the first system) and the unemployment channel (error correction mechanism and 2004 break remain highly significant). The main contribution of this specification lies in the equation D(ERVIR), where the interaction term is significantly driven by the long-term imbalance (its t-statistic is 2.089) — an adjustment channel that did not exist in the first system, which treated ERV and IR in a purely additive manner.

In this way, the preceding results reveal an ambiguity that must be resolved before concluding on the economic relevance of the interaction channel. On the one hand, the ERVIR term opens a statistically active short-term adjustment channel (with a t-value of 2.089); on the other hand, its long-term coefficient, like those of ERV and IR taken in isolation, is not individually significant in the complete five-variable system—a result consistent with a collinearity problem rather than the actual absence of an effect. It therefore becomes necessary to distinguish between these two possible interpretations: either the ERVIR interaction does not, in itself, constitute a robust determinant of Burundian unemployment, or its real effect is masked by the collinearity it mechanically maintains with its ERV and IR components in the cointegration relationship.

The latter option is preferred because, practically speaking, even though Burundi is weakly integrated into global financial markets, ignoring the analysis of this channel revealed by the interaction between exchange rate volatility and interest rates due to the multicollinearity problem would shorten the transmission channel of the effects of international financial markets on the Burundian financial system and render the model a false additive one. Furthermore, applying techniques to correct this problem would remove the information provided by the model, a practice which is discouraged by Brambor et al. (2006). These authors emphasize that if a model includes an interaction term, all constitutive terms must be included. This is because the objective is no longer to test individual unconditional coefficients, but rather to calculate marginal effects (Brambor et al., 2006). Furthermore, this interaction channel can be assimulated to that of the uncovered interest rate parity (UIP) hypothesis, according to which, in the presence of expectations and in the absence of a risk premium, the interest rate differential between two countries should exactly offset the expected depreciation of the exchange rate (Meredith & Chinn, 1998). In short, this hypothesis states that the interest rate predicts future fluctuations in the exchange rate. This hypothesis is widely discussed in international finance literature, although it is controversial (Chinn & Meredith, 2005; Chinn & Zhang, 2015; Engel, 1996; Engel, 2016; Engel et al., 2022). This uncovered interest rate parity is expressed as follow:

$$i_t^d - i_t^f = E_t[\Delta e_{t+1}] + \rho_t \quad (9)$$

Where i_t^d is the domestic nominal lending interest rate in period t (interest rate in the home country set by BRB, Burundi); i_t^f is the foreign nominal interest rate in period t (interest rate in partner country such as that set by FED, USA); $i_t^d - i_t^f$ is the interest rates differential; $E_t[\Delta e_{t+1}]$ is the expected depreciation of the BIF between t and t+1; and ρ_t is the exchange rate risk premium at period t. The risk premium ρ_t is the additional compensation demanded by lenders and investors for agreeing to hold assets denominated in domestic currency, beyond simply compensating for anticipated depreciation. It specifically compensates for the uncertainty surrounding this anticipation—that is, the risk that the realized exchange rate will deviate from its expected value—and not the expected depreciation itself, which is already captured by the $E_t[\Delta e_{t+1}]$ term. By capturing the degree of uncertainty surrounding the anticipation of depreciation, ρ_t captures the volatility of the exchange rate and not its direction. However, financial theory (particularly those that consider risk aversion, such as that of Lucas1982) establishes that the premium increases with the conditional variance of the exchange rate of the following form:

$$\rho_t = f\left(\sigma_{\varepsilon,t}^2\right), \qquad f' > 0 \quad (10)$$

Where $\sigma_{\varepsilon,t}^2$ is precisely what our ERV variable seeks to measure empirically.

Considering the above theoretical and empirical foundations, in the next sections, we consider the second VECM with the interaction term ERVIR and we therefore deal with a multiplicative model rather than the previous additive one. The former means that the regression of the unemployment rate (UR) on exchange rate volatility (ERV) depends on the specific values of the lending interest rate (IR) for which the slope of the unemployment rate (UR) on exchange rate volatility (ERV) is measured. That is to say, the effect of exchange rate volatility on the unemployment rate in Burundi is a conditional effect that necessarily operates through the lending interest rate channel. But before continuing with the results of the VECM with interaction term in the next steps, the validity of this VECM was subjected to a battery of diagnostic tests. The results are summarized in Table 8 for residuals and Table 9 for stability.

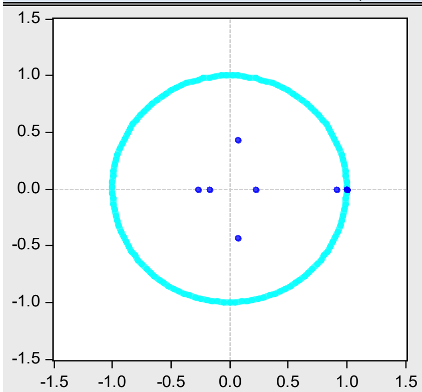
Table 8. Diagnostic test results on VECM with interaction

Test hypothesis	Null hypothesis	Test&Statistic	Stat-value	Prob.
Autocorrelation	No serial autocorrelation	Serial Correlation LM test/Rao F-stat	1.243054	0.2314
Heteroscedasticity	Existence of homoscedasticity	White test/Chi-Sq.	251.4093	0.1093
Normality test	Normal multivariate residuals	Cholesky Lutkepohl/Jarque-Bera	10.50760	0.3971

Source: Authors'computation using Eviews 14.

Table 9. VECM stability test with interaction

(a) Inverse Roots AR Characteristic Polynomial



(b) Roots of Characteristic Polynomial

Root	Modulus
1.000000	1.000000
1.000000	1.000000
1.000000	1.000000
1.000000	1.000000
0.908787	0.908787
0.067408 - 0.434611i	0.439807
0.067408 + 0.434611i	0.439807
-0.273688	0.273688
0.227229	0.227229
-0.170954	0.170954

VEC specification imposes 4 unit root(s).

Source: Authors'computation using Eviews 14.

Regarding the homoscedasticity hypothesis, the joint White test in levels and squares does not allow us to reject the null hypothesis of homoscedasticity [Chi-sq. = 251.4093, df = 225, p = 0.1093]. And although two individual components show marginal significance at 5%, the joint test, more robust to multiple tests, concludes that there is constant residual variance. The multivariate normality of the residuals, assessed using the Lütkepohl decomposition, is also validated. Neither the joint skewness tests [p = 0.3971] reject H0, attesting to a normal distribution of innovations, which is remarkable given the sample size [n = 33, 1991-2025]. The absence of residual dynamics is confirmed by the LM test of serial autocorrelation. Whether at a given order [Lag 1 : p = 0.3855; Lag 2 : p = 0.3489] or cumulatively [1 to 2 : p = 0.1599], the assumption of no serial correlation is maintained, guaranteeing the efficiency of the estimators. Finally, the analysis of the roots of the characteristic polynomial, reported in Table 9 and illustrated by the unit circle, confirms the stability of the system. In accordance with the VECM specification requiring k = r = 4 unit roots for 5 endogenous variables and one cointegrating vector [r = 1], the four theoretical unit roots are indeed found [modulus = 1.000000]. The remaining roots have a modulus strictly less than one, the highest being 0.9087, indicating strong persistence without explosive behavior and ensuring convergence towards long-term equilibrium.

Since the VECM with interaction is globally well-specified, homoscedastic, normal, and stable, we calculate marginal effects. The starting point is the cointegration equation of the VECM from Table 7. It can be written in the form :

$$\text{CointEq1: } 1.00 \times UR(-1) + b_1 \times ERV(-1) + b_2 \times IR(-1) + b_3 \times ERVIR(-1) + b_4 \times EDS(-1) + C = 0 \quad (11)$$

With:

$\mathrm{b_1} = -80.19807$, its standard error(se) $= 92.3028$, t = [-0.86886] ;

$\mathrm{b_2} = -0.842797$, its standard error(se) $= 0.79387$, t = [-1.06162] ;

$\mathrm{b_3} = 8.003648$, its standard error(se) $= 6.15225$, t = [1.30093] ;

$\mathrm{b_4} = -0.280038$, its standard error(se) $= 0.03408$, t = [-8.21705] ; et

$\mathrm{C} = 28.73765$

Therefore, the equation UR is of the form:

$$\mathrm{UR} = 80.19807 \times \mathrm{ERV} + 0.842797 \times \mathrm{IR} - 8.003648 \times \mathrm{ERVIR} + 0.280038 \times \mathrm{EDS} - 28.73765 \tag{12}$$

For the stock of external debt (EDS), the interpretation is direct and relates to the value and direction of its estimated coefficient, $-b_4 = 0.280038$, which is positively and statistically significant at the 5% level [t = -8.21705]. In the long-term equilibrium, an increase in the stock of external debt is associated with an increase in the unemployment rate. This is the first result that underpins the thesis of *"unemployment driven by external debt*".

To calculate the marginal effect of ERV on UR due to the fact that b_1 is not the right direct effect of ERV on UR (this is because ERV also appears in the interaction), we use the following form:

$$\frac{\partial \mathrm{UR}}{\partial \mathrm{ERV}} = \mathrm{b_1} + \mathrm{b_3} \times \mathrm{IR} = 80.19807 - 8.003648 \times \mathrm{IR} \tag{13}$$

This is the marginal effect of exchange rate volatility on unemployment which is a straight line that depends on the values of the interest rate (IR). It is the first transition from a constant coefficient to a conditional effect. Then, we compute the interest rate critical threshold at which this effect vanishes. To do this, resolving equation (13) becomes:

$$\mathrm{IR}^* = \frac{80.19807}{8.003648} = 10.02018954\% \tag{14}$$

Below this interest rate critical threshold, all other things being equal, the marginal effect of exchange rate volatility on unemployment is positive (exchange rate volatility destroys employment, i.e., it increases the unemployment rate), above it, all other things being equal, the marginal effect of exchange rate volatility on unemployment is negative (exchange rate volatility improves employment, i.e., it reduces the unemployment rate). The sign of the marginal effect of exchange rate volatility on the unemployment rate changes with the interest rate. Now, since the value of the marginal effect of exchange rate volatility is not fixed, it becomes necessary to calculate confidence intervals to identify when this effect is significant or not, depending on the level of the interest rate. The variance of the conditional marginal effect $\frac{\partial UR}{\partial ERV} = b_1 + b_3 IR$ is calculated using the Delta Formula method from the Johansen variance-covariance matrix below.

$$\mathrm{Var}\left(\frac{\partial \mathrm{UR}}{\partial \mathrm{ERV}}\right) = \mathrm{Var}(\mathrm{b_1}) + \mathrm{IR}^2 \times \mathrm{Var}(\mathrm{b_3}) + 2 \times \mathrm{IRCov}(\mathrm{b_1}, \mathrm{b_3}) \tag{15}$$

We produced the Johansen variance-covariance matrix in Eviews 14, which is given below.

$$\begin{array}{c}\textbf{Variables}\\ \mathrm{UR}\\ \mathrm{ERV}\\ \mathrm{IR}\\ \mathrm{ERVIR}\\ \mathrm{EDS}\end{array}
\begin{array}{c} \begin{array}{ccccc}\mathrm{UR} & \mathrm{ERV} & \mathrm{IR} & \mathrm{ERVIR} & \mathrm{EDS}\end{array}\\
\begin{bmatrix}
0.859320 & 0.021598 & 1.230390 & 0.459356 & 41.40104\\
0.021598 & \mathbf{0.003615} & 0.034930 & 0.057609 & 1.663649\\
1.230390 & 0.034930 & 4.531931 & 0.976866 & 66.60127\\
0.459356 & \mathbf{0.057609} & \mathbf{0.976866} & 0.972276 & 31.83306\\
41.40104 & 1.663649 & 66.60127 & 31.83306 & 2431.311
\end{bmatrix}\end{array} \tag{16}$$

From this matrix we retrieve Varb ($\mathrm{b_1}$) = 0.003615, Var (b_3) = 0.976866 and cov (b_1, b_3) = 0.057609, allowing us to construct the standard error $\mathrm{se} = \sqrt{\mathrm{Var}}$ and the 95% confidence interval $\mathrm{IC} = \mathrm{Effect} \pm 1.96 \times \mathrm{se}$ as well as the $\mathrm{t-statistic} = \frac{\mathrm{Effect}}{\mathrm{se}}$ for each level of IR. Therefore, by replacing, we get :

$$\mathrm{Var}\left(\frac{\partial \mathrm{UR}}{\partial \mathrm{ERV}}\right) = 0.003615 + \mathrm{IR}^2 \times 0.976866 + 2 \times \mathrm{IR} \times 0.057609 \tag{17}$$

Thus, using formulas (13) and (17), for each level of the interest rate, we calculate the marginal effect of exchange rate volatility, the standard error (se), the Student's t-statistic and the confidence interval. The results of the calculations are given in Table 10 in the appendix. Using the results in Table 10, we depict, according to the interest rate levels, the marginal effect of exchange rate volatility on unemployment rate and the 95% confidence interval. Figure 1 below illustrates the direction and the significance level of each of the marginal effect of exchange rate volatility according to different interest rate levels.

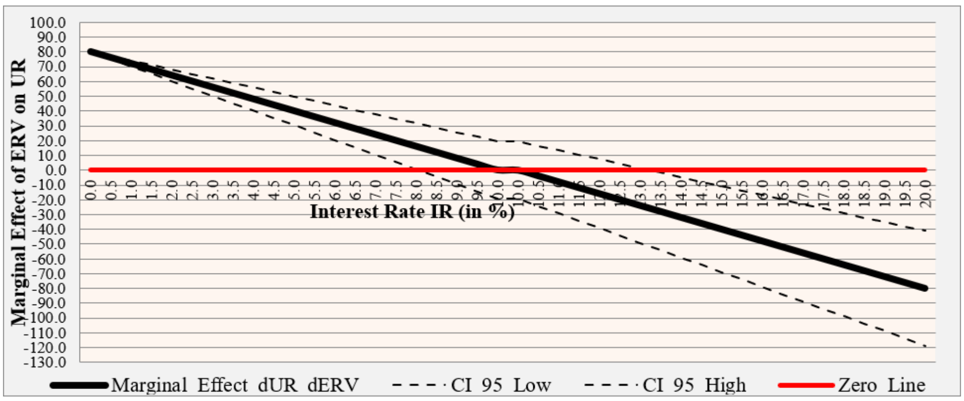


Figure 1. Conditional marginal effect of Exchange Rate Volatility on Unemployment Rate-VECM with ERVIR interaction
Source: Plotted by the authors (See data used in the Appendix).

The Figure 1 reveals a conditional relationship clearly structured by the level of the lending interest rate in Burundi. For low IR levels (below 8%), the marginal effect of exchange rate volatility on unemployment is positive and statistically significant—at IR = 0%, the effect is +80.20 (confidence interval [80.08; 80.32], t = 1333.9). At IR = 5%, it remains significantly positive (+40.18, CI [30.40; 49.96]). As the interest rate increases, this effect decreases linearly and loses its statistical significance in an intermediate range (approximately between IR = 8.5% and IR = 13%, where the confidence interval includes zero). The effect disappears precisely at a threshold IR^* = 10.029%, a pivotal value beyond which the relationship between exchange rate volatility and unemployment reverses and becomes significantly negative for high interest rates (at IR = 20%, this effect = -70.87, CI [-118.64; -41.11]).

This traditional structure confirms, visually and quantitatively, the existence of a genuine interaction effect between exchange rate volatility and interest rates on Burundian unemployment, rather than a fixed additive effect: the impact of exchange rate volatility on the labor market is not uniform but depends closely on the prevailing interest rate regime—exacerbating unemployment when credit is cheap, but mitigating, or even reversing, it when the lending rate is high. This result offers an economic interpretation consistent with the previously mentioned uncovered interest rate parity (UIP) mechanism: when interest rates are already high — a sign of active monetary defense against exchange rate instability — additional exchange rate volatility ceases to exert upward pressure on unemployment, as monetary policy absorbs part of the shock.

4.2 Answers to research questions and validation of hypotheses

The estimation of the vector error correction model (VECM) applied to the Burundian economy, incorporating the unemployment rate (UR), exchange rate volatility (ERV), the lending interest rate (IR), their interaction term (ERVIR), and the external debt stock (EDS), provides consistent and robust answers to the four research questions posed.

Regarding the second question, concerning the validity of the hypothesis of unemployment driven by external debt, the long-term relationship establishes that the external debt stock constitutes the dominant structural anchor of unemployment (normalized coefficient of -0.280038, t = -8.21705, the strongest significance in the entire system). This result is corroborated in the short term by the error correction mechanism: the debt adjustment coefficient (α_{EDS} = 2.297653, t = 4.94268) is considerably higher than that of unemployment (α_{UR} = -0.019733, t = -3.07394), indicating that debt recalibrates rapidly in response to imbalances, while unemployment only corrects about 2% per period. Hypothesis 2 is therefore validated, both in the long and short term.

Regarding the first question, relating to a growing effect of exchange rate volatility on unemployment, the complete long-term relationship does not allow us to conclude directly: neither ERV (t = -0.86886), nor IR (t = -1.06162), nor ERVIR (t = 1.30093) are individually significant, due to collinearity between these three variables correlated by the construction. The table and graph of marginal effects, derived from these same coefficients, resolve this ambiguity: the effect $\frac{\partial \mathrm{UR}}{\partial \mathrm{ERV}} = 80.198 - 8.004 \times \mathrm{IR}^*$ is strongly positive and significant at low interest rates (+80.198 at IR = 0%, t = 1333.91), disappears at a threshold IR^* = 10.02%, and then becomes significantly negative at high interest rates (-79.875 at IR = 20%, t = -4.038). Since the effect is neither increasing nor universal, Hypothesis 1 is not validated in its initial formulation. This same result determines the answer to the third question: the interaction between ERV and IR does not modulate unemployment in only one direction, but in both directions depending on the prevailing interest rate regime—aggravating the effect at low rates, attenuating it, and then reversing it at high rates. Hypothesis 3 is therefore only partially validated, as the interaction has a real and significant effect, but not a uniformly aggravating one.

Finally, the fourth question, specifically concerning the conditional nature of the previous effect, finds a direct affirmative answer in the same result: the effect of exchange rate volatility on unemployment depends statistically and significantly on the prevailing interest rate regime, with an identified and quantified critical threshold (IR^* = 10.02%). Hypothesis 4 is therefore fully validated.

4.3 Results discussion

The validation of hypothesis 2 is consistent with a coherent historical interpretation offered by structural breaks. The pivotal year of 2004, marking the true end of the civil war towards democratic elections since 1993 in Burundi, has a significant negative effect on short-term unemployment (D2004 on D(UR): -0.572132, t = -3.80644), reflecting the immediate improvement in the labor market after the conflict, while its effect on debt (D2004 on D(EDS): -9.326135, t = -0.98505) remains insignificant—the post-conflict debt reduction dynamic not yet fully underway at this stage. The year 2009, corresponding to the completion of the Heavily Indebted Poor Countries Initiative (HIPC), strikingly reverses this pattern: it significantly increases short-term unemployment (D2009 on D(UR): 0.315187, t = 1.92037) while producing the most abrupt and significant drop in the debt stock in the entire model (D2009 on D(EDS): -57.24427, t = -4.81636). This decoupling between rapid debt relief and the absence of immediate improvement in the labor market concretely illustrates, in a documented historical episode, the adjustment speed gap already highlighted by the α coefficients. The 2015 political crisis reproduces this same pattern (D2015 on D(UR): 0.348211, t = 2.04855; D2015 on D(EDS): -46.48613, t = -3.77656), reinforcing the robustness of this observation across two distinct episodes and confirming that this is not a one-off coincidence but a recurring structural mechanism.

The refutation of hypothesis 1 and the validation of hypothesis 4 are, for their part, illuminated by the theory of uncovered interest rate parity augmented by a risk premium ($\mathrm{i}_t^d - \mathrm{i}_t^f = \mathrm{E}_t[\Delta \mathrm{e}_{t+1}] + \rho_t$, with ρ_t growth in ERV). This theory predicts that the domestic interest rate already partially incorporates exchange rate volatility at the time it manifests itself, so that a fixed and uniformly increasing effect of ERV on UR is not economically plausible. The results empirically confirm this prediction: at low interest rates, the risk premium associated with exchange rate volatility has not yet been factored into the cost of credit, and an ERV shock then strikes an unprotected economy, with a direct and maximal effect on unemployment. At already high interest rates, the system has already absorbed this premium through a previous monetary adjustment, so that an additional ERV shock has less room to impact investment and employment, even reversing the sign of its effect.

The interplay of these two results—persistence of unemployment despite rapid debt repayment, and exchange rate sensitivity of unemployment conditioned by the history of interest rate adjustments—reveals a dual hysteresis structure consistent with the subject of this research. On the one hand, a direct channel where external debt shocks have a lasting impact on the level of unemployment, as the speed of adjustment in the labor market is structurally lower than that of debt. On the other hand, there is an indirect channel where the very sensitivity of unemployment to exchange rate shocks depends on the inherited interest rate regime, itself shaped by the history of exchange rate volatility. Burundian unemployment thus appears to be governed by path dependency dynamics rather than by an instantaneous and asymmetric adjustment to macroeconomic shocks.

5 Conclusion and Recommendations

5.1 Conclusion

This research establishes that unemployment in Burundi is structurally determined by the stock of long-term external debt, with an asymmetric adjustment mechanism that permanently embeds the effects of debt shocks in the labor market – a result verified both on the cointegration relationship (t = -8.217) and on the speed of correction differences (α_EDS = 2.298 versus α_UR = -0.020) and on the historical episodes of 2004, 2009 and 2015. At the same time, exchange rate volatility does not exert a fixed effect on unemployment, but an effect strictly conditioned by the prevailing interest rate regime, positive and marked below a threshold of about 10.02 percent, then attenuated and finally reversed above it. All of these results converge to highlight a double-channel hysteresis phenomenon — driven by external debt and modulated by the exchange rate-interest rate interaction — which characterizes the dynamics of unemployment in the Burundian economy over the period 1991-2025.

5.2 Economic policy recommendations

The results call for recommendations based on the two identified structural channels. Regarding external debt, whose long-term relationship with unemployment is robustly established (t = -8.217) and whose asymmetric speed of adjustment (α_EDS = 2.298 versus α_UR = -0.020) generates a hysteresis effect observed in 2009 and 2015, the Burundian authorities should not equate debt relief with an immediate solution to unemployment: any debt reduction program must be accompanied by active employment policies (targeted training, support for entrepreneurship, hiring incentives, and so on), otherwise the effects of past debt shocks will continue to weigh heavily on the labor market.

Regarding the interaction between exchange rate volatility and interest rates, the effect of which on unemployment is conditional on the monetary regime (positive below an interest rate critical threshold of 10.02%, negative above it), the Bank of the Republic of Burundi should adjust its vigilance regarding exchange rate stability according to the level of interest rates: priority should be given to controlling the exchange rate during periods of low interest rates, when its aggravating effect is strongest; attention should also be paid to the effects of monetary tightening itself during periods of already high interest rates. This implies better coordination between exchange rate policy and interest rate policy, as these two levers interact in a non-additive way with regard to employment.

Finally, a structural reform of the labor market, aimed at increasing its flexibility and responsiveness, would help reduce the magnitude of the identified hysteresis by bringing the rate of adjustment of unemployment closer to the faster rate of adjustment of other macroeconomic variables in the system.

Declaration of Competing Interests

The authors declare that they not aware of any competing financial interests or personal relationships that may have influenced the work described in this document.

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Ethical considerations

The article followed all ethical standards appropriate for this kind of research.

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Appendix

Table 1. Conditional Marginal Effect of Exchange Rate on Unemployment Rate

IR (%)	Marginal Effect : $\frac{\partial UR}{\partial ERV}$	Variance	se	t-stat	CI : 95% Lower Bound	CI : 95% Upper Bound	Zero Line
0.0000	80.1981	0.0036	0.0601	1333.9112	80.0802	80.3159	0.0000
0.5000	76.1962	0.3043	0.5516	138.1299	75.1151	77.2774	0.0000
1.0000	72.1944	1.0911	1.0446	69.1145	70.1471	74.2418	0.0000
1.5000	68.1926	2.3641	1.5376	44.3514	65.1790	71.2062	0.0000
2.0000	64.1908	4.1232	2.0306	31.6124	60.2109	68.1707	0.0000
2.5000	60.1890	6.3684	2.5236	23.8507	55.2428	65.1351	0.0000
3.0000	56.1871	9.0998	3.0166	18.6261	50.2746	62.0996	0.0000
3.5000	52.1853	12.3173	3.5096	14.8693	45.3065	59.0641	0.0000
4.0000	48.1835	16.0209	4.0026	12.0380	40.3384	56.0286	0.0000
4.5000	44.1817	20.2107	4.4956	9.8277	35.3702	52.9931	0.0000
5.0000	40.1798	24.8866	4.9886	8.0543	30.4021	49.9576	0.0000
5.5000	36.1780	30.0487	5.4817	6.5998	25.4339	46.9221	0.0000
6.0000	32.1762	35.6969	5.9747	5.3854	20.4658	43.8866	0.0000
6.5000	28.1744	41.8312	6.4677	4.3562	15.4977	40.8511	0.0000
7.0000	24.1725	48.4517	6.9607	3.4727	10.5295	37.8156	0.0000
7.5000	20.1707	55.5583	7.4537	2.7061	5.5614	34.7800	0.0000
8.0000	16.1689	63.1511	7.9468	2.0347	0.5932	31.7445	0.0000
8.5000	12.1671	71.2299	8.4398	1.4416	-4.3749	28.7090	0.0000
9.0000	8.1652	79.7950	8.9328	0.9141	-9.3431	25.6735	0.0000
9.5000	4.1634	88.8461	9.4258	0.4417	-14.3112	22.6380	0.0000
10.0000	0.1616	98.3834	9.9188	0.0163	-19.2793	19.6025	0.0000
10.0202	**0.0000**	**98.7788**	**9.9388**	**0.0000**	**-19.4800**	**19.4800**	**0.0000**
10.5000	-3.8402	108.4069	10.4119	-0.3688	-24.2475	16.5670	0.0000
11.0000	-7.8421	118.9165	10.9049	-0.7191	-29.2156	13.5315	0.0000
11.5000	-11.8439	129.9122	11.3979	-1.0391	-34.1838	10.4960	0.0000
12.0000	-15.8457	141.3940	11.8909	-1.3326	-39.1519	7.4605	0.0000
12.5000	-19.8475	153.3620	12.3839	-1.6027	-44.1201	4.4250	0.0000
13.0000	-23.8494	165.8162	12.8770	-1.8521	-49.0882	1.3895	0.0000
13.5000	-27.8512	178.7564	13.3700	-2.0831	-54.0563	-1.6460	0.0000
14.0000	-31.8530	192.1829	13.8630	-2.2977	-59.0245	-4.6815	0.0000
14.5000	-35.8548	206.0954	14.3560	-2.4975	-63.9926	-7.7170	0.0000
15.0000	-39.8567	220.4941	14.8490	-2.6841	-68.9608	-10.7525	0.0000
15.5000	-43.8585	235.3789	15.3421	-2.8587	-73.9289	-13.7880	0.0000
16.0000	-47.8603	250.7499	15.8351	-3.0224	-78.8971	-16.8235	0.0000
16.5000	-51.8621	266.6070	16.3281	-3.1762	-83.8652	-19.8590	0.0000
17.0000	-55.8639	282.9502	16.8211	-3.3211	-88.8333	-22.8945	0.0000
17.5000	-59.8658	299.7796	17.3141	-3.4576	-93.8015	-25.9300	0.0000
18.0000	-63.8676	317.0951	17.8072	-3.5866	-98.7696	-28.9656	0.0000
18.5000	-67.8694	334.8968	18.3002	-3.7087	-103.7378	-32.0011	0.0000
19.0000	-71.8712	353.1846	18.7932	-3.8243	-108.7059	-35.0366	0.0000
19.5000	-75.8731	371.9585	19.2862	-3.9341	-113.6741	-38.0721	0.0000
20.0000	-79.8749	391.2186	19.7792	-4.0383	-118.6422	-41.1076	0.0000