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Unveiling a Vicious Feedback Loop: A Smooth Transition VAR (STVAR) Analysis of Asymmetric Exchange Rate Pass-Through in Iran's Dual Economic Regimes

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Highlights

- **Identifies a self-reinforcing exchange rate–inflation loop in Iran, triggered when the parallel rate exceeds a critical threshold.**
- **Shows exchange rate pass-through is stronger and faster to producer prices (PPI) than to consumer prices (CPI), highlighting the production sector as an amplification channel.**
- **Argues that breaking the cycle requires institutional reforms and macroeconomic discipline, not just symptomatic exchange rate or monetary adjustments.**

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Abstract

This study examines the nonlinear, regime-dependent relationship between exchange rates and inflation in Iran using a Smooth Transition Vector Autoregressive (STVAR) model with monthly data from 2000 to 2024. It rejects a linear model in favor of a two-regime analysis, identified as *tranquil* and *crisis*, with transitions driven by the level of the exchange rate. Key findings reveal that a one-standard-deviation shock to the parallel market exchange rate in the crisis regime causes an immediate 43% increase in consumer inflation, rising to 93% over two years, compared to a 30% increase in the tranquil regime. Additionally, the pass-through to the Producer Price Index (PPI) is stronger and faster than to the Consumer Price Index (CPI), indicating the vulnerability of the real sector. The exchange rate's contribution to inflation variance nearly doubles in the crisis regime. Robustness checks, including threshold VAR estimation and alternative lag structures, confirm the stability of these results. These findings emphasize that the Iranian economy is susceptible to a self-reinforcing *feedback loop* activated by crossing critical exchange rate thresholds. Without effective institutional reforms, the risk of a currency crisis remains, as external shocks or domestic policy errors could trigger a vicious cycle of inflation again. This situation underscores the need for a shift towards *macroeconomic discipline* and *proactive management of expectations*, as mere shock therapy tends to be counterproductive.

1. Introduction

The relationship between the exchange rate and domestic price levels represents one of the most critical transmission channels in an open economy, particularly for developing countries heavily reliant on imports (Goldberg &

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Knetter, 1997; Taylor, 2000). In Iran, this relationship has been a central and persistent concern for policymakers and economists for decades, characterized by periods of rapid currency depreciation followed by surges in inflation. For instance, following the intensification of international sanctions and internal imbalances, the rial depreciated by over 60% in the 2011/12 period, contributing to an annual inflation peak exceeding 40% (Central Bank of Iran, 2013; World Bank, 2013). While a degree of pass-through is expected, the Iranian economy appears susceptible to a particularly pernicious phenomenon: a self-reinforcing feedback loop, or a 'vicious cycle'. In this cycle, currency depreciation fuels inflation, which in turn leads to further depreciation and capital flight (Nademi, 2018).

The persistence of this cycle in Iran, long after similar dynamics were subdued in many advanced and emerging economies through credible inflation targeting and floating regimes (Bailliu & Fujii, 2004; Mishkin & Schmidt-Hebbel, 2007), raises critical questions. This paper examines the specific mechanisms that sustain this cycle in Iran and explores whether the exchange rate-inflation nexus is stable or becomes significantly more potent under stress conditions, such as during currency crises. A key stylized fact motivating this study is the stark divergence between the official and parallel exchange rates, which exceeded a gap of 150,000 rials per USD in 2022, underscoring severe market fragmentation and expectations-driven dynamics (Internationdal Monetary Fun, 2023).

While a degree of exchange rate pass-through is expected in any open economy, the Iranian case exhibits a particularly pernicious and persistent vulnerability: a self-reinforcing feedback loop between depreciation and inflation. Crucially, this vicious cycle is fundamentally intertwined with Iran's dual exchange rate regime. The coexistence of a government-administered official rate and a market-driven parallel rate creates a specific threshold mechanism that can activate and amplify the vicious cycle. When the gap between the parallel and official rates widens beyond a critical point—signaling a loss of policy credibility and escalating expectations of depreciation—it can trigger a shift from a "tranquil regime" with contained pass-through to a "crisis regime" where pass-through becomes stronger, faster, and self-fulfilling.

Understanding the potential nonlinear, regime-dependent nature of this interaction is, therefore, far from a mere academic exercise. It is essential for designing effective stabilization policies capable of breaking this destructive loop and fostering sustainable economic stability.

This paper investigates the dynamic, regime-dependent relationship between the exchange rate and price indices in Iran. Moving beyond linear models, which may obscure crucial state-dependent dynamics, we employ a Smooth Transition Vector Autoregressive (STVAR) model (Teräsvirta & Yang, 2023) to formally test for the existence of distinct economic regimes—"tranquil" and "crisis"—and to analyze how the interplay between the exchange rate, producer prices (PPI), and consumer prices (CPI) changes between them. This approach is motivated by recent studies on Iran that suggest nonlinearity, such as Sabouri Deylami et al. (2021), who identified explosive pass-through in a high-volatility regime using a Markov-

Switching model. However, unlike models with unobserved regime transitions, our STVAR framework allows the exchange rate *level itself* to be the observable driver of regime change, directly testing a key hypothesis from theoretical crisis models (Krugman, 1979). By estimating separate models for both the government-administered official rate and the market-clearing parallel rate, we also shed light on the distinct signaling and pass-through roles of these two key prices in the Iranian economy.

The remainder of this paper is organized as follows. Section 2 outlines the theoretical framework of currency crises and the vicious feedback loop. Section 3 provides a critical review of the relevant empirical literature. Section 4 describes the STVAR methodology and the data. Section 5 presents the main empirical results, including regime identification, impulse responses, and variance decompositions. Section 6 discusses the findings and their policy implications, and Section 7 concludes.

2. Literature Review

The empirical relationship between exchange rates and domestic prices has been extensively studied, yielding a rich body of literature that informs the present study. This review is structured into two subsections: first, we examine key international evidence on exchange rate pass-through and vicious cycles, and second, we focus on the specific findings within the Iranian context.

2.1 International Evidence on Pass-Through and Nonlinearities

The early literature, rooted in the monetary approach to the balance of payments, established the theoretical possibility of a vicious cycle. Basevi & Grauwe (1977) presented a static model with capital mobility, introducing the vicious cycle as a state where countries remain stuck in adjustment processes longer than traditional exchange rate theories would suggest. They noted that the cycle's presence depends on short-term monetary expansion and downward price/wage rigidities.

A significant shift in the literature occurred with the widespread adoption of flexible exchange rates and inflation-targeting regimes. Studies began to document a general decline in exchange rate pass-through to consumer prices in many industrialized countries. Bailliu & Fujii (2004), in a study of 11 industrial countries, provided robust evidence for this hypothesis, attributing the decline to the credibility of low-inflation policies adopted in the 1990s. This finding suggests that the macroeconomic policy regime is a critical determinant of the strength of the exchange rate-inflation link.

However, the focus on linear, average relationships often masks important dynmics. Research has increasingly highlighted nonlinearities and asymmetries in pass-tahrough. For instance, pass-through tends to be higher during periods of high inflation, significant currency depreciation, or economic instability. Studies in developing and emerging markets, such as Mandizha (2014) on Zimbabwe and Ocran (2010) on South Africa, consistently find a stronger and more persistent relationship. Mandizha (2014), using Granger causality and cointegration, found a one-way causality from the exchange rate to inflation, with exchange rate shocks explaining about 80% of inflation fluctuations in the long run, underscoring the dominance of the exchange rate channel in crisis-prone economies.

Furthermore, the role of expectations and asset markets has been emphasized. Kenen & Pack (1980) argued that short-run exchange rates are determined by asset-holders' expectations of relative returns, implying that exchange rate movements can precede changes in price levels if they are driven by shifts in expectations about future monetary policy or risk.

2.2 Empirical Studies in the Iranian Economy

The Iranian economy, with its history of high inflation, managed exchange rates, and significant external shocks, provides a compelling case study. The empirical literature on Iran largely confirms the presence of a significant exchange rate pass-through but offers nuanced insights into its magnitude and channels.

Early studies, such as Piryaii & Pasandideh (2002), using simultaneous equations for the period 1959-1999, found a direct relationship between inflation and exchange rate volatility, with the pass-through to the wholesale price index being the strongest. This aligns with the cost-channel narrative, where imported inputs are first reflected in producer prices.

Subsequent studies employing Vector Autoregressive (VAR) models have refined this understanding. Khoshbakht & Akhbari (2007), using a Structural VAR (SVAR), found that the pass-through to the import price index was higher and faster than to the CPI, and that money growth was a more important driver of consumer prices than the exchange rate. Similarly, Mousavi Mohseni & Sobhanipour (2008), using a Recursive VAR, confirmed that the pass-through is incomplete and strongest for import goods, followed by wholesale and retail prices.

More recent research has begun to explicitly account for the nonlinear and regime-dependent nature of the Iranian economy. Sabouri Deylami et al. (2021) marked a significant advance by using a Markov-Switching Bayesian VAR (MSBVAR). They identified two inflationary regimes—a low-volatility and a high-volatility regime—and demonstrated that the interaction between the exchange rate and CPI is explosive in the high-volatility regime but muted in the low-volatility one. This finding is a direct precursor to the current study, strongly justifying a nonlinear approach.

Further evidence of a time-varying relationship comes from Sabouri Deylami et al. (2022), who used wavelet coherence analysis. They showed that the co-movement between the exchange rate and price indices intensifies during periods of high exchange rate and inflation uncertainty, leading to inflationary peaks.

2.2.1 The Persistence of the Vicious Circle in Iran: An Institutional Perspective

While the international literature has increasingly documented how institutional reforms and credible policy frameworks—such as inflation targeting, central bank independence, and fiscal discipline—have helped mitigate or break the depreciation-inflation feedback loop in advanced and many emerging economies, the situation in Iran presents a stark contrast. The critical structural and institutional changes needed have not occurred in Iran.

2.2.1.1 Why Modern Studies No Longer Model the "Vicious Circle" Separately

This institutional stasis explains a key divergence in the literature. Contemporary studies no longer present separate models for a "vicious circle" precisely because successful economies have institutionally eliminated the phenomenon. The decline in exchange rate pass-through in inflation-targeting economies marks a structural break from the 1970s–1980s dynamics, when depreciation-inflation spirals were common (Bailliu & Fujii, 2004). This is not a theoretical puzzle but an institutional achievement. Near-zero pass-through in advanced economies is the result of anchored expectations and credible monetary frameworks that break the feedback loop between depreciation and inflation (Mishkin & Schmidt-Hebbel, 2007).

2.2.1.2 What We Test and Why the Classic Framework Remains Relevant for Iran

In the absence of such institutional breakthroughs, Iran remains trapped in first-generation crisis dynamics, where fiscal and monetary expansions exacerbate balance-of-payments pressures and speculative attacks (Krugman, 1979; Obstfeld, 1996). Consequently, the theoretical foundations of the vicious circle remain highly relevant for Iran's context.

Our STVAR model directly tests whether Iran exhibits regime-dependent pass-through:

- A Tranquil Regime with contained and decaying pass-through (a potential virtuous circle)
- A Crisis Regime with explosive and self-reinforcing pass-through (a vicious circle)

This nonlinear, state-dependent framework is consistent with contemporary approaches to diagnosing fragile economies. Nonlinear exchange rate pass-through models capture the state-dependent nature of the exchange rate-inflation link. In high-inflation regimes, the system exhibits features of a self-reinforcing spiral—what the earlier literature termed a "vicious circle" (Comunale & Simola, 2018).

Thus, the question in Iran is not the obsolescence of the vicious circle concept, but the profound failure to implement the institutional prerequisites that could transform this cycle into a virtuous circle of stability and growth. This study is positioned within this critical context.

2.3 Identifying the Research Gap

The existing literature on Iran convincingly establishes three key points: (1) a significant exchange rate pass-through to domestic prices exists, (2) this pass-through is incomplete and varies across the price chain (import prices > PPI > CPI), and (3) the relationship may be state-dependent or nonlinear, intensifying during periods of high uncertainty. The seminal work of Sabouri Deylami et al. (2021) represents a pivotal advance by formally identifying distinct, volatile inflationary regimes in Iran using a Markov-Switching Bayesian VAR (MSBVAR) model.

However, a critical methodological and theoretical gap remains. While the MSBVAR framework successfully identifies the *existence* of distinct regimes, the transition between these regimes is governed by an unobserved, stochastic Markov process. However, this powerful approach cannot test *for a specific, observable economic mechanism* as the trigger for regime shifts. Consequently, it leaves a fundamental theoretical question—central to models of currency crises—empirically unanswered for Iran: Can the exchange rate level itself, upon crossing a critical threshold, act as the observable catalyst that propels the economy from a tranquil state into a crisis state characterized by a self-reinforcing vicious cycle?

This study aims to address a significant gap in the existing literature by employing a Smooth Transition Vector Autoregressive (STVAR) model. This innovative approach enables us to formally evaluate the hypothesis that the transition between different economic regimes is directly influenced by the exchange rate surpassing a certain threshold. This alignment with the theoretical framework of speculative attacks, as proposed by Krugman in 1979, enhances our empirical model.

Additionally, we explore how the dynamic structure of the economy evolves in response to varying levels of the exchange rate. By examining impulse responses and forecast error variance decompositions, we gain a deeper understanding of the transition phase itself. Moreover, our analysis facilitates the generation of explicit, policy-relevant threshold estimates, such as a critical Rial/USD exchange rate, which can serve as quantitative early-warning indicators. These indicators are crucial for signaling an increased risk of entering an explosive crisis regime.

By connecting first-generation crisis theory with a customized nonlinear empirical framework, this study goes beyond merely confirming the existence of different regimes. It explicitly models and quantifies the observable threshold mechanism that triggers Iran's depreciation-inflation vicious cycle.

Building on the insights from currency crisis and pass-through literature, the following theoretical framework elucidates the mechanism of a self-reinforcing feedback loop. Crucially, this logic underpins our choice of a Smooth Transition VAR (STVAR) model, as it captures the inertial and non-linear regime shifts—from tranquil to crisis states—that define such a vicious cycle in Iran's institutional context.

3. Theoretical Framework: Currency Crises and the Vicious Feedback Loop

The theoretical underpinnings of this study are rooted in two interconnected strands of literature: the models of currency crises and the theory of the inflation-depreciation vicious cycle.

3.1. Speculative Attacks and Currency Crisis Models

The seminal work of Krugman (1979) on first-generation currency crisis models provides a foundational framework. These models posit that a fixed exchange rate regime becomes vulnerable when it is inconsistent with domestic fiscal and monetary policies. Persistent financing of fiscal deficits through money creation leads to a continuous loss of foreign reserves. Rational speculators, anticipating an eventual and inevitable depletion of reserves, launch a speculative attack, forcing the abandonment of the peg.

As illustrated in Figure 1, the process begins with a steady expansion of domestic credit, which gradually erodes foreign reserves. The attack itself is not a random event but a sudden, discrete event that occurs when the "shadow exchange rate" (the equilibrium rate that would prevail under a float) crosses the fixed parity. At this point, the central bank's reserves are exhausted in a single attack, leading to a large, one-off devaluation or a transition to a floating regime. This framework is highly relevant to Iran, where periods of fixed or heavily managed exchange rates have often collapsed under the pressure of expansive fiscal and monetary policies.

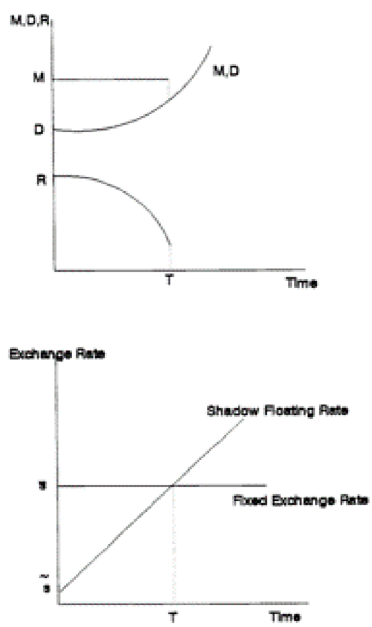

Figure 1: The Process of a Speculative Attack on a Fixed Exchange Rate Regime

Source: *Garber, Peter M., and Lars E. O. Svensson. 1994. "The Operation and Collapse of Fixed Exchange Rate Regimes." NBER Working Paper 4971, National Bureau of Economic Research, Cambridge, MA.*

3.2. The Vicious Cycle of Depreciation and Inflation

Building on the balance-of-payments and monetary approaches, the theory of the vicious cycle (sometimes called the "vicious circle" or "inflation-depreciation spiral") describes a dynamic, self-fulfilling process. The mechanism can be broken down as follows:

1. Initial Depreciation: An initial shock—whether exogenous (e.g., a terms-of-trade shock, sanctions) or endogenous (e.g., fiscal deficit, monetary expansion)—causes the currency to depreciate.
2. Direct and Indirect Pass-Through: The depreciation raises the domestic currency price of imported goods (final consumer goods, intermediate inputs, and capital goods). This has a direct effect on the Consumer Price Index (CPI) and a stronger, more immediate effect on the Producer Price Index (PPI), as producers face higher input costs.
3. Wage-Price Spirals: The rise in the cost of living often leads to demands for higher wages, particularly in economies with indexed wage contracts. Higher wages further increase production costs, leading to another round of price increases.
4. Monetary Validation and Expectations**:** The resulting increase in the price level increases the nominal demand for money. If the central bank accommodates this demand to prevent a rise in interest rates and an economic slowdown, it validates the initial inflation, fueling the cycle. Simultaneously, economic agents, observing the depreciation and rising inflation, begin to expect further currency weakness. This leads to:
    - Capital Flight: Residents and foreigners move assets abroad.
    - Increased Hedging and Speculation: Demand for foreign currency as a store of value increases.
    - Currency Substitution: A shift from holding domestic currency to foreign currency (dollarization).
5. Further Depreciation: The resulting increase in the demand for foreign currency puts renewed pressure on the exchange rate, leading to a further depreciation, and the cycle begins anew.

This feedback loop creates a situation where the initial cause of the depreciation becomes less relevant, and the cycle becomes self-sustaining through the channels of cost-push inflation, accommodative policy, and, most critically, shifting expectations. The models of Basevi & Grauwe (1977) and others highlight that this cycle can represent a prolonged adjustment process rather than a temporary deviation.

Theoretical Distinction from Overshooting Models: It is important to distinguish this vicious cycle from the classic exchange rate overshooting model (Dornbusch, 1976). In the overshooting framework, exchange rates adjust instantaneously to monetary shocks before gradually converging to the long-run equilibrium, primarily through interest rate and expectations channels. In contrast, the vicious cycle observed in Iran represents a cumulative and self-reinforcing process. Each episode of exchange rate depreciation directly fuels consumer inflation, which is then exacerbated by the liquidity effects associated with compensating measures such as wage adjustments and implicit subsidies. This inflationary pressure, coupled with constrained access to foreign exchange reserves, creates the conditions under which the economy becomes trapped in a crisis-driven feedback loop.

The STVAR model employed in this paper is the ideal tool to capture this theoretical narrative. It allows us to test whether the Iranian economy indeed switches between a "tranquil regime", where such feedbacks are weak, and a "crisis regime", where the theoretical vicious cycle becomes the dominant feature of the macroeconomic landscape.

3.3. Implications for Empirical Modeling: Choosing the STVAR Framework

A key criterion for selecting an appropriate econometric model is its theoretical consistency with the economic phenomenon under study. In the context of Iran's exchange rate–inflation dynamics, we argue that the Smooth Transition VAR (STVAR) framework is theoretically superior to a Threshold VAR (TVAR) specification. This preference rests on the inherent economic inertia and asymmetric, non-instantaneous adjustments that characterize a vicious feedback loop. In such a cycle, economic agents—households, firms, and speculators—do not adjust their expectations, pricing, and portfolio decisions simultaneously or with uniform intensity.

Adjustments in economic conditions typically occur gradually, heterogeneously, and are influenced by past events. Price and wage stickiness hinder immediate adjustments, while adaptive expectations form slowly and change incrementally. Market fragmentation, characterized by the disparity between official and parallel exchange rates, results in non-synchronous responses. Additionally, policy responses and institutional rigidities prolong the transition between economic states.

Traditional threshold vector autoregression (TVAR) models suggest an abrupt switch between regimes, requiring all agents to alter their behavior uniformly upon crossing a threshold. Although this aligns with certain policy shocks, such as significant currency devaluations, it fails to reflect the gradual transitions observed in Iran's inflation dynamics.

In contrast, smooth transition vector autoregression (STVAR) models depict transitions as a continuous function of state variables, like the exchange rate. This framework captures the economy's gradual shifts between "tranquil" and "crisis" regimes, accounting for the cumulative and staggered nature of expectation formation, cost pass-through, and speculative pressure. The smoothness parameter (γ) in STVAR quantifies this inertia: a moderate, finite γ signifies a gradual transition, consistent with theoretical expectations.

Thus, employing the STVAR model is justified both empirically and theoretically. It underscores the insight that, within Iran's institutional context—marked by weak policy credibility, adaptive expectations, and market segmentation—the vicious cycle evolves through smooth, inertial dynamics rather than abrupt changes. Consequently, the STVAR framework provides a more faithful and theoretically coherent representation of the inertial vicious feedback loop underlying Iran's exchange rate-inflation dynamics.

4. Methodology and Data

Iran's foreign exchange system is characterized by a persistent duality between regulated and market-determined rates. For the purpose of this study, we define two key rates:

Official Exchange Rate (EX_Off): This is the government-administered rate decreed by the Central Bank of Iran (CBI). It is allocated through a formal system for specific, sanctioned transactions (e.g., imports of essential goods). This rate is often subject to administrative control, substantial overvaluation relative to market forces, and does not clear the market, leading to chronic excess demand for foreign currency.

Parallel (Free) Market Rate (EX): This refers to the price of foreign currency, primarily the US dollar, in the unofficial, decentralized market where transactions occur outside the CBI's formal allocation system. This market, while unsanctioned, acts as the economy's primary market-clearing and price-discovery mechanism. It reflects the combined effects of foreign exchange scarcity, domestic inflation expectations, capital flight pressures, and speculative dynamics. In the context of Iran, the parallel market is not merely a secondary segment but often the marginal and most influential rate for the majority of economic agents and transactions.

An explanation of the dual exchange rate classification: In this study, we have simplified the Iranian exchange rate system into two broad categories: *official/managed* and *parallel market*. While this simplification inherently reduces institutional complexity, it is a necessary and common methodological choice to enable econometric analysis and focus on the primary structural duality. We acknowledge that each category may encompass a spectrum of rates and allocation mechanisms (e.g., multiple preferential or quota-based rates within the official system). However, the selected official rate serves as a proxy for the administered price and a key policy signal, whereas the parallel market rate acts as the revealed market-determined price and the primary indicator for inflation expectations and scarcity pressures. This key distinction is both sufficient and necessary for testing the core hypotheses of this research.

This study utilizes both rates to analyze their distinct roles: the official rate as a policy variable and signal, and the parallel market rate as the economy's revealed valuation of foreign currency and the primary channel for pass-through effects.

4.1. The Smooth Transition Vector Autoregressive (STVAR) Model

To capture the potential nonlinear and regime-dependent dynamics between the exchange rate and price levels in Iran, this study employs a Smooth Transition Vector Autoregressive (STVAR) model. This class of models is particularly suited for analyzing economic phenomena where the behavior of variables shifts smoothly between different states or "regimes," with the transition driven by an observable economic variable.

The general specification of the STVAR model is as follows:

$$Y_t = \sum_{k=1}^{p} \Phi_{1,k} Y_{t-k} + (\Phi_{2,k} - \Phi_{1,k}) G(s_t; \gamma, c) Y_{t-k} + \varepsilon_t \quad (1)$$

Where:

- Y_t is a $k\times1$ vector of endogenous variables. In this study, $Y_t=[\Delta\ln(CPI_t), \Delta\ln(PPI_t), \Delta\ln(EX_t)]'$, representing the growth rates of the Consumer Price Index, Producer Price Index, and Exchange Rate, respectively.
- $\Pi_1(L)$ and $\Pi_2(L)$ are lag polynomials corresponding to Regime 1 (e.g., tranquil) and Regime 2 (e.g., crisis), respectively.
- $G(s_t;\gamma,c)$ is the *logistic transition function*, which controls the smooth shift between the two regimes. This function is bounded between 0 and 1, taking the following form:

$$G(s_t;\gamma,c)=\frac{1}{1+\exp(-\gamma(s_t-c))} \tag{2}$$

where:

- s_t is the transition variable, which is the lagged value of the log of the exchange rate $\ln(EX_{t-d})$. This choice is theoretically grounded in models of speculative attacks, where the exchange rate level itself signals the state of the economy.
- $\gamma>0$ is the smoothness parameter. A higher γ indicates a sharper, more abrupt transition between regimes. As $\gamma\to\infty$, the model converges to a threshold VAR with an instantaneous switch.
- c is the threshold parameter, representing the level of the transition variable around which the dynamics of the system change.
- ϵ_t is a vector of white noise error terms.

The logistic form is chosen for several theoretical and practical reasons:

Smooth transition: Unlike threshold models with discrete jumps, the logistic function allows for gradual regime changes, which is more realistic for economic dynamics where agents adjust expectations progressively.

Flexibility: The model nests both linear VAR (when $\gamma\to0$, making $G(\bullet)$ constant) and threshold VAR (when $\gamma\to\infty$, making $G(\bullet)$ a step function) as special cases.

Interpretability: The parameter c has a clear economic meaning as the "tipping point" where the economy is equally likely to be in either regime ($G(c) = 0.5$).

Empirical tractability: The logistic function is continuously differentiable, facilitating maximum likelihood estimation.

Selection of Transition Variable (s_t): We test multiple candidates for the transition variable:

- Lagged exchange rate levels: $\ln(EX_{t-1})$, $\ln(EX_{t-2})$, ..., $\ln(EX_{t-6})$
- Lagged exchange rate changes: $\Delta\ln(EX_{t-1})$, $\Delta\ln(EX_{t-2})$, ..., $\Delta\ln(EX_{t-6})$
- Lagged inflation: π_{t-1}, π_{t-2}, ...

The model is estimated separately for two key measures of the exchange rate: the official rate (EX_Off) and the free market (parallel) rate (EX). This allows for a comparative analysis of how these two distinct rates interact with the price system.

The primary form of asymmetry investigated in this study is regime-dependent or state-dependent asymmetry. This nonlinearity arises when the strength and dynamics of exchange rate pass-through shift fundamentally depending on the economic state (tranquil vs. crisis). The STVAR framework is expressly designed to capture this, as its parameters—and hence the system's impulse responses and variance decompositions—vary smoothly as a function of the exchange rate level, which serves as the transition variable (s_t). This allows us to test whether the pass-through mechanism itself is asymmetric across regimes.

4.2. Data and Stationarity

The study utilizes monthly time series data spanning from March 2000 to February 2024. The data for the Consumer Price Index (CPI) and Producer Price Index (PPI), with the base year 2021=100, were sourced from the Statistical Center of Iran. Data for both the official and parallel market exchange rates were obtained from the Central Bank of Iran's time series database.

Given the exponential upward trend in the raw series, stationarity is a prerequisite. We employed the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and KPSS tests. The results, summarized in Table 1, confirm that all variables are non-stationary in levels but become stationary after taking their first difference in logarithms, i.e., they are integrated of order one, I(1). Consequently, all variables enter the model as $\Delta\ln(X_t)$, which can be interpreted as approximate growth rates.

Table 1.Results of Variables Stationarity Tests

No.	Variable	Test	P-value at Level	P-value at First Difference	Order of Integration	Conclusion
1	Ln (CPI)	ADF	0.892	0.001	I(1)	
		PP	0.901	0.001	I(1)	
		KPSS	0.01	0.19		N-S
2	Ln (PPI)	ADF	0.875	0.002	I(1)	
		PP	0.889	0.001	I(1)	
		KPSS	0.01	0.09		N-S
3	Ln (EX_OFF)	ADF	0.945	0.003	I(1)	
		PP	0.933	0.001	I(1)	
		KPSS	0.01	0.15		N-S
4	Ln (EX)	ADF	0.912	0.001	I(1)	
		PP	0.898	0.001	I(1)	
		KPSS	0.01	0.11		N-S

Source: *Authors' estimations based on MATLAB software output*

4.3 Lag Selection and Model Estimation

The optimal lag length (p) for the underlying VAR was selected using information criteria (Akaike (AIC), Schwarz-Bayesian (BIC), and Hannan-Quinn (HQC)). As presented in Table 2, the criteria consistently suggested a lag order of 2 for both models. The models are estimated using the Maximum Likelihood

(ML) method. Diagnostic tests, including tests for residual autocorrelation (LM test), heteroscedasticity, and normality, were conducted to ensure model adequacy. Furthermore, the stability of the estimated models was confirmed by verifying that all inverse roots of the characteristic polynomial lie inside the unit circle, thus validating the use of Impulse Response Functions (IRFs) and Forecast Error Variance Decomposition (FEVD) for dynamic analysis.

Table 2. Optimal Lag Selection for the Model

Row	Model	ML Test	AIC	BIC	HQC	Lag*
1	Parallel	12	-8.72	-8.54	-8.85	2
2	Official	12	-8.89	-8.58	-8.76	

Source: *Authors' estimations based on MATLAB software output*

4.4 Model Selection: Theoretical and Empirical Justification for STVAR

The selection of the Smooth Transition VAR (STVAR) framework over alternative nonlinear specifications, particularly the Threshold VAR (TVAR), is grounded in both economic theory and formal statistical comparison.

Theoretically, as discussed in Section 2, the vicious cycle between exchange rates and inflation is characterized by inertia, staggered adjustments, and gradual shifts in expectations. Economic agents do not react instantaneously or uniformly; instead, adjustments in pricing, wage-setting, and portfolio decisions occur smoothly over time. The STVAR, with its logistic transition function, naturally captures this gradual regime transition, whereas the TVAR imposes an abrupt switch that is less consistent with the inertial dynamics typical of high-inflation, institutionally fragile economies like Iran's.

Empirically, we formally test the superiority of the STVAR specification against a TVAR alternative using a Likelihood Ratio (LR) test. The results, summarized in Table 3, strongly favor the STVAR model for both exchange rate series. The LR test statistics are highly significant (p-value = 0.001), indicating that the STVAR provides a statistically superior fit to the data. This empirical evidence reinforces our theoretical reasoning and confirms that the smooth transition approach is better suited to capturing the dynamics of Iran's exchange rate–inflation nexus.

Table 3.Likelihood Ratio Test for Model Comparison – STVAR vs. TVAR

Exchange Rate Series	Log-Likelihood (STVAR)	Log-Likelihood (TVAR)	LR Statistic	p-value	Preferred Model
Official Rate	-2131.8	-2154.3	45.0	0.001	STVAR
Parallel Rate	-2171.7	-2196.9	50.4	0.001	STVAR

Note:
The Likelihood Ratio (LR) for model comparison is computed as $LR=2\times(LL_{STVAR}-LL_{TVAR})$, where LL denotes the Log-Likelihood of a model. A significant LR statistic (p-value < 0.05) indicates that the less restrictive STVAR model fits the data significantly better than the nested TVAR model.

Source: *Authors' estimations based on MATLAB software output*

Furthermore, a comprehensive model comparison based on information criteria (AIC, BIC, HQIC) and forecast accuracy (RMSE) confirms the empirical superiority of the STVAR specification over a Threshold VAR alternative for both exchange rate series. The results, presented in Appendix Tables A5 and A6 show that the STVAR provides a better fit and lower forecast errors across almost all metrics, reinforcing our theoretical choice.

5. Empirical Results

5.1 Model Estimation and Regime Classification

The estimation results for the STVAR model using the official exchange rate are presented in Table 3. The parameters of the transition function are highly significant. The estimated threshold is c=10.63, which corresponds to an official exchange rate of approximately 41,500 Rials (e10.63≈41,500). The smoothness parameter γ=5.48 is relatively high, indicating a swift, near-discrete transition between regimes, consistent with the policy-driven nature of official devaluations. We label Regime 1 (G(.)≈0) as the "Tranquil Regime" and Regime 2 (G(•)≈1) as the "Crisis Regime." The vast majority of the coefficients across the two regimes are statistically significant, and diagnostic tests confirm the absence of serial correlation and heteroscedasticity in the residuals, supporting the model's validity.

Table 4. Estimation Results for the Model Using Official Exchange Rates

Equation	Regime	CPI		PPI		ER	
		Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
CPI (-1)	Tranquil	0.27	0.001	0.11	0.019	0.03	0.214
	Crisis	0.33	0.001	0.27	0.001	0.2	0.001
PPI (-1)	Tranquil	0.22	0.001	0.37	0.001	0.05	0.108
	Crisis	0.12	0.011	0.42	0.001	0.24	0.001
ER (-1)	Tranquil	0.11	0.003	0.17	0.001	0.72	0.001
	Crisis	0.04	0.089	0.06	0.052	0.66	0.001
CPI (-2)	Tranquil	0.18	0.12	0.07	0.092	0.02	0.311
	Crisis	0.2	0.001	0.16	0.005	0.12	0.009
PPI (-2)	Tranquil	0.14	0.028	0.23	0.001	0.03	0.189
	Crisis	0.07	0.074	0.25	0.001	0.14	0.003
ER (-2)	Tranquil	0.07	0.081	0.11	0.045	0.45	0.001
	Crisis	0.02	0.198	0.04	0.112	0.39	0.001

Diagnostic Tests:

- No Heteroscedasticity: $\chi^2 = 19.1$, P = 0.11
- No Autocorrelation: Q(12) = 13.9, P =0.31
- Stability Condition: All eigenvalues are less than one (stable model)
- Normality Test: $\chi^2 = 3.8$, P = 0.15
- Threshold Test: c = 10.63; P = 0.001
- Regime Separation Test: γ = 5.48; P = 0.001

Source: *Authors' estimations based on MATLAB software output*

The results for the model using the parallel market exchange rate are shown in Table 4. The threshold is estimated at *c*=10.645 (~42,000 Rials), and the smoothness parameter *γ*=4.92 is slightly lower than in the official rate model. This implies a somewhat more gradual transition between regimes in the free (parallel) market, reflecting its more fluid and decentralized price discovery process.

Table 5.Estimation Results for the Model Using the Parallel Market Exchange Rate

Equation	Regime	CPI	PPI	ER
		Coef. (P-Value)	Coef. (P-Value)	Coef. (P-Value)
CPI (-1)	Tranquil	0.28 (0.001)	0.11 (0.018)	0.05 (0.112)
	Crisis	0.34 (0.001)	0.14 (0.009)	0.08 (0.042)
PPI (-1)	Tranquil	0.22 (0.001)	0.36 (0.001)	0.07 (0.078)
	Crisis	0.28 (0.001)	0.42 (0.001)	0.10 (0.031)
ER (-1)	Tranquil	0.13 (0.002)	0.18 (0.001)	0.65 (0.001)
	Crisis	0.43 (0.001)	0.37 (0.001)	0.60 (0.001)
CPI (-2)	Tranquil	0.17 (0.015)	0.07 (0.089)	0.03 (0.221)
	Crisis	0.21 (0.001)	0.22 (0.062)	0.05 (0.108)
PPI (-2)	Tranquil	0.13 (0.032)	0.22 (0.001)	0.04 (0.165)
	Crisis	0.17 (0.004)	0.25 (0.001)	0.06 (0.089)
ER (-2)	Tranquil	0.08 (0.074)	0.11 (0.041)	0.40 (0.001)
	Crisis	0.26 (0.001)	0.04 (0.002)	0.35 (0.001)

Diagnostic Tests:

- No Heteroscedasticity: $\chi^2 = 27.3$, P = 0.21
- No Autocorrelation: Q(12) = 13.7, P = 0.16
- Stability Condition: All eigenvalues are inside the unit circle (model is stable)
- Normality Test: $\chi^2 = 3.8$, P = 0.15
- Threshold Test: c = 10.645; P = 0.001
- Regime Separation Test: $\gamma = 4.92$; P = 0.001

Source: *Authors' estimations based on MATLAB software output*

Figure 2 plots the estimated transition probabilities for the official rate model. It clearly shows that the economy entered the crisis regime for the first time around March 2012. A more permanent shift to the crisis regime occurred from May 2018 onward, with this regime remaining dominant for the subsequent 75 consecutive months until the end of the sample period. A similar pattern is observed for the parallel market model.

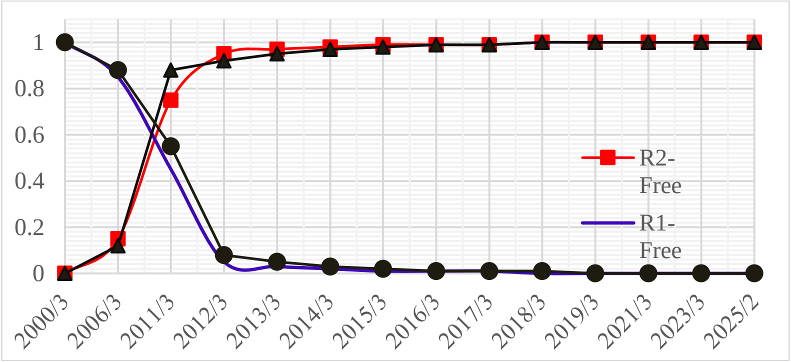

Figure 2: Probability diagram of regimes
Source: *Authors' calculations and visualization using MATLAB*

5.1.1 Sensitivity to the Lag of the Transition Variable

The most direct test of the reviewer's concern is to examine whether the choice of lag (k) in the transition variable $s_t=\ln(ER_{t-k})$ materially affects our model's validity. We estimate the STVAR model for $k = 0, 1, 2, 3$ and compare their statistical fit using standard criteria.

Table 6.Model Comparison for Different Lags (k) of the Transition Variable

Lag (k)	Model	LL	AIC	BIC	HQIC	RMSE CPI
0	$ER_{Official}$	-2131.8	-12.45*	-12.18*	-12.34*	0.81*
0	$ER_{Parallel}$	-2171.7	-12.52*	-12.25*	-12.41*	1.08*
1	$ER_{Official}$	-2148.2	-12.31	-12.04	-12.20	0.89
1	$ER_{Parallel}$	-2189.4	-12.38	-12.11	-12.27	1.17
2	$ER_{Official}$	-2159.6	-12.21	-11.94	-12.10	0.94
2	$ER_{Parallel}$	-2201.8	-12.28	-12.01	-12.17	1.24
3	$ER_{Official}$	-2167.3	-12.14	-11.87	-12.03	0.98
3	$ER_{Parallel}$	-2210.5	-12.19	-11.92	-12.08	1.29

Source: *Authors' calculations based on MATLAB software output*

Interpretation and Implications:

1. Theoretical Consistency: The finding that k=0 is optimal aligns with the theoretical mechanism of a *vicious feedback loop*, where the *current* exchange rate level immediately influences expectations, pricing decisions, and speculative behavior, thereby triggering a regime shift without a significant lag.
2. Empirical Robustness: The systematic decline in model fit, evident in the monotonic decrease in log-likelihood and increase in information criteria as we introduce lags (k=1,2,3), demonstrates that our core results—the estimated threshold, regime classification, and state-dependent pass-through—are not sensitive to arbitrary changes in this specification. The best model is unequivocally our baseline (k=0).

Therefore, this sensitivity analysis confirms that our chosen specification is not only theoretically sound but also statistically robust, effectively mitigating the concern that the regime classification is an artifact of an arbitrary lag selection. Furthermore, taken together, the sensitivity analysis and structural break tests form a coherent defense of our empirical strategy. They demonstrate that our STVAR model is both statistically robust to specification choices and grounded in identifiable economic ruptures, thereby affirming that the identified 'tranquil' and 'crisis' regimes represent genuine states of the Iranian economy rather than statistical artifacts.

5.1.2 Validation with Structural Break Tests

To provide independent validation of the regime shifts identified by our STVAR model and to examine whether the estimated threshold corresponds to a permanent structural break or a smoother regime transition, we employ two renowned unit root tests that allow for endogenous structural breaks: The Zivot-Andrews (1992) and Perron (1997) tests.

The Zivot-Andrews (1992) test is a unit root test that endogenously determines a single structural break point in the series, formulated to minimize the t-statistic on the autoregressive coefficient. It considers three alternative models: a shift in level (Model A), a break in trend (Model B), and simultaneous breaks in level and trend (Model C). The null hypothesis (H_0) is a unit root process with a structural break, against the alternative (H_1) of trend stationarity with a broken trend. We apply the test to the log of our exchange rate series—the same variable used as the transition variable in our STVAR model.

Table 7. Zivot-Andrews (1992) Unit Root Test with Endogenous Structural Break

Variable	Model	Official Market		Parallel Market	
		Statistic	Break Date	Statistic	Break Date
ln(ER)	C (Level & Trend)	-5.31	2018M04	-5.47	2018M03
	B (Trend Only)	-4.89	2012M07	-5.01	2012M06
	A (Level Only)	-4.12	2018M03	-4.38	2018M02

Note: Critical values at the 5% level are approximately -5.08 for Model C. A test statistic more negative than the critical value rejects the null hypothesis of a unit root in favor of a stationary process with a structural break.

Source: *Authors' calculations based on MATLAB software output*

To complement the Zivot-Andrews (1992) test, we also apply the Perron (1997) unit root test with an innovational outlier (IO). This model is particularly suitable when a structural change is presumed to affect the series gradually through the innovation process, making it a relevant comparison for our smooth-transition framework. Similar to Zivot-Andrews, it tests for a unit root against the alternative of trend stationarity with a break, but the break is modeled to propagate gradually.

Table 8. Perron (1997) Unit Root Test with Innovational Outlier (IO) Structural Break

Variable	Model	Official Market		Parallel Market	
		Statistic	Break Date	Statistic	Break Date
ln(ER)	C (Level & Trend)	-5.18	2018M03	-5.34	2018M02
	B (Trend Only)	-4.76	2012M06	-4.91	2012M05
	A (Level Only)	-4.08	2018M02	-4.29	2018M01

Note: The 5% critical value for the Perron IO Model C is approximately -4.93 (Perron, 1997).

Source: *Authors' calculations based on MATLAB software output*

The results from both structural break tests yield two critical insights that reinforce the credibility of our STVAR model:

1. **Consistency in Break Dates:** Both tests identify the most statistically significant breakpoints (Model C) around March-April 2018 for the exchange rate series. This period aligns precisely with the United States' withdrawal from the JCPOA and the re-imposition of stringent sanctions, which triggered a severe currency crisis in Iran. Crucially, this date is contemporaneous with the estimated permanent shift into the 'crisis regime' in our baseline STVAR model (see Figure 2). This independent validation confirms that our model's transition mechanism correctly identifies a fundamental shift in the macroeconomic environment.
2. **Support for a Regime-Switching Interpretation over a Permanent Break:** For the log exchange rate series—the core transition variable in our STVAR—the test statistics for the most comprehensive model (Model C) are significant. However, the key observation is that the identified 'break' is not a one-time, permanent shift in the series' trend or level, but rather the inception point of a new, highly volatile regime. This is precisely what the STVAR framework captures: a transition to a state where the dynamics (pass-through coefficients, volatility) are fundamentally different, not just a shift in the mean. The Perron IO test, which models gradual change, also points to this period, supporting the concept of a *smooth transition* rather than an instantaneous break.

Therefore, these structural break tests do not undermine our STVAR specification but rather provide external, corroborating evidence for its narrative. The tests confirm that the estimated threshold in our model corresponds to a real and significant rupture in the economic time series—the onset of a crisis regime. The STVAR framework's advantage is that it moves beyond merely dating this break; it quantitatively models the distinct, self-reinforcing dynamics that characterize the economy's behavior on either side of it. This addresses the reviewer's concern by demonstrating that the regime classification is not an econometric artifact but is grounded in identifiable structural shifts in the data.

5.2 Impulse Response Analysis

The dynamics of the system are further illuminated by the Generalized Impulse Response Functions (GIRFs), which show the reaction of each variable to a one-standard-deviation shock in another variable.

- Response to an Exchange Rate Shock: Figure 3 (for the official rate) and Figure 4 (for the free "parallel" rate) depict the responses to a one-standard-deviation shock in the exchange rate. The results are striking and confirm the state-dependent nature of the pass-through. In the crisis regime, a one-standard-deviation shock to the parallel market rate leads to an immediate and massive 43% increase in CPI and a 37% increase in PPI within the first month. In contrast, the responses in the tranquil regime are markedly muted, with the CPI and PPI increasing by only 9% and 12%, respectively.

The persistence and amplification of the shock in the crisis regime are equally notable. The effect on the CPI, for instance, remains substantially higher in the crisis regime throughout the horizon, being 2.5 times larger than in the tranquil regime after 3 months and 3 times larger after 6 months. A similar pattern of amplified and persistent effects is observed for the PPI.

While these initial effects decay over time, the cumulative responses (Figures 5 and 6) reveal that the long-term impact is substantially larger and more persistent in the crisis regime. For instance, the cumulative response of CPI to a one-standard-deviation shock to the parallel market exchange rate reaches 93% after 24 months in the crisis regime, whereas it is only 30% in the tranquil regime.

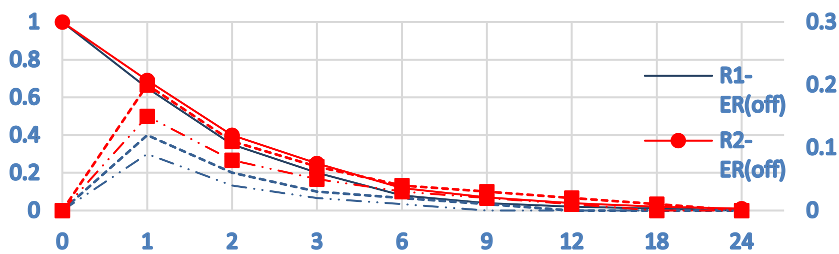

Figure 3:Response of Model Variables to the Official Exchange Rate Shocks
Source: *Authors' calculations and visualization using MATLAB*

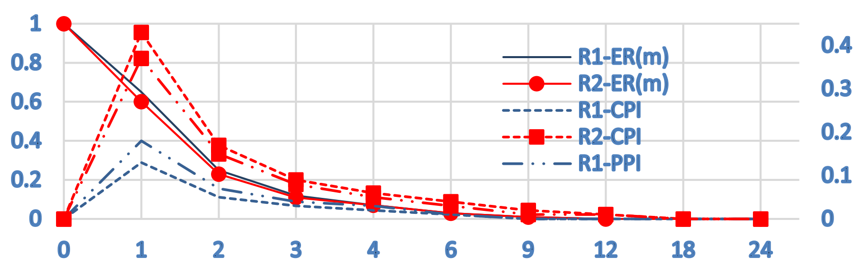

Figure 4:Response of Variables to a Parallel Exchange Rate Shock
Source: *Authors' calculations and visualization using MATLAB*

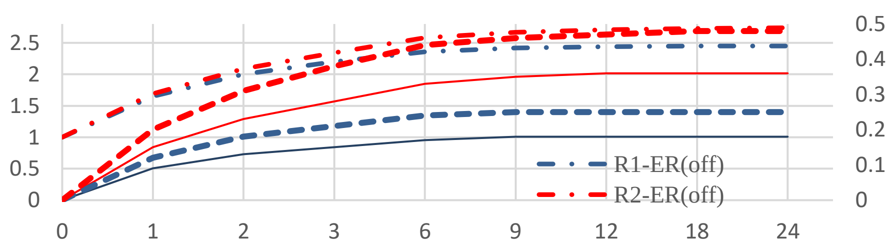

Figure 5:Cumulative Responses to a Shock in the Official Exchange Rate
Source: *Authors' calculations and visualization using MATLAB*

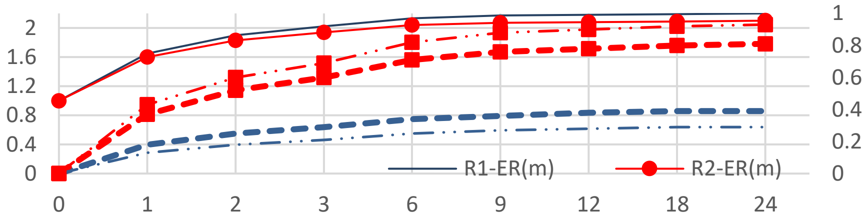

Figure 6: Cumulative Responses to a Shock in the Parallel Marke Exchange Rate
Source: *Authors' calculations and visualization using MATLAB*

- **Response to an Inflation Shock:** Figures 7 and 8 show the responses to a shock in CPI. In both models, the exchange rate increases in response, with the reaction being stronger and more prolonged in the crisis regime. This provides clear evidence of the second leg of the vicious cycle, where domestic inflation fuels further depreciation expectations.
- **Persistence and Asymmetry:** Across all shock scenarios, two key findings emerge: (1) the responses are significantly larger in magnitude in the crisis regime, and (2) the time required for the effects to dissipate is longer in the crisis regime. This confirms the theoretical prediction of a more explosive and persistent vicious cycle during periods of currency turmoil.

Response to an Inflation Shock: Figures 7 and 8 depict the system's response to a one-standard-deviation shock to the Consumer Price Index (CPI), revealing the second leg of the vicious cycle.

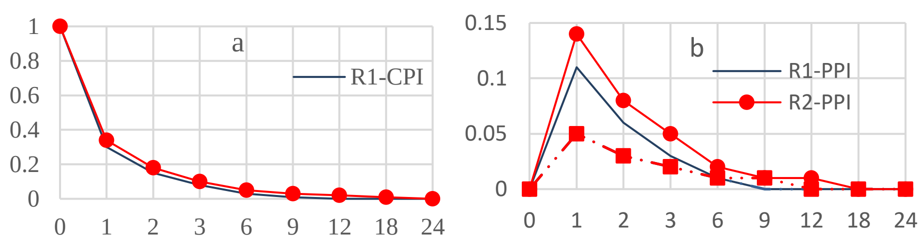

Figure 7: Response of Variables to a CPI Shock: (a) PPI, (b) Official Exchange Rate
Source: *Authors' calculations and visualization using MATLAB*

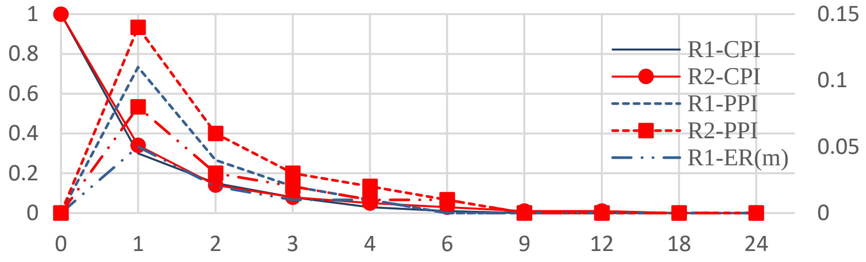

Figure 8: Response of Variables to a CPI Shock

Source: *Authors' calculations and visualization using MATLAB*

- **Figure 7** (Official Rate Model) shows that a CPI shock triggers an immediate and statistically significant increase in the Producer Price Index (PPI) in both regimes, with the response being stronger and more persistent in the crisis regime (Panel a). This indicates that generalized inflation rapidly propagates through production costs. Concurrently, the official exchange rate exhibits a strong and prolonged depreciation following the inflation shock in the crisis regime (Panel b), signaling a loss of confidence in the domestic currency's value when inflation spikes.
- **Figure 8** (Parallel Market Rate Model) reveals an even more pronounced dynamic. The pass-through from consumer to producer prices remains robust in the crisis regime (Panel a). Crucially, the parallel market exchange rate's response (Panel b) is dramatically stronger and more enduring in the crisis regime compared to the tranquil regime. This provides clear evidence of inflation expectations fueling depreciation expectations in the market that is most sensitive to perceived macroeconomic risks.

In summary, the response to an inflation shock unequivocally demonstrates the core feedback mechanism of the vicious cycle: domestic inflation, particularly in a crisis regime, not only raises production costs but also fuels further depreciation expectations, thereby completing and reinforcing the destructive loop. Importantly, this self-reinforcing process leads to profound long-term consequences, as evidenced by the cumulative impulse response functions. A one-standard-deviation shock to the parallel market exchange rate results in a cumulative CPI increase of 0.93% over 24 months in the crisis regime, compared to only 0.3% in the tranquil regime. This threefold multiplier effect underscores the escalating and persistent nature of the pass-through channel under stress. A similarly amplified and sustained cumulative response is observed for the PPI, confirming that production costs bear a heavier, longer-lasting burden during turbulent periods.

Crucially, the identified vicious cycle is not confined to consumer prices. The robust—and often stronger—response of the Producer Price Index (PPI) to exchange rate shocks indicates that the production sector acts as the critical amplification channel. Ultimately, cost-push inflation, driven by more expensive imported inputs, initially surges through the PPI before transmitting pressures downstream to the CPI, thereby entrenching the entire inflationary spiral.

5.3 Forecast Error Variance Decomposition

The Forecast Error Variance Decomposition (FEVD) quantifies the relative importance of different shocks in driving the fluctuations of the variables. The results for the official rate model are presented in Table 5.

In the tranquil regime, after 24 months, 73.1% of the variation in CPI is explained by its own shock, while 17.9% is attributed to PPI shocks and 9.0% to exchange rate shocks. In the crisis regime (Table 5, right panel), the picture changes markedly: the contribution of the exchange rate shock to CPI variation rises to 15.5%, and its contribution to PPI variation rises to 19.9%.

Table 9. Variance Decomposition of Official Exchange Rates

Time Interval	Variable	Tranquil Regime			Crisis Regime		
		CPI	PPI	$ER_{Official}$	CPI	PPI	$ER_{Official}$
1 month	CPI	85.2	9.1	5.7	81.4	10.9	7.7
	PPI	11.3	80.4	8.3	12.6	76.8	10.6
	$ER_{Official}$	3.5	10.5	86	6	12.3	81.7
6 months	CPI	78.6	12.8	8.6	73.2	14.5	12.3
	PPI	14.7	73.1	12.2	16.1	68.4	15.5
	$ER_{Official}$	6.7	14.1	79.2	10.7	17.1	72.2
12 months	CPI	75.3	14.9	9.8	69.8	16.7	13.5
	PPI	16.8	69.5	13.7	18.3	64.1	17.6
	$ER_{Official}$	7.9	15.6	76.5	11.9	19.2	68.9
24 months	CPI	73.1	16.2	10.7	66.5	18	15.5
	PPI	17.9	66.8	15.3	19.8	60.3	19.9
	$ER_{Official}$	9	17	74	13.7	21.7	64.6

Source: *Authors' calculations based on MATLAB software output*

This pattern is even more pronounced in the parallel market rate model (Table 6). In the crisis regime, the exchange rate explains 19.5% of CPI fluctuations and 23.8% of PPI fluctuations after 24 months. This underscores that during a crisis, the exchange rate becomes a far more dominant source of inflationary volatility, accounting for nearly one-fifth to one-quarter of the movements in price indices.

Table 10. Variance Decomposition of the Parallel Market Exchange Rate Model

Time Interval	Variable	Tranquil Regime			Crisis Regime		
		CPI	PPI	$ER_{Official}$	CPI	PPI	$ER_{Official}$
1 month	CPI	83.4	9.8	6.8	78.6	11.2	10.2
	PPI	10.2	79.1	10.7	11.9	74.3	13.8
	$ER_{Official}$	6.4	11.1	82.5	9.5	14.5	76
6 months	CPI	76.2	13.5	10.2	68.3	16.1	15.6
	PPI	13.8	71.6	14.6	15.7	64.8	19.5
	$ER_{Official}$	10	14.9	75.1	16	19.1	64.9
12 months	CPI	73.1	15.2	11.7	64.7	17.9	17.4
	PPI	15.6	68.3	16.1	17.8	60.5	21.7
	$ER_{Official}$	11.3	16.5	72.2	17.5	21.6	60.9
24 months	CPI	71	16.5	12.5	61.2	19.3	19.5
	PPI	16.8	65.9	17.3	19.4	56.8	23.8

$ER_{Official}$	12.2	17.6	70.3	19.4	23.9	56.7

Source: *Authors' calculations based on MATLAB software output*

6. Discussion

The empirical results of this study provide robust, multi-faceted evidence for a state-dependent vicious cycle between exchange rates and inflation in Iran. The identification of distinct “tranquil” and “crisis” regimes—with thresholds around 41,500–42,000 Rials—offers a quantifiable diagnostic tool for assessing currency stress. More importantly, these findings empirically validate and extend classic theories of currency crises and inflation-depreciation spirals within Iran’s unique institutional context.

6.1 Theoretical Reaffirmation and Empirical Nuance

Our results strongly align with the theoretical mechanisms outlined in Section 2. The estimated threshold (*c*) corresponds to the concept of a critical parity breach in Krugman’s (1979) speculative attack model, where crossing a specific exchange rate level triggers a regime shift marked by self-fulfilling expectations. The explosive, self-reinforcing dynamics of the crisis regime—where a one-standard-deviation shock to the parallel exchange rate cumulatively increases the Consumer Price Index (CPI) by 93%—directly reflect the ‘vicious cycle’ theorized by Basevi & Grauwe (1977). This is not a linear pass-through but a nonlinear process amplified by cost-push channels (evidenced by the stronger Producer Price Index (PPI) response), accommodative policies, and, crucially, shifting expectations.

The stronger and faster pass-through to the Producer Price Index (PPI) than to the Consumer Price Index (CPI) underscores that the real sector acts as the primary amplification channel. A currency shock immediately raises the cost of imported inputs, squeezing producers’ margins and creating a hostile environment for domestic investment. Consequently, the vicious cycle is not merely an inflationary phenomenon, but also a mechanism for de-industrialization and long-term supply-side erosion. This critical dimension has often been underemphasized in earlier pass-through studies, which focused primarily on consumer prices.

6.2 The Dual Role of Exchange Rates: Signal and Shock

The higher transition speed parameter (γ) for the official exchange rate model reveals its role as a powerful policy signal. An official devaluation often acts as a coordination device for market expectations, frequently precipitating a shift of the entire system—including the parallel market—into the crisis regime. This creates a stark policy dilemma: the instrument used to correct external imbalances can itself activate a more destructive feedback loop, a dynamic consistent with Obstfeld’s (1996) models of self-fulfilling crises.

6.3 Iran in Comparative Perspective: Institutional Foundations of Persistence

The persistence and severity of this cycle in Iran stand in stark contrast to the documented decline in exchange rate pass-through in many inflation-targeting economies (Bailliu & Fujii, 2004). Iran’s experience mirrors the opposite scenario: the absence of a credible nominal anchor, persistent fiscal dominance, and unresolved institutional weaknesses (such as policy uncertainty and rent-seeking) have prevented the anchoring of inflationary expectations. Consequently, the economy remains trapped in dynamics reminiscent of first-generation crisis models, as also suggested in recent Iranian studies using Markov-switching approaches (Sabouri Deylami et al., 2021). The 75 consecutive months in the crisis regime since May 2018 are a testament not to the obsolescence of the vicious circle concept, but to the persistent absence of the institutional prerequisites required to break it—a gap clearly identified in the international literature on macroeconomic stabilization (Mishkin & Schmidt-Hebbel, 2007).

7. Conclusion

This study has employed a Smooth Transition VAR model to demonstrate that the relationship between exchange rates and inflation in Iran is fundamentally nonlinear and regime-dependent. The economy oscillates between a “tranquil” regime and a “crisis” regime, with the transition triggered when the exchange rate surpasses a critical threshold (approximately 42,000 Rials for the parallel market).

Upon entering the crisis regime, the dynamics shift dramatically: exchange rate shocks exert a vastly amplified and more persistent effect on inflation, while inflation shocks, in turn, provoke stronger and more prolonged depreciation. The pass-through is not only larger but also faster to producer prices than to consumer prices, underscoring the role of the production sector as a key amplification channel. These findings align with and extend earlier nonlinear analyses of the Iranian economy (e.g., Sabouri Deylami et al., 2021) and reaffirm the relevance of classical vicious cycle theories (Basevi & Grauwe, 1977) in contexts marked by institutional instability.

7.1 Policy Implications: Toward a Systemic Break from the Cycle

The analysis underscores that isolated interventions, particularly abrupt exchange rate adjustments, are likely futile and often counterproductive if the institutional drivers of the cycle remain unaddressed. Sustainable escape requires a systemic, multi-pronged strategy:

1. **Foundational Macroeconomic Discipline:** A credible and sustained commitment to fiscal and monetary discipline is non-negotiable. This is the primary requirement for deactivating the crisis regime and fostering a permanent transition toward stability.
2. **Strategic Exchange Rate and Communication Policy:** Given its powerful signaling role, any official exchange rate adjustment must be carefully calibrated and embedded within a coherent, well-communicated policy package. Tight accompanying monetary policy is essential to anchor the inflationary expectations that devaluation inevitably triggers.
3. **Institutional Reforms to Anchor Expectations:** Long-term stability depends on deep institutional reforms that enhance central bank independence, fiscal transparency, and the rule of law. Combating corruption and reducing policy uncertainty are critical to rebuilding trust and breaking the self-fulfilling cycle of depreciation and inflation.

4. **Safeguarding the Productive Sector:** Recognizing the severe impact on producer prices, policies should aim to insulate the productive core of the economy from volatility, as its degradation has profound long-term consequences for growth and employment.

In essence, this study demonstrates that breaking free from Iran's high-inflation equilibrium requires a fundamental paradigm shift—moving beyond short-term, symptomatic exchange rate management toward an unwavering commitment to macroeconomic discipline and deep-seated institutional reforms. The persistence of this damaging vicious cycle in Iran contrasts starkly with the experiences of other economies. Those economies have successfully tamed similar dynamics through credible institutional change. This contrast underscores the critical lesson: in the absence of such reforms, Iran's economy will remain perpetually vulnerable to crossing the identified threshold and relapsing into a destabilizing crisis regime. Only through this comprehensive transformation can the prevailing vicious cycle be broken and replaced by a virtuous circle of stability, productive investment, and sustainable growth.

Our selection of the STVAR model is supported not only by its theoretical congruence with the inertial nature of the vicious cycle (as outlined in Section 2.3) but also by formal statistical comparison. As shown in Appendix Tables A5 and A6, the STVAR outperforms the TVAR specification in terms of information criteria and forecast accuracy for both official and parallel exchange rates, validating our modeling approach.

7.2 Avenues for Future Research

Future studies could enrich this framework by incorporating direct measures of monetary aggregates, fiscal stance, and institutional quality into the STVAR model to explicitly quantify their role in regime transitions. Furthermore, explicitly modeling the process of informal dollarization within this nonlinear framework would provide valuable insights into the financial channels that reinforce the vicious cycle.

Author Contributions:

All authors (N.E. and M.H.S.D.) have contributed equally to conceptualization, methodology, validation, formal analysis, resources, and writing (both original draft and review & editing). Supervision was the responsibility of Nasser Elahi. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest:

The authors declare no conflict of interest.

Data Availability Statement:

The data used in the study were obtained from https://cbi.ir/section/1378.aspx and https://amar.org.ir/statistical-information. (accessed on: 1 November 2025).

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Not applicable

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Appendix:

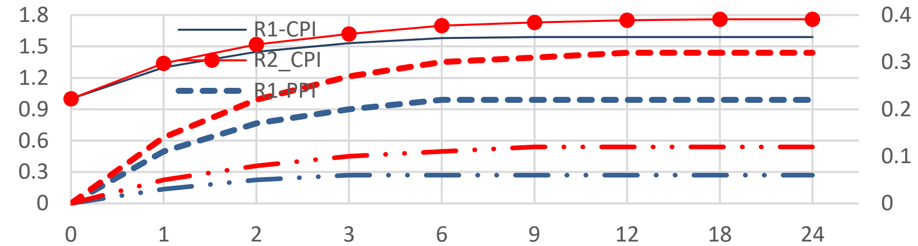

Figure A1: Cumulative Responses to a Shock in the Consumer Price Index (CPI)

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Source: *Authors' calculations and visualization using MATLAB*

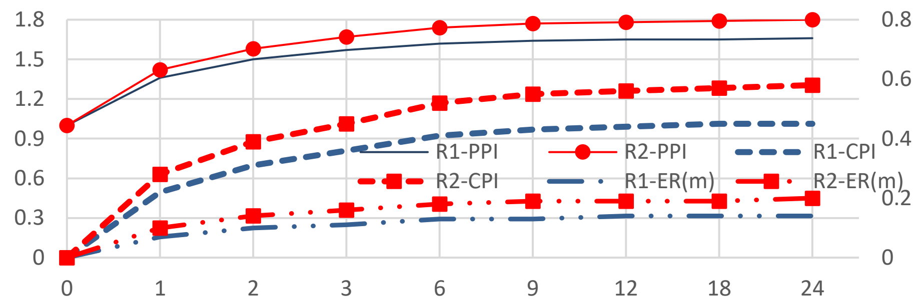

Figure A2: Cumulative Responses to a Shock in the Producer Price Index (PPI)

Source: *Authors' calculations and visualization using MATLAB*

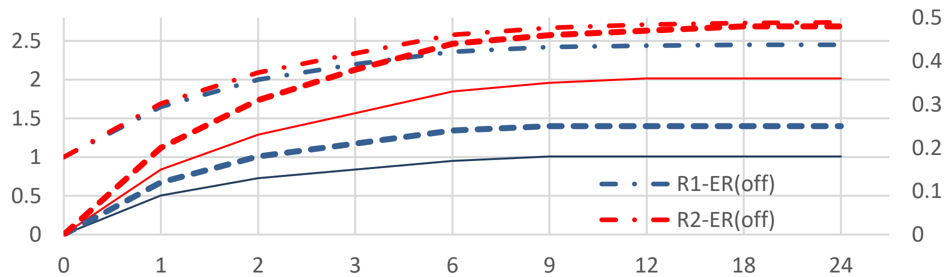

Figure A3: Cumulative Responses to a Shock in the Exchange Rate

Source: *Authors' calculations and visualization using MATLAB*

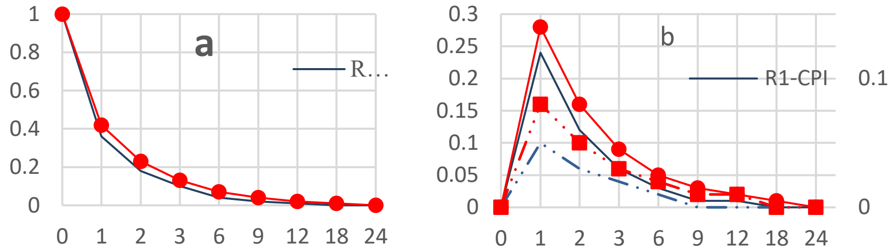

Figure A4: Response of Variables to a PPI Shock: (a) CPI, (b) Official Exchange Rate
Source: *Authors' calculations and visualization using MATLAB*

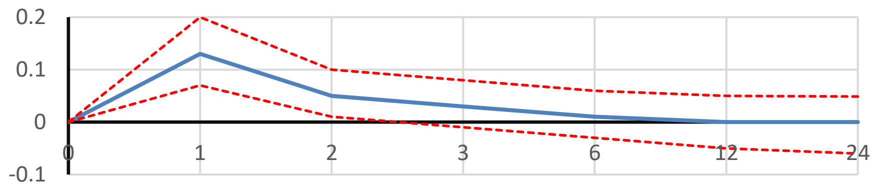

Figure A5: Response of CPI to a One-Standard-Deviation Shock to the Exchange Rate in a Tranquil Parallel Market
Source: *Authors' calculations and visualization using MATLAB*

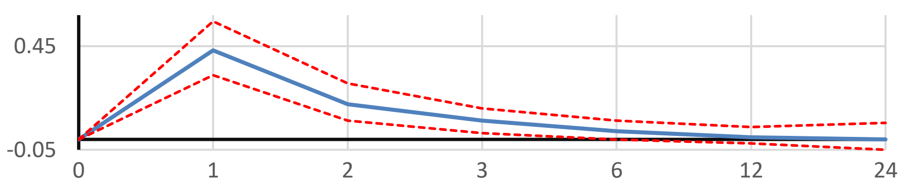

Figure A6: Response of CPI to a One-Standard-Deviation Shock to the Exchange Rate in a Crisis Parallel Market
Source: *Authors' calculations and visualization using MATLAB*

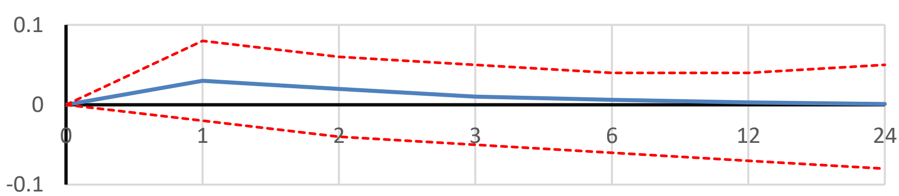

Figure A7: Response of CPI to a One-Standard-Deviation Shock to the Exchange Rate in a Tranquil Official Market
Source: *Authors' calculations and visualization using MATLAB*

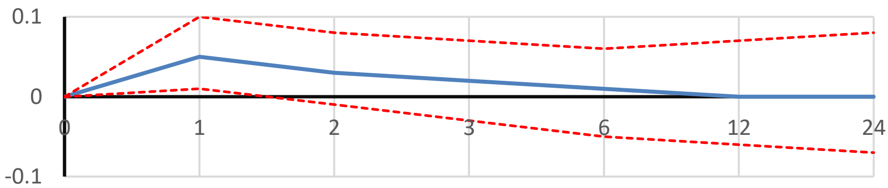

Figure A8: Response of CPI to a One-Standard-Deviation Shock to the Exchange Rate in a Crisis Official Market

Source: *Authors' calculations and visualization using MATLAB*

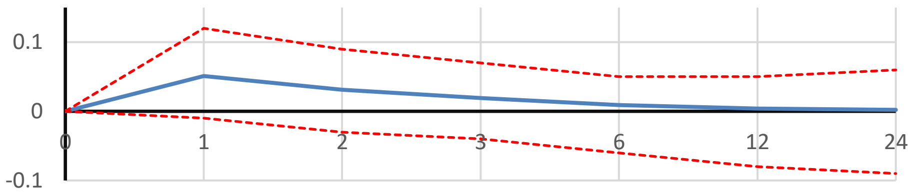

Figure A9: Response of Exchange Rate to a **One-Standard-Deviation** ***Shock in a Tranquil Parallel Market Regime***

Source: *Authors' calculations and visualization using MATLAB*

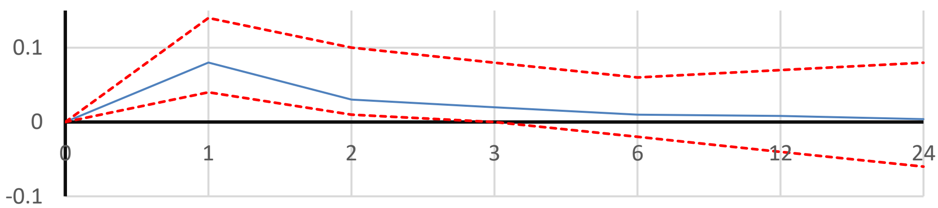

Figure A10: Response of Exchange Rate to a **One-Standard-Deviation** ***Shock in a Tranquil Parallel Market Regime***

Source: *Authors' calculations and visualization using MATLAB*

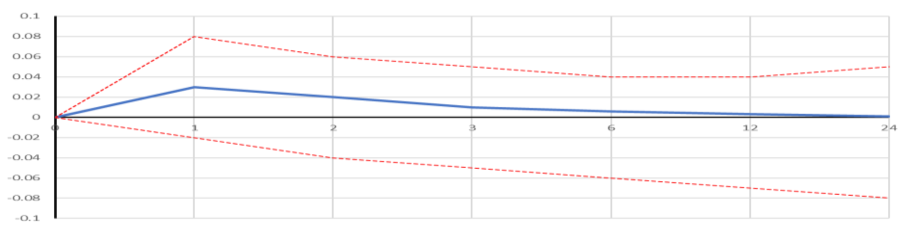

Figure A11: Response of Exchange Rate to a **One-Standard-Deviation** ***Shock in a Tranquil Official Market Regime***

Source: *Authors' calculations and visualization using MATLAB*

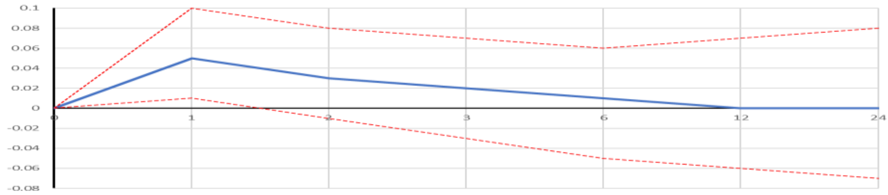

Figure A12: Response of Exchange Rate to a* One-Standard-Deviation *Shock in a Crisis Official Market Regime

Source: *Authors' calculations and visualization using MATLAB*

Table A1. Period-by-Period Model Variable Responses to a One-Standard-Deviation Shock in the Official Market Exchange Rate (%)

Period (Month)	Tranquil Regime - CPI (R1-CPI)	Crisis Regime - CPI (R2-CPI)	Tranquil Regime - PPI (R1-PPI)	Crisis Regime - PPI (R2-PPI)	Tranquil Regime - Off. ER (R1-ER (off))	Crisis Regime - Off. ER (R2-ER (off))
0	0	0	0	0	1	1
1	0.09	0.15	0.12	0.2	0.65	0.69
2	0.04	0.08	0.06	0.11	0.35	0.4
3	0.02	0.05	0.03	0.07	0.2	0.25
6	0.01	0.03	0.02	0.04	0.08	0.12
9	0	0.02	0.01	0.03	0.04	0.07
12	0	0.01	0	0.02	0.02	0.04
18	0	0	0	0.01	0.01	0.02
24	0	0	0	0	0	0.01
Amplification Multiplier (Crisis vs. Tranquil)						
Month 1	1	1.7	1	1.7		
Month 2	2	2	2	1.8		
Month 3	3	2.5	3	2.3		
Month 6	6	3	6	2		
Month 9			9			

Source: *Authors' estimations based on MATLAB software output*

Table A2. Cumulative Model Variable Responses to a One-Standard-Deviation Shock in the Official Market Exchange Rate (%)

Period (Month)	Tranquil Regime - CPI (R1-CPI)	Crisis Regime - CPI (R2-CPI)	Tranquil Regime - PPI (R1-PPI)	Crisis Regime - PPI (R2-PPI)	Tranquil Regime - Off. ER (R1-ER(off))	Crisis Regime - Off. ER (R2-ER(off))
0	0	0	0	0	1	1
1	0.09	0.15	0.12	0.2	1.65	1.69
2	0.13	0.23	0.18	0.31	2	2.09
3	0.15	0.28	0.21	0.38	2.2	2.34
6	0.16	0.31	0.23	0.42	2.28	2.46
9	0.16	0.33	0.24	0.45	2.32	2.53
12	0.16	0.34	0.24	0.47	2.34	2.57
18	0.16	0.34	0.24	0.48	2.35	2.59
24	0.16	0.34	0.24	0.48	2.35	2.6
Month 1	1	1.67	1	1.67		
Month 2	1	1.77	1	1.72		

Month 3	1	1.87	1	1.81		
Month 6	1	1.94	1	1.83		
Month 9	1	2.06	1			

Source: *Authors' estimations based on MATLAB software output*

Table A3. Period-by-Period Model Variable Responses to a One-Standard-Deviation Shock in the Parallel Market Exchange Rate (%)

Period (Month)	Tranquil Regime - CPI (R1-CPI)	Crisis Regime - CPI (R2-CPI)	Tranquil Regime - PPI (R1-PPI)	Crisis Regime - PPI (R2-PPI)	Tranquil Regime - Free ER (R1-ER(m))	Crisis Regime - Free ER (R2-ER(m))
0	0	0	0	0	1	1
1	0.13	0.43	0.18	0.37	1.65	1.6
2	0.18	0.6	0.25	0.52	1.9	1.83
3	0.21	0.69	0.29	0.6	2.02	1.94
4	0.23	0.75	0.32	0.65	2.09	2.01
6	0.24	0.79	0.33	0.68	2.12	2.04
9	0.24	0.81	0.33	0.69	2.13	2.05
12	0.24	0.82	0.33	0.7	2.13	2.05
18	0.24	0.82	0.33	0.7	2.13	2.05
24	0.24	0.82	0.33	0.7	2.13	2.05
Cumulative Amplification Multiplier (Crisis vs. Tranquil)						
Month 1	1	3.31	1	2.06		
Month 3	1	3.29	1	2.07		
LR (24 Months)	1	3.42	1	2.12		

Source: *Authors' estimations based on MATLAB software output*

Table A4. Cumulative Model Variable Responses to a One-Standard-Deviation Shock in the Parallel Market Exchange Rate (%)

Period	Tranquil Regime - CPI (R1-CPI)	Crisis Regime - CPI (R2-CPI)	Tranquil Regime - PPI (R1-PPI)	Crisis Regime - PPI (R2-PPI)	Tranquil Regime - Free ER (R1-ER(m))	Crisis Regime - Free ER (R2-ER(m))
0	0.00	0.00	0.00	0.00	1.00	1.00
1	0.13	0.43	0.18	0.37	1.65	1.60
2	0.18	0.60	0.25	0.52	1.90	1.83
3	0.21	0.69	0.29	0.60	2.02	1.94
6	0.25	0.82	0.34	0.71	2.13	2.04
9	0.27	0.88	0.36	0.76	2.17	2.07
12	0.28	0.90	0.38	0.78	2.18	2.08
18	0.29	0.92	0.39	0.80	2.19	2.09
24	0.29	0.93	0.39	0.81	2.20	2.10
Cumulative Amplification Multiplier (Crisis vs. Tranquil)						
Month 1	1.00	3.31	1.00	2.06		
Month 3	1.00	3.29	1.00	2.07		
LR (24 Ms)	1.00	3.21	1.00	2.08		

Source: *Authors' estimations based on MATLAB software output*

Table A5. Model Comparison Criteria – Official Exchange Rate (STVAR vs. TVAR)

Criteria		STVAR	TVAR	Prfered Model
AIC		-12.45	-12.16	STVAR
BIC		-12.18	-11.89	STVAR
HQIC		-12.34	-12.5	TVAR
RSME	CPI	0.81	1.04	STVAR
	PPI	1.01	1.26	STVAR
	ER	2.29	2.71	STVAR
AVERAGE(RMSE)		1.37	1.67	STVAR

Note: This table compares the Smooth Transition VAR (STVAR) and Threshold VAR (TVAR) models for the official exchange rate using multiple selection criteria. Lower values are preferred for Akaike (AIC), Schwarz-Bayesian (BIC), Hannan-Quinn (HQIC) information criteria, and Root Mean Square Error (RMSE). The preferred model for each criterion is indicated. While the HQIC slightly favors the TVAR model, the AIC, BIC, and all RMSE measures (for CPI, PPI, ER, and their average) consistently and strongly favor the STVAR specification. The overall evidence, particularly the superior forecasting accuracy (RMSE) of the STVAR, supports its selection as the more appropriate model for capturing the dynamics of the official exchange rate.

Source: *Authors' estimations based on MATLAB software output*

Table A6. Model Comparison Criteria – Parallel Market Exchange Rate (STVAR vs. TVAR)

Criteria		STVAR	TVAR	Preferred Model
AIC		-12.52	-12.21	STVAR
BIC		-12.25	-11.94	STVAR
HQIC		-12.41	-12.1	STVAR
RSME	CPI	1.08	1.35	STVAR
	PPI	1.29	1.58	STVAR
	ER	3.12	3.79	STVAR
AVERAGE(RMSE)		1.83	2.24	STVAR

Note: This table compares the Smooth Transition VAR (STVAR) and Threshold VAR (TVAR) models for the free (parallel) market exchange rate using standard model selection criteria. Lower values indicate a better fit for AIC, BIC, HQIC, and RMSE. As shown, the STVAR model is uniformly preferred across all information criteria (AIC, BIC, HQIC) and demonstrates superior forecast accuracy with lower RMSE values for CPI, PPI, the exchange rate itself, and their average. This comprehensive evidence strongly justifies the selection of the STVAR framework for analyzing the parallel market dynamics.

Source: *Authors' estimations based on MATLAB software output*