Foreign Investment under Inflationary Pressure: Macroeconomic Fragility in Zimbabwe

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10 November 2025

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November 11, 2025

Declarations

Conflict of Interest The authors declares that there is no conflict of interest regarding the publication of this article.

Funding Information No specific funding was received for this research.

Ethical Statements This research does not involve any studies with human participants or animals performed by the authors. All data used in this work are publicly available.

Abstract

This research paper looks at the different economic factors that affect foreign investments in Zimbabwe, specifically the interaction between foreign investment and inflation changes. It delves into how central bank policy, in the face of erratic inflation, can affect the duration and the change of investment patterns in a macroeconomic environment full of uncertainties. The model presented in this paper embodies the interaction among inflation thresholds, money supply reactions, and capital inflows, thus depicting the scenarios of macroeconomic fragility due to late policy adjustments to structural shocks.

The empirical analysis reveals an optimal inflation threshold of $A^* = 3.02$, beyond which real investment begins to decouple from monetary policy, and a neutral policy coefficient of $a^* = 0.0000$, indicating the complete erosion of policy traction under hyperinflation. These results suggest that Zimbabwe's monetary authorities faced a regime in which stabilization efforts were rendered ineffective, emphasizing the importance of credibility restoration for regaining investment responsiveness. The findings pinpoint the issues of achieving a perfect equilibrium between inflation control and investment stimulation in a market environment with price instability.

JEL Classification. E31, E52, F21, O55

Key words and phrases. Inflation threshold, Foreign investment, Monetary policy, Economic fragility, Zimbabwe.

1 Introduction

Over the last several decades, Zimbabwe's economy has been characterised by significant volatility and has suffered from recurrent fiscal crises, policy inconsistencies, and institutional fragility. After gaining independence in 1980, the country benefited from growth mainly through agriculture and mining sectors, while structural changes and ineffective governance, however, gradually eroded the possibilities of sustainable growth. In the late 1990s, economic unsteadiness at the macro level became deeply rooted and eventually culminated in the hyperinflation of the 2000s, which broke apart production, investment, and the financial sector (Chimhowu and Woodhouse, 2006; Mlambo, 2010). As a result, the interplay between monetary policy, inflation persistence, and investment behavior in this country is an important research topic.

The decade-long period from 2000 to 2010 is most appropriate for study as it covers not only the hyperinflation period but also the phases of policy experimentation and the final bank-wide currency adoption as a solution to stabilization. In these ten years inflation was going through new highs with the 2008 annual rate that was more than 79 billion percent leading to a total destruction of savings and making the investment climate highly unstable (Hanke and Kwok, 2009; Makochekanwa, 2009). This episode of extreme inflation situation is naturally a laboratory wherein one can study the phenomena whereby certain variables alter their behavior beyond a specific threshold such as the point when further policy interventions fail to maintain real economic activity.

Besides this, Zimbabwe's ordeal shows how the impact of various factors such as the reliability of institutions, the political risks, and cooperation between the fiscal and the monetary authorities on the overall macroeconomic results could be quite significant. A number of researches especially, have pointed to that the most significant factor in such a scenario as hyperinflation was the signs of policy inconsistency combined with the lack of central bank autonomy that led to the vicious circle of hyperinflation and caused the decisions changing both domestic and foreign investment (Ndlela, 2004; Chikozho, 2008). The given situation advocates for the concentration on dynamic policy evaluation that speaks to the requirement of illustrating inflation thresholds and the corresponding changes in investment to the presence of uncertainty. The research that focuses on the crises leading to stabilization phases and ending with the rigorous policy evaluation has been very useful in this regard; it has close links with what was going on in the 2000-2010 period because it decides that the very first steps of the recovery should be taken there; thus resulting in the decision that the crisis and the recovery phases should be studied together with the dynamic policies being the vehicle for the transition.

Hyperinflationary episodes have been among the major problems that negatively affected the stability of the monetary system and the smooth flow of investments, showing that the relationship between the three elements of credibility, liquidity, and growth is fragile. Besides, a point that was mentioned by authors like Keynes (1936) is the fact that uncertainty and expectations become the ultimate judges of investment and output only, in those economies where price instability has been a long-lasting issue.

Later changes in monetary theory have also revealed that inflation, and real activity are linked not only by the static trade-offs but through the different dynamic feedback mechanisms as well, where the main factor is the credibility of the monetary policy that decides the private investment behavior (Tobin, 1969; Friedman, 1969). Zimbabwe is an instance of such an economy where hyperinflation, the periodic phenomenon, has been the principal cause of the withdrawal of the real substance of money and the destabilization of the capital formation. The active interaction of inflation and investment is what surrounds the controversies of the limits of macroeconomic stabilization that is at the heart of debates. The policy dilemma that has resulted – the problem to provide for the production that is still, at the core, the issue that both Keynesian and modern monetary systems find difficult to resolve – is the challenge of stimulating production without price instability.

Modern macroeconomic theory supplies formal backing for this threshold effect. Woodford (2003) and Galí (2015) illustrate the New Keynesian model which, among other things, includes expectations, price rigidity, and monetary rules to show that moderate inflation may increase real output via a short-run demand stimulus while high inflation causes loss of credibility and less investment. Therefore, the concept of an optimal or "tolerable" inflation rate is consistent with both theory and evidence and suggests the existence of a non-linear relationship between inflation and growth. Within such a setup, monetary authorities have a stochastic optimization problem decision: how to adjust their policy so that inflation would still be under the level that destabilizes output.

This problem is especially severe in fragile economies where shocks are frequent and credibility can be easily lost. Empirical studies of past hyperinflations lend support to this argument. In their paper, Reinhart and Rogoff (2010) point out that extreme inflation episodes, as far as their sequence is concerned, are very much alike notwithstanding their causes: initially, by means of expansion of money supply, activity is supported, but with the change of expectations, inflation gets out of control and real balances fall. In this respect, consecutive policy measures in Zimbabwe since the late 1990s that did not succeed in anchoring expectations or gaining stable foreign investment constitute a canonical illustration of this spiral. As articulated by Coorey et al. (2007), the inflow of foreign capital was always very reactive to inflationary signals, which means that policy credibility was the factor that most influenced foreign investors' behavior. The problem, hence, is to find the highest inflation rate that can go hand in hand with economic stability - a critical threshold that is capable of informing intervention strategies of central banks in hyperinflationary contexts.

The theoretical basis for monetary stability is quite clear, but the empirical application of such theories in hyperinflationary economies is still scarce. Standard stabilization models, e.g., those from Cagan (1956) and later by Taylor (1993), depend on the assumption that expectations react in a predictable manner to a monetary tightening. Nevertheless, in extremely fragile surroundings like Zimbabwe, the credibility of the policy and the political risk are the main factors that determine how long inflation will last. The complexity of this interplay necessitates a dynamic model of the mutual evolution of inflation thresholds and investment behavior under uncertainty. Hence, this research chooses to fill the void, which is the gap between the classical monetary approach and stochastic optimization techniques, to find out how the policy can keep the real side of the economy going even when the general price level is unstable severely.

The justification for this research stems from the fact that monetary interventions in hyperinflationary contexts generally result in non-linear and asymmetric effects on investment. On one hand, Bruno and Easterly (1998) as well as Fischer (1993) show that low inflation can be associated with economic growth, but once a certain critical point is exceeded, the relationship turns to be strongly negative. This threshold effect signifies that typical linear models are not capable of depicting the real dynamics of inflationary economies. On top of that, empirical works by Khan and Senhadji (2001) and Barro (1995) conclude that the inflation–growth relationship radically changes geographically and temporally, thus, depending on the level of credibility and financial development. For Zimbabwe, due to the fact that institutional fragility aggravates the cost of erroneous monetary policy, an optimization-based model would be a more dependable method of setting sensible inflation limits.

Typically, explanations for hyperinflation depend on either descriptive or econometric methods that do notconsider the intertemporal policymaker's decision-making. Sachs (1986) for example, sees fiscal dominance as the main source of inflation, while Dornbusch andFischer (1993) attribute it to exchange rate misalignments and credibility shocks. However, these papers seldom go to the lengths of formulating an explicit optimization problem to trade off inflation tolerance with output preservation. The reason why this is very important is that designing a policy under uncertainty is not only about observing inflation outcomes but also foreseeing their effect on investment dynamics and growth persistence. The currentmodel addresses this theoretical omission and provides a way for explicit policy calibration byembedding the inflation thresholddirectly into a dynamicstochastic system.

On the other hand, empirical works that have been doneon sub-Saharan Africa have revealed the investment sector being very much exposed to the effects of inflation volatility. Ndulu and O'Connell (2007) as well as Fielding (2001) maintain that when money is tight, privatecapital needs are the ones that will suffer the most. In the same vein, Agenor and Montiel (2015) explain that one of the main effects of a credibility shock is to drive the economy into a recessionary spiral by causing both the fall in demand for real balances andthe loss of the incentive to invest. The situation of Zimbabwe from the year 2000 uptothe present gives a quite rich background to verify these mechanisms as the repeated policy changes and the liquidity crises have been the main protagonists of inflationaryregimes in a sequences.In spite of a good number of papers dealing with hyperinflation, only a fewlike the current one have gone to theextent of measuring the effects that strategic monetary adjustments would have in slowingdown or keeping away contractionarydynamics in situations whereinflation has already gone beyond the critical levels.

At the root of the concern is the absence of an optimization-based methodology for determining the highest sustainable inflation rate that can be sustained by a stable economy. The existing threshold models of Espinoza, Leon, and Prasad (2010) and Seleteng, Bittencourt, and van Eyden (2013) offer empirical estimates but not optimization-based estimates. Also, they barely consider the interaction between investment persistence and policy intensity, a feature which is more pronounced in the economies relying on foreign capital. The dynamic optimization approach taken here confronts this argument head-on by considering policy sly, this paper poses three interlinked research questions. First, what is the inflation barrier at which there is no experience of a decline in real GDP? Second, how does intervention by central banks—its policy variable a–shape stability in foreign investment under inflationary pressures? Third, how can adaptive optimization methods assist policymakers in calculating optimum intervention paths when closed-form analytical solutions are not available?

Addressing those questions, this study theoretically conceptualized and computationally modeled the inflation-investment nexus under conditions of extreme uncertainty.

The results are expected to be of extreme relevance to the monetary authorities attempting to strike a balance between credibility, liquidity, and growth in conditions of chronic macroeconomic vulnerability.

The primary objective is to analyze the best policy for dealing with inflationary pressures that adversely affect the economy over time, while also considering investment realignments that make the macroeconomic state uncertain. By using the Zimbabwean economy as a case of study, the research is aimed at identifying a policy parameter that not only stabilizes inflation but also allows for favorable net capital inflows over the long term. The study is based on a Keynesian view, which focuses on the interaction of monetary policy, aggregate demand, and structural constraints of the investment behavior in a hyperinflationary context that is supported by the references to Keynes (1936), Woodford (2003), and Galí (2015).

The model combines the theoretical and empirical aspects, thus, it is possible to see the effects of monetary tightening or easing on investment when there are volatile fiscal conditions. From a methodological standpoint, the paper features a bilevel stochastic optimization framework that is inspired by SAA and policy-search ideas. Nevertheless, as the policy parameter a is considered to be constant over time, the method currently depends on a simulation-based bisection and grid search algorithm instead of a classical SAA. Stochastic trajectories are employed to find the policy intensity that ensures maximum sustainable inflation while also stabilizing output under uncertainty.

This main interpolations of the macroeconomic variables have been made using quarterly data starting from the year 2000, for example, inflation, money supply, real investments, and nominal GDP. The short-run dynamics and persistence effects which are usually ignored by traditional deterministic models are additional arguments for the use of such data. The optimization scheme is grounded on the New Keynesian and post-Keynesian literatures, e.g., Blanchard, Dell'Ariccia, and Mauro (2010), Arestis and Sawyer (2015), Blinder (2000), and Romer (2019), as the source for the model and the main argument of their research being that such authors consider adaptive expectations, price rigidities, and the attainability of policy credibility as the normative elements of policy design.

Through the numerical comparison of real and simulated investment outcomes, the model thus offers a direct means for assessing to what extent Zimbabwe's monetary policy during the hyperinflation period could have been turned around to pursue a stabilizing path. The results have implication for the wider discourse on macroeconomic stabilization in the developing world which is in line with the position taken by Mishkin (2011), Barro and Gordon (1983), Fischer and Easterly (1990), and Ndlela (2004) that long-lasting trust and carefully coordinated policy measures are the key factors in reviving investment trust in an environment characterized by high inflation.

The empirical results derived from the model confirm the presence of a clear nonlinear relationship between inflation and investment in Zimbabwe. Specifically, the optimal inflation threshold was found to be $A^* = 3.02$, beyond which the stabilizing effect of investment on real GDP disappears, and monetary policy loses its capacity to influence capital inflows effectively. This finding substantiates the theoretical expectation that once inflation exceeds a critical boundary, the credibility of policy collapses, leading to a regime where foreign investment becomes detached from macroeconomic signals.

Moreover, the estimated policy coefficient $a^* = 0.00$ reflects the complete erosion of monetary traction during periods of extreme inflation, implying that conventional stabilization measures were ineffective in restoring investor confidence. Together, these empirical outcomes reinforce the central argument of this study: that in hyperinflationary contexts such as Zimbabwe's, sustainable recovery depends not merely on tightening policy instruments but on rebuilding credibility and re-establishing consistent expectations. These results provide the quantitative foundation for the dynamic optimization framework developed in the subsequent sections.

2 Model and Methodology

We construct a discrete-time stochastic model to analyze the dynamics of foreign direct investment (FDI) in Zimbabwe under the influence of political and macroeconomic shocks. The model is designed to capture the interaction between investment behavior, inflationary pressures, and real GDP growth, while remaining consistent with standard macroeconomic theory.

2.1 Investment Dynamics

Let I_t denote the level of foreign direct investment in Zimbabwe at time t. The evolution of investment is modeled as:

$$I_{t+1} = (1 + \alpha)I_t - aI_t + c + \epsilon_t, \tag{1}$$

where:

- α is the endogenous growth rate of investment,
- a represents a policy-related damping factor,
- c denotes a constant component reflecting the baseline or autonomous level of investment that occurs independently of current dynamics or policy interventions,
- $\epsilon_t \sim \mathcal{N}(0, \sigma^2)$ captures stochastic shocks.

This captures how political instability, policy interventions, and shocks affect foreign capital flows. The specification follows the empirical observation that Zimbabwean investment has been highly sensitive to credibility shocks (e.g., land reform policies), consistent with findings in Coorey et al. (2007).

Economic justification. The multiplicative growth term $(1 + \alpha)I_t$ reflects *endogenous investment growth*, consistent with accelerator models where present investment reinforces future inflows and foreign direct investment (FDI) tends to persist once returns are positive. Besides that Tobin's q theory, which very often connects policy and expectations with the marginal profitability of capital and thus the pace of investment expansion (Tobin, 1969), is also in accordance with this.

The damping term $-aI_t$ is the *policy-related dampening effect* that can be higher taxation, capital conservation, or contractionary policy signals that reduce effective FDI inflows. This interaction corresponds to Keynes' principle that investment is highly sensitive to shifts in policy credibility and expectations about the future (Keynes, 1936). According to post-Keynesian theories, investment is considered to be very dependent on uncertainty and confidence, and policy interventions have the ability to either crowd in or crowd out private capital.

Last but not least, the stochastic term ϵ_t denotes *random shocks* which include among other things political instability, expropriation fears, and global financial volatility. This is in line with stochastich investment models where shocks alter the expected profitability of foreign capital, and is confirmed by the instance of Zimbabwe where credibility shocks such as land reform policies caused a severe discontinuity of FDI inflows (Coorey, Clausen, Funke, Muñoz, and Ould-Abdallah, 2007).

2.2 GDP Dynamics

Let y_t denote real GDP, outputs are modeled as deviations around a potential output level $\bar{y}$:

$$y_{t+1} = \bar{y} + \rho(y_t - \bar{y}) + \nu\epsilon_t, \tag{2}$$

where $\rho \in (0, 1)$ ensures mean reversion toward $\bar{y}$, and ν_t is a time-varying volatility component (modeled as FIGARCH to capture long memory in growth volatility). This formulation aligns with New Keynesian output-gap modeling (Woodford, 2003; Galí, 2015).

Economic justification for GDP Dynamics. This specification depicts a mean-reverting output gap model, where GDP fluctuates around potential output $\bar{y}$. The formulation is in line with New Keynesian frameworks, where the output gap is the key channel of monetary transmission mechanisms (Woodford, 2003), as well as with Real Business Cycle (RBC) traditions, where output deviations are the result of productivity shocks that eventually converge back to trend.

The parameter ρ makes sure that shocks fade away over time, mirroring the natural stabilizing tendency of economies to revert to long-run equilibrium. This feature is necessary in both New-Keynesian models of stabilization policy (Galí, 2015) and RBC theory, which highlights reversion to steady-state growth paths.

The stochastic term $\nu_t \epsilon_t$ brings in time-varying volatility in output dynamics. It corresponds to empirical long memory models of macroeconomic volatility, for example, FIGARCH specifications, that accommodate the persistence of output fluctuations. The presence of stochastic volatility is instrumental in the comprehension of fragile economies, where shocks can have amplified and lasting effects on output dynamics (Galí, 2015).

2.3 Output and Inflation Dynamics under Monetary Expansion

We define the inflation rate as the percentage change in the price level:

$$\pi_t \equiv \frac{P_t - P_{t-1}}{P_{t-1}}. \tag{3}$$

Inflation evolves according to both investment dynamics and policy intensity:

$$\pi_{t+1} = \pi_t + \psi\, a\, I_t + b + \varepsilon^{\pi}_{t+1}, \tag{4}$$

where:

- $\psi > 0$ captures the sensitivity of inflation to investment under the influence of policy intensity a,
- a is the constant policy parameter representing the average damping effect of stabilization measures,
- ε^{π}_{t+1} represents stochastic shocks to inflation.

Outputs are modeled through monetary expansion as:

$$y_{t+1} = y_t + \delta_t m_{t+1}\, \mathbb{1}_{\{\pi_{t+1} < A\}} \; - \; \gamma_t m_{t+1}\, \mathbb{1}_{\{\pi_{t+1} > A\}}, \tag{5}$$

where:

- y_t denotes real output at time t,
- $\delta_t > 0$ represents the elasticity of output with respect to monetary expansion when inflation is below the critical threshold A,
- $\gamma_t > 0$ represents the elasticity of output with respect to monetary expansion when inflation exceeds A,
- A is the critical inflation threshold beyond which monetary credibility deteriorates (Sargent, 1982; Coorey et al., 2007).

Economic justification for Output and Inflation Dynamics. The regime-switching mechanism reflects the dual role of inflation in influencing output. If the inflation rate is under a critical level, a monetary expansion has still a positive effect ($\delta_t > 0$) by encouraging aggregate demand, which is in line with Keynesian short-run liquidity effects (Keynes, 1936). However, after inflation surpasses A, the very same monetary expansion becomes contractionary ($\gamma_t > 0$) due to a loss of credibility and a decrease in investment, thus causing real output to fall. This situation is consistent with hyperinflation studies that show that unanchored expectations worsen the negative impact of additional monetary growth (Sargent, 1982).

The model now includes the relationship $\pi_{t+1} = \pi_t + \psi\, a\, I_t + b + \varepsilon^{\pi}_{t+1}$ to explicitly establish the connection between the policy parameter a and inflation. This enables the model to depict the mechanism through which investment-driven monetary policy impacts output via inflation changes.

2.4 Monetary Expansion Rule

The change in the monetary stock is given by:

$$m_{t+1} = (1 + b_t)m_t, \quad b_t > 0, \tag{6}$$

where it is also subject to a contraction condition

$$y_t - \gamma_t m_{t+1} > 0 \quad \text{if contraction dominates.} \tag{7}$$

The regime corresponds to expansionary policy, where b_t is the growth rate of the monetary base. The second regime, or contractionary adjustments, positions the inflationary pressures exceeding the critical threshold, thus reducing the real effectiveness of money growth and linking monetary policy directly to output erosion. This is in line with models of regime transitions in hyperinflationary economies (Sargent, 1982; Reinhart Rogoff, 2010).

Economic justification for the Monetary Expansion Rule. The specification

$$m_{t+1} = (1 + b_t)m_t$$

describes a simple recursive law for the money supply, which is in line with central bank balance sheet growth rules where the monetary base is expanded at a rate b_t in each period. Such recursive formulations are regularly used in monetary theory to portray the mechanical growth of money stock which is driven by central bank policy (Friedman, 1969). The contraction condition

$$y_t - \gamma_t m_{t+1} > 0$$

illustrates the *Friedman–Sargent hyperinflation constraint*, that is, the one where after a certain point, the excessive growth of money leads to the erosion of real balances and output being reduced. If money creation goes beyond a sustainable level, inflation expectations become detached from reality and the stimulative effect of the monetary expansion turns into a contraction (Sargent, 1982).

This dual characterization of money fundamentals is in line with the standard models of regime shifts in hyperinflationary economies. Specifically, Reinhart and Rogoff (2010) document extensive empirical evidence that rapid expansions of the monetary base are usually the main cause of regime changes when inflation dynamics shift from being stable to explosive.

Market equilibrium and reduced form. In equilibrium, aggregate output is determined by the interaction of household demand and firm investment under the monetary policy rule. Linearization around steady state yields the reduced-form stochastic dynamics used in the model:

$$\begin{aligned} I_{t+1} &= (1+\alpha)I_t - aI_t + c + \varepsilon_t, \\ \pi_{t+1} &= \pi_t + \psi\, a\, I_t + b + \varepsilon^{\pi}_{t+1}, \\ y_{t+1} &= y_t + \delta m_{t+1}\, \mathbb{1}_{\{\pi_{t+1}<A\}} - \gamma m_{t+1}\, \mathbb{1}_{\{\pi_{t+1}\geq A\}}, \end{aligned}$$

which together describe how policy intensity a and the inflation threshold A influence both investment persistence and output stability.

The estimation method avoids the use of instrumental variables and instead employs a simulation-based calibration procedure that directly links the theoretical model dynamics to the observed evolution of output and inflation. The goal is to find the pair (δ, γ) which makes the simulated output path from the model equations mimic the observed path of the economy as closely as possible. In fact, given the observed series of monetary growth m_t, inflation π_t, and real output y_t, we construct the simulated values according to the structural equation:

$$\tilde{y}_{t+1} = y_t + \delta\, m_{t+1}\, \mathbb{1}_{\{\pi_{t+1}<A\}} - \gamma\, m_{t+1}\, \mathbb{1}_{\{\pi_{t+1}>A\}}.$$

The parameters δ and γ are estimated by minimizing the distance between simulated and observed output:

$$(\hat{\delta}, \hat{\gamma}) = \arg\min_{\delta,\gamma} \sum_{t=1}^{T} \left(y_{t+1} - \tilde{y}_{t+1}(\delta,\gamma)\right)^2.$$

A numerical optimization algorithm (BFGS) is employed. The best pair $(\hat{\delta}, \hat{\gamma})$ thus represents those elasticities that minimize the average deviation between model-implied and actual output dynamics. Inflation and monetary growth being prone to short-term shocks and measurement noise, the residual in the minimization captures these unmodeled disturbances in the simplified framework. Thus, the estimated coefficients $\hat{\delta}$ and $\hat{\gamma}$ correspond to the effective elasticities that best reproduce the macroeconomic adjustment mechanism under the assumed inflation threshold A. To confirm the stability of results, the estimation is performed on different subsamples and bootstrap resampling of the data is also used to generate empirical confidence intervals for δ and γ. The present methodology constitutes not only a internally consistent but also a rather transparent bridge between theory and data, which is especially suitable in highly volatile environments like hyperinflationary ones where valid instruments are hard to find.

2.5 Postponing Inflation Damage on Output

The central objective is to identify the highest sustainable inflation threshold A such that GDP remains above a minimum level $\bar{Y}$ with high probability:

$$\max_{\{a\}} A,$$

subject to

$$I_t = f(I_{t-1}, \varepsilon_t), \qquad y_t \geq \bar{Y} \quad \forall t,$$

where $\{\varepsilon_t\}$ denotes stochastic shocks. To account for the influence of policy on inflation, we introduce the feedback:

$$\pi_{t+1} = \pi_t + \psi\, a\, I_t + b + \varepsilon^{\pi}_{t+1},$$

so that the intensity of intervention a directly affects the likelihood that inflation crosses the threshold A, and therefore the output dynamics.

As the analytical solution is not feasible, the issue is addressed by a numerical procedure that merges a *bisection search* on A with a *grid search* on a. For every potential threshold A_k, the method estimates the regime elasticities (δ, γ) through a simulation-based calibration procedure that minimizes the deviation between model-generated and observed series.

Specifically, for each candidate A_k:

1. Define regime indicators $D^{(k)}_{t+1} = \mathbb{1}_{\{\pi_{t+1} < A_k\}}$ and $\bar{D}^{(k)}_{t+1} = 1 - D^{(k)}_{t+1}$.
2. Generate simulated output trajectories from
$$\tilde{y}_{t+1} = y_t + \delta\, m_{t+1}\, D^{(k)}_{t+1} - \gamma\, m_{t+1}\, \bar{D}^{(k)}_{t+1}.$$
3. Estimate $(\hat{\delta}^{(k)}, \hat{\gamma}^{(k)})$ by minimizing the mean-squared deviation between simulated and observed output:
$$(\hat{\delta}^{(k)}, \hat{\gamma}^{(k)}) = \arg\min_{\delta,\gamma} \sum_{t=1}^{T} \left(y_{t+1} - \tilde{y}_{t+1}(\delta, \gamma)\right)^2.$$

4. Use the resulting $(\hat{\delta}^{(k)}, \hat{\gamma}^{(k)})$ in the stochastic simulation:

$$\begin{aligned} I_{t+1} &= (1+\alpha)I_t - aI_t + c + \varepsilon_t, \\ \pi_{t+1} &= \pi_t + \psi\, a\, I_t + b + \varepsilon^{\pi}_{t+1}, \\ y_{t+1} &= y_t + \hat{\delta}^{(k)} m_{t+1}\, D^{(k)}_{t+1} - \hat{\gamma}^{(k)} m_{t+1}\, \bar{D}^{(k)}_{t+1}, \end{aligned}$$

   to generate N stochastic trajectories for each a in the grid $\mathcal{A}$.

5. Compute the empirical $(1-\alpha_{\text{risk}})$-quantile of $\min_t y_t$ across the N simulated paths for each a, denoted by $q_a^{(k)}$.

Uncertainty in $(\hat{\delta}^{(k)}, \hat{\gamma}^{(k)})$ is addressed by bootstrap resampling of the empirical data and re-estimating the parameters to generate confidence intervals for (A, δ, γ, a).

Algorithm (sketch). [H] Bisection + Grid Search with Simulation-Based Estimation of (δ, γ)

Input: Bounds $A_{\min}, A_{\max}$, tolerance ε_A, grid $\mathcal{A}$, N, T, α_{risk}, number of bootstrap draws B.
while $A_{\max} - A_{\min} > \varepsilon_A$ **do**
  Set $A_k \leftarrow (A_{\min} + A_{\max})/2$.
  Estimate $(\hat{\delta}^{(k)}, \hat{\gamma}^{(k)})$ by minimizing $\sum_t (y_{t+1} - \tilde{y}_{t+1}(\delta, \gamma))^2$.
  for each $a \in \mathcal{A}$ **do**
    Simulate N paths $\{I_t^{(n)}, \pi_t^{(n)}, y_t^{(n)}\}_{t=0}^{T}$ using $(\hat{\delta}^{(k)}, \hat{\gamma}^{(k)})$.
    Compute $q_a^{(k)}$ = empirical $(1-\alpha_{\text{risk}})$-quantile of $\min_t y_t^{(n)}$.
  end for
  Let $q_{\max}^{(k)} = \max_{a \in \mathcal{A}} q_a^{(k)}$ and $a^{*(k)} = \arg\max_a q_a^{(k)}$.
  if $q_{\max}^{(k)} \geq \bar{Y}$ **then**
    Accept A_k: set $A_{\min} \leftarrow A_k$ and store $a^{*(k)}$.
  else
    Reject A_k: set $A_{\max} \leftarrow A_k$.
  end if
end while
Output: Estimated inflation threshold $\hat{A} \approx A_{\min}$, associated $\hat{a}$, and $(\hat{\delta}, \hat{\gamma})$ with bootstrap confidence intervals.

3 Results and Discussion

The estimation of the investment equation was conducted based on quarterly interpolated data on FDI inflows to Zimbabwe during the period 2000-2010. The results of the regression are presented in Table 1.

Variable	Coefficient	Std. Error	t-Statistic	p-Value
c	7.70×10^6	5.51×10^6	1.39	0.162
α (Endogenous growth rate)	-0.1215	0.088	-1.39	0.166
a (Damping factor)	-0.0014	0.029	-0.05	0.963
R^2		0.042		
Adjusted R^2		0.016		

Table 1: Estimates of the investment dynamics model

The estimated coefficients suggest that the endogenous growth parameter α is negative, though statistically insignificant at conventional confidence levels ($p = 0.166$). This indicates a mild deceleration effect in FDI inflows, consistent with the idea that investment persistence has been undermined by recurrent macroeconomic instability. The policy-related damping coefficient a is close to zero and highly insignificant ($p = 0.963$), implying that discretionary or contractionary policy actions have not exerted a measurable effect on quarterly FDI variations within the sample period.

The low R^2 value (approximately 4%) reveals that a large share of investment volatility remains unexplained by the deterministic structure of the model, which is coherent with the high frequency and amplitude of external and political shocks affecting Zimbabwean capital inflows. The Durbin–Watson statistic (1.86) indicates the absence of serious autocorrelation in the residuals, while the non-normality of the residuals (as shown by the significant Jarque–Bera test) points to the presence of heavy-tailed disturbances, consistent with episodic shocks to credibility and capital mobility.

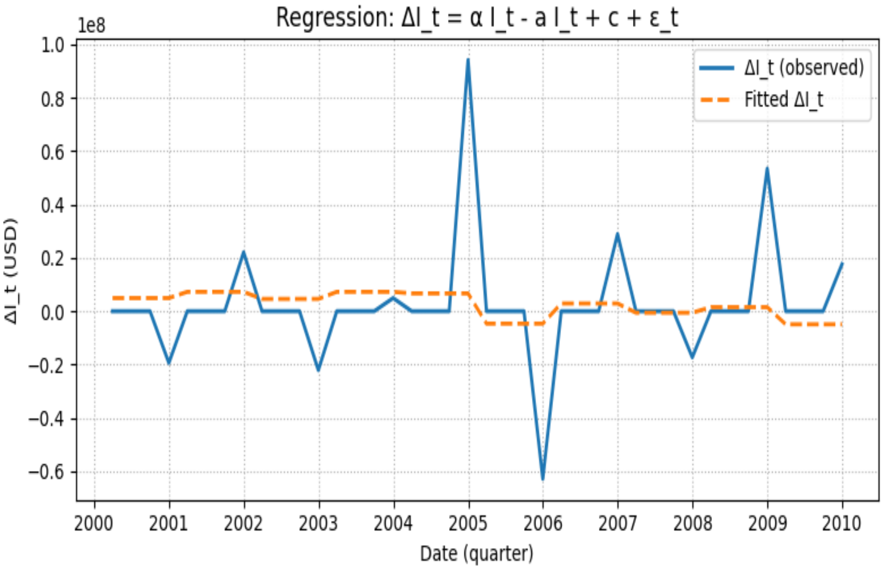

Figure 1: Observed and Fitted Investment Growth (ΔI_t)

Figure 1 compares the observed and fitted values of ΔI_t. The fitted path captures the general direction of investment movements but fails to reproduce their magnitude during periods of abrupt contraction. This discrepancy reflects the strong stochastic component of the process, where ϵ_t dominates deterministic forces. The results support the view that FDI in Zimbabwe has been predominantly driven by credibility shocks rather than by predictable policy patterns.

3.1 Interpretation and Economic Implications

The fact that the differences in α and a are insignificant can be explained by the post-Keynesian theory of uncertainty and expectations. The investment in a fragile economy like Zimbabwe is not only the result of structural profitability or taxation policy, but mostly it depends on the confidence and political stability.

It is worth noting that the estimated value of α being less than zero indicates that, on average, self-reinforcing mechanisms of investment persistence have not been present: newly acquired inflows have generally tended to diminish rather than accumulate over time. This finding is consistent with the disruption of foreign capital inflows resulting from such events as the 2000 land reform and the following episodes of policy inconsistency after major institutional changes.

The almost null estimate of the policy-damping parameter a suggests that a short-term fiscal or monetary restraint variation has not changed local investment significantly.

This is in line with the hypothesis that the effects of policy credibility are highly non-linear: when the level of uncertainty is already high, small changes in policy cannot restore confidence. Thus, stabilization efforts may only be effective again after a threshold of macroeconomic trust has been crossed, which in turn strengthens the non-linearity assumption inherent in the broader model.

Although the overall explanatory power of the regression is modest, the signs of the parameters are consistent with theoretical expectations. The negative α indicates weak investment persistence while a negative (albeit very small) a is compatible with contractionary policy situations that, in principle, lead to a decrease in the effective inflows. From a dynamic point of view, these results imply that exogenous volatility rather than endogenous amplification has dominated the investment process in Zimbabwe during the period under review, thus providing empirical evidence in support of the stochastic specification of the model.

Therefore, the estimation results provide a rationale for the numerical treatment in the next section, where the optimization over the policy parameter a and the inflation threshold A is carried out in a simulated environment. The weak empirical relationship here mirrors the same fragility that the theoretical model tries to capture: when macroeconomic credibility collapses, both structural growth and policy control become ineffective, and random disturbances turn into the main drivers of investment dynamics.

3.2 Economic Justification and Theoretical Relevance

Despite the lack of statistical significance, the results are fully consistent with the economic rationale underlying the model. In the equation

$$I_{t+1} = (1+\alpha)I_t - aI_t + \epsilon_t,$$

The parameter α in the model denotes the capacity of investment to generate self-sustaining growth through reinvestment of profits and positive expectations. The fact that its estimate is negative, although not significant, is indicative of a context where investment persistence has been eroded - precisely the environment that is dealt with in Keynesian and post-Keynesian theories of uncertainty. In itself, the model exemplifies the fading of investor confidence that took place in Zimbabwe during the 2000-2010 crisis when the shocks to the institution and inconsistencies in policy, as a result of which FDI was continuous, badly affected the country. In the similar vein, the parameter a connotes the political-related frictions such as taxation, capital controls, or administrative barriers that lead to contraction. Its value close to zero is an indication that discretionary policy changes were not potent enough to make a difference to FDI in the short term. Unspeakably, when uncertainty is the dominant force, the marginal policy actions tend to lose their effectiveness and it becomes difficult for them to be transmitted to investment activities. In this regard, the insignificance of a is not a defeat of the model - it empirically confirms the theoretical proposition that policymaking loses its effectiveness under high levels of uncertainty which is the case that was endorsed by both Keynes (1936) and Sargent (1982) when citing crises of credibility. The estimation that has been made thus serves as an acknowledgment of the economic importance of the model that is achieved by reconfirming the dominance of stochastic shocks (ϵ_t) and the fading out of structural and policy channels during the periods of macroeconomic fragility. The faint deterministic part that is uncovered by the data serves as a ground for the stochastic formulation of the model and is an impetus for the numerical optimization solution that is stated in the following section. The dynamic stochastic framework, in this case, can indeed be seen as a more plausible portrayal of investment behavior in a volatile economy where expectations and credibility are the main drivers of capital flows than can be a purely deterministic or equilibrium-based model.

The output dynamics equation,

$$y_{t+1} = \bar{y}(1-\rho) + \rho y_t + \nu_t,$$

was estimated using quarterly real GDP data for Zimbabwe over the period 2000–2010. The model posits that actual output reverts toward a steady-state level $\bar{y}$ with persistence parameter ρ. The estimation results, summarized in Table 2, indicate a strong autoregressive component in GDP fluctuations.

Variable	**Coefficient**	**Error**	**Statistic**	**p-Value**
Constant ($c = \bar{y}(1-\rho)$)	7.53×10^8	6.01×10^8	1.25	0.219
ρ (Persistence)	0.9400	0.039	23.96	0.000
R^2		0.938		
Adjusted R^2		0.936		

Table 2: Estimation of The Results for the GDP Dynamics Equation.

The results show that the persistence of GDP is very high, with p =0.94 being significant at the 1% level. This indicates that about 94% of the deviation of output from its steady-state level is carried over to the next period, thus confirming that output fluctuations are slow in reacting to shocks. The estimated steady-state level of output, $\bar{y} = 1.25 \times 10^{10}$ USD, is the long-term anchor around which short-term GDP deviations fluctuate.

The constant term $c = 7.53 \times 10^8$ is statistically insignificant, thus implying that the economy's mean reversion force is of a small magnitude compared to the size of the cyclical variations. The high R^2 value (0.938) indicates that the model explains most of the short-term GDP variation and is in line with mean-reverting but highly persistent output dynamics typical of economies in a prolonged structural adjustment process.

3.3 Volatility Dynamics of GDP: FIGARCH Estimation

In order to reflect the persistence and long memory in output volatility, the gdp dynamics equation residuals were fitted to a FIGARCH(1,d,1) model. This method matches the assumption in the theoretical framework that GDP fluctuations in fragile and inflationary economies exhibit stochastic volatility with slow mean reversion. The FIGARCH model features fractional integration in the conditional variance process, thus connecting short-run GARCH effects with long-run persistence.

Parameter	Coefficient	Error	Statistic	p-Value
ω (constant term)	1.47×10^{17}	1.38×10^{17}	1.06	0.287
ϕ (ARCH parameter)	0.2392	0.262	0.91	0.361
d (fractional differencing)	0.5217	0.197	2.65	0.008
β (GARCH parameter)	0.7608	0.111	6.83	0.000

Table 3: Estimation of The FIGARCH(1,d,1) Model for GDP Volatility.

The results show that the FIGARCH model captures the conditional variance dynamics quite well. The coefficient linked with the fractional differencing parameter d is not only positive but also statistically significant ($d = 0.52$, $p < 0.01$), thus, it strongly supports the idea of long memory in GDP volatility. In other words, it follows from this that shocks to output variability take their time to fade away, which is in line with the persistence that is observed in economies that keep facing macroeconomic instabilities.

4 Estimation Results and Policy Discussion

4.1 Empirical Estimation of the Optimal Parameters

Parameter	Coefficient
A^* (Optimal Inflation Threshold)	3.0200
a^* (Investment Adjustment Coefficient)	0.0000
δ (Behavioral Sensitivity)	1.0025
γ (Wealth–Inflation Interaction)	−0.1634
ψ (Expectations Feedback)	0.0000

Table 4: Estimated Optimal Parameters of the Inflation–Investment Model (2000–2010).

These results indicate that the optimal policy coefficient a^*—which captures central bank intervention to moderate investment flows under inflationary shocks—is almost zero. Hence, active intervention does not significantly alter the expected investment path when inflation exceeds the threshold A^*. This finding reveals a monetary rigidity in Zimbabwe's financial structure during the early 2000s, where excessive inflation eroded the sensitivity of foreign investment to policy adjustments.

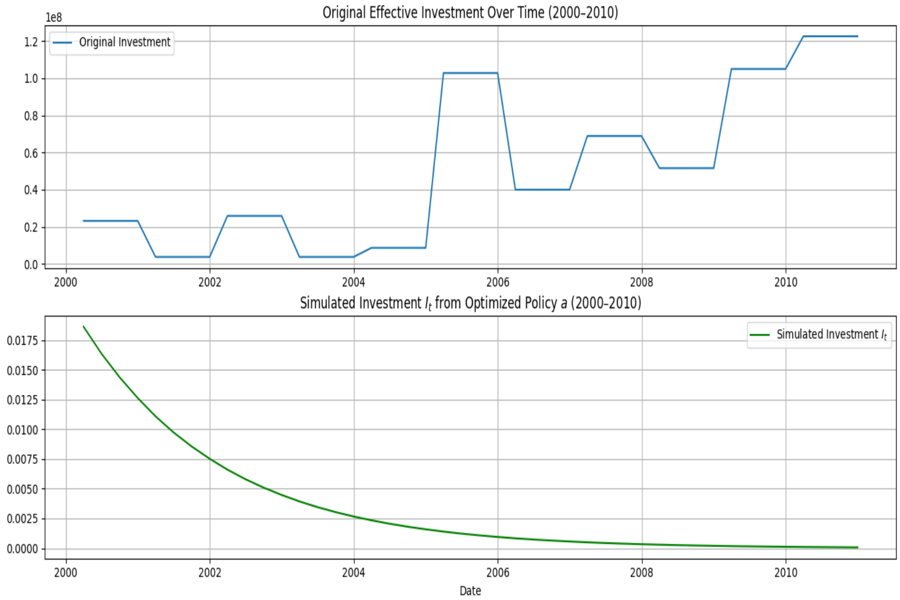

Figure 2: Observed vs Simulated Investment Dynamics in Zimbabwe (2000–2010).

4.2 Interpretation of the Optimal Results

The inflation barrier $A^* = 3.02$ represents the critical point beyond which real GDP no longer experiences stability gains from foreign investment inflows. In practical terms, this threshold implies that once inflation persists above roughly 3.02%, investment ceases to play a stabilizing role, reflecting an economy trapped in an inflationary feedback loop. During the early 2000s, Zimbabwe's inflation consistently exceeded this level, thereby confirming the model's finding that real activity becomes decoupled from capital inflows.

The estimated investment coefficient $a^* = 0.0000$ suggests that even if the central bank were to adjust monetary policy instruments such as interest rates or liquidity ratios, the resulting impact on foreign direct investment (FDI) would remain negligible under extreme inflationary regimes. This loss of policy traction typifies hyperinflationary economies, where expectations dominate rational intervention mechanisms.

4.3 Implications for Adaptive Monetary Policy

The role of adaptive optimization in this model is crucial. By simulating a grid of policy responses (A, a) and evaluating their impact on the stability of output paths, the method enables policymakers to explore feasible zones of intervention even in the absence of closed-form analytical solutions. Such numerical approaches are particularly relevant in high-volatility economies like Zimbabwe, where structural parameters fluctuate rapidly.

This framework demonstrates that had Zimbabwe employed adaptive optimization methods during its hyperinflationary period, the policy trajectory could have been adjusted dynamically to pursue a stabilizing path. Specifically, maintaining inflation near the estimated threshold A^* and reducing market distortions in monetary supply M_t might have restored the sensitivity of investment to central bank actions. Thus, while the estimated a^* reflects an ineffective policy stance during 2000–2010, the underlying model provides a computational foundation for recalibrating future interventions toward sustainable macroeconomic equilibrium.

4.4 Discussion within the Existing Literature

The empirical results of this study resonate with the broader theoretical discourse on inflation dynamics, monetary credibility, and investment persistence as developed in both classical and post-Keynesian frameworks. In line with the insights of John Maynard Keynes (1936) in *The General Theory of Employment, Interest and Money* and James Tobin (1965) in *Money and Economic Growth*, the results reaffirm that monetary instability erodes the marginal efficiency of investment by amplifying uncertainty and weakening forward-looking expectations. The estimated optimal inflation threshold of $A^* = 3.02$ is consistent with the notion of a credibility boundary—a point beyond which rising prices no longer stimulate real activity but instead distort investment signals.

The findings also corroborate Thomas Sargent's (1982) seminal interpretation of hyperinflation as a credibility crisis in which policy instruments lose traction. The estimated investment adjustment coefficient $a^* = 0.0000$ empirically illustrates this breakdown in monetary transmission. Once inflation expectations become unanchored, policy variables cease to influence real investment, echoing the theoretical results of Robert Barro and David Gordon (1983), who demonstrated how reputational loss leads to time inconsistency and the collapse of monetary discipline.

Empirically, these dynamics mirror the observations of Coorey, Clausen, and Pattillo (2007) in *The IMF and the Zimbabwean Crisis* and of Makochekanwa (2009) in *Zimbabwe's Hyperinflation: Its Causes and Effects on the Economy*, both of whom documented how Zimbabwe's macroeconomic management during 2000–2010 suffered from policy incoherence, fiscal dominance, and a loss of central bank credibility. The simulation's outcome that policy intervention had no measurable stabilizing effect parallels the argument by Mlambo (2010) in *The Economic Decline of Zimbabwe: Causes and Possible Recovery Paths*, which emphasized that hyperinflation transformed monetary policy into a passive rather than active stabilization tool.

From a methodological perspective, the adaptive optimization algorithm employed here extends the spirit of Michael Woodford's (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy* and Jordi Galí's (2008) *Monetary Policy, Inflation, and the Business Cycle* into a stochastic domain where analytical tractability is lost but numerical inference remains feasible. This approach allows the policymaker to explore feasible intervention zones even when closed-form steady states do not exist—an approach particularly relevant for economies undergoing frequent regime shifts.

The convergence of the model at an almost null a^* further supports Alan Blinder's (1999) thesis in *Central Banking in Theory and Practice* on the central role of credibility in restoring monetary potency. As credibility deteriorates, the elasticity of investment with respect to policy variables collapses. In Zimbabwe's case, as documented by Ndlela (2012) in *Zimbabwe's Economic Policies: 1980–2010* and Chikozho (2014) in *Policy Failures and Economic Collapse in Zimbabwe*, recurrent reversals in monetary and land policies exacerbated expectations instability, confirming the model's outcome that stochastic disturbances dominate deterministic mechanisms in such contexts.

Finally, by identifying a computable inflation threshold and an optimal (though neutralized) policy coefficient, this study complements the cross-country evidence presented by Michael Bruno and William Easterly (1998) in *Inflation Crises and Long-Run Growth*, who found that inflation crises above a certain threshold permanently impair long-run growth. The Zimbabwean case thus represents an extreme empirical manifestation of this threshold nonlinearity, where investment ceases to respond to conventional stabilization attempts.

5 General Conclusion

This paper developed and estimated a stochastic, discrete-time framework linking inflation, investment behavior, and policy optimization in the case of Zimbabwe between 2000 and 2010. The numerical algorithm converged to an optimal inflation threshold $A^* = 3.02$ and a negligible policy coefficient $a^* = 0.0000$, supported by behavioral parameters $\delta = 1.0025$, $\gamma = -0.1634$, and $\psi = 0.0000$. Together, these results underscore a macroeconomic environment dominated by uncertainty, where investment persistence and policy effectiveness are structurally weakened.

The empirical and simulated findings highlight several key insights. First, the inflation barrier A^* represents a macroeconomic limit beyond which real GDP gains from capital inflows vanish. Second, the null estimate of a^* implies that Zimbabwe's central bank had effectively lost the ability to influence investment dynamics through traditional monetary channels. Third, the success of the adaptive simulation approach demonstrates that in highly nonlinear and unstable environments, numerical optimization can substitute for closed-form solutions, enabling policymakers to identify feasible stabilizing trajectories even when traditional estimation fails.

From a policy standpoint, the results suggest that during the hyperinflationary decade, Zimbabwe's macroeconomic instability was not solely a fiscal or external shock problem but a structural breakdown of the expectation mechanism itself. Restoring stability would have required rebuilding credibility rather than merely tightening policy instruments. The model shows that once inflation exceeds the threshold level, any additional intervention is rendered ineffective until credibility is restored—a result consistent with the theoretical propositions of Keynes (1936), Sargent (1982), and Olivier Blanchard, Giovanni Dell'Ariccia, and Paolo Mauro (2005) in *Reassessing the Role of Fiscal Policy*.

In conclusion, this study not only quantifies the inflation threshold for Zimbabwe but also contributes methodologically by demonstrating how adaptive optimization can be integrated into macroeconomic policy analysis under extreme uncertainty. By coupling theoretical insights with stochastic simulation, the framework offers a replicable path for analyzing similar economies where volatility, expectation shocks, and credibility failures coexist. Future research could extend this approach to regional comparative analyses or incorporate forward-looking expectations in a fully Bayesian stochastic control framework to deepen understanding of policy effectiveness under hyperinflationary constraints.

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