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Macroeconomic Responses to Productivity and Global Demand Shocks: A Comparative Analysis of Developing and Developed Economies

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Abstract

This study explores the structural factors that differentiate the macroeconomic responses of Pakistan and a developed economy to domestic and global shocks within a Dynamic Stochastic General Equilibrium (DSGE) framework. Using the model put forward in Gali & Monacelli (2005), we calibrated key parameters to reflect Pakistan's economy, allowing for a comparative analysis of impulse response functions (IRFs) generated for output, inflation, interest rate, and exchange rate under (a) the labor productivity and (b) the world demand shock. In comparison with those for Canada, an advanced economy, the estimation of model parameters for Pakistan reveals relatively lower degree of openness, higher sensitivity of inflation to the output gap, lower price stickiness, lower coefficient of relative risk aversion (CRRA), lower disutility of labor supply and lower persistence of productivity shocks. These factors lead to reduced monetary policy responses, higher inflation volatility, and short-lived benefits from productivity gains. In order to contextualize, if only the persistence of the positive productivity shock for Pakistan is equated to that of Canada, the output response more than doubles, highlighting the need for structural reforms in that direction.

JEL Classification: D12, E13, O47

Key Words: Dynamic Stochastic General Equilibrium (DSGE), Small Open Economy (SOE), Productivity Changes, World Demand

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Non-Technical Summary

Economies around the world face both positive and negative shocks. However, the economic impacts of these shocks differ across countries owing to differences in economic structure, agents' behavior, and social norms. For policy analysis, understanding the source and magnitude of these differences is important.

In this paper, we compare Pakistan's economic responses to domestic labor productivity and world demand shocks. For benchmark comparison, we estimate economic responses under the above-mentioned shocks for Canada. For simplicity, we assume a similar general equilibrium economic framework as given by Gali & Monacelli, 2005 for both economies. The only difference comes from the set of estimated deep parameters that are based on Pakistan and Canada specific economic features.

Under a productivity shock, the results indicate that Pakistan's economic growth responds more strongly than Canada's. However, due to inadequate capital, weaker technological absorption, and lower financial inclusion, the benefits of this shock are short-lived despite having more labor.

Furthermore, under a positive world demand shock, Pakistan's export response is smaller than Canada's due to relatively lower global integration. Also, initial exchange rate appreciation is short-lived as the demand for imported goods rises along with the increase in households' spending amid higher demand for labor and increase in export earnings.

1. Introduction

Compared to developed economies, emerging economies like Pakistan often exhibit different economic responses to both domestic and international shocks. Understanding such differences and their triggers is essential for designing specific policies that are optimal for these countries. Specifically, such exercise can enable policymakers to identify and prioritize structural elements that can be improved to gain higher and lasting benefits from favorable economic shocks, while building resilience in response to negative shocks.

To this end, previous studies have successfully applied DSGE models to examine cross-country economic responses, emphasizing the role of parameters like trade openness, sectoral composition, and labor market rigidities in shaping these responses. Christiano, Eichenbaum, and Evans (2005) explore how monetary policy transmission differs across economies due to nominal rigidity and openness. Adolfson et al. (2007) analyzes how incomplete exchange rate pass-through influences shock responses in an open economy DSGE model, revealing parameter-driven variations. Smets and Wouters (2003) compare the euro area with other advanced economies, highlighting the role of consumption habits and wage rigidities in shaping model dynamics. Justiniano and Preston (2010) further investigate the responses of small open economies to foreign demand shocks, using Canada and Australia to demonstrate how structural differences influence the transmission of shocks.

To effectively yield a comparative picture of distinct countries, there is the need to have a uniform structure so that underlying theoretical prepositions remain consistent. In this vein, we selected the DSGE model given in Gali & Monacelli (2005). It is a small open economy framework that provides a suitably generalized system for capturing fundamental economic relationships broadly applicable across different economies in the New Keynesian macroeconomic setup. This model is well-established for analyzing the impacts of productivity and global demand shocks.

The model is widely adapted to analyze different research objectives with targeted modification. For instance, Lubik & Schorfheide (2007) retained the original theoretical structure and only simplified the terms of trade element to be exogenous for tractability. Caldara et al. (2020) used this model to analyze the impact of trade policy uncertainty on the macro-economy. They modified the firm structure by including heterogeneity, endogenous entry and exit in export markets with sunk cost. More recently, Auclert et al. (2025) borrowed this model to analyze the macroeconomic transmission of large-scale tariff shocks, such as the US 2025 tariff episode. They have provisioned for incomplete international financial markets, imports as an intermediate input in export production, sticky nominal wages and flexible goods prices.

In this paper, we apply the original Gali & Monacelli (2005) DSGE framework to the Pakistan's economy and compare the responses of positive domestic labor productivity and world demand shocks with those of Canada, as given in the paper. We find the given model is reasonable enough in context of Pakistan's economy, whereas the relative strength of various interrelations and channels depend on the model parameter values. In summary, it is a good starting point to capture and compare underlying macroeconomic and structural dynamics that impact the economic

outcomes of different countries in response to common shocks. In doing so, we calibrated the model parameters using Pakistan's data to accurately reflect the country specific underlying economic conditions. In this regard, the parameter values for price stickiness, labor supply elasticity and trade openness, and coefficient of relative risk aversion (CRRA), are some of the major elements that distinguish Pakistan's economic landscape from that of Canada.

After calibrating the model parameters for Pakistan, the impact of two exogenous shocks on model variables is analyzed for both countries (Pakistan and Canada). Key results under the positive productivity shock are as follows: (i) Initially Pakistan depicts a relatively higher increase in output due to higher margin available in efficiency improvement; however, the impact dissipates quickly due to low persistence of the productivity shock. (ii) There is lower disutility of labor supply due to large population, higher unemployment and lower wages. (iii) Price adjustment is quicker due to lower competitive market structure; hence, inflation rebounds rather quickly.

Under the positive world demand shock, (i) Pakistan depicts a relatively persistent increase in output due to less disutility from supplying labor. (ii) However, appreciation in exchange rate is less due to lower degree of openness. (iii) Since domestic prices have higher sensitivity with regards to the output gap, which closes quickly in response to higher global demand, deceleration in CPI inflation is low.

The rest of the paper is structured as follows: Section 2 outlines the key features of the adopted DSGE model and discusses the parameter calibration process, while Sections 3 and 4 present the results and the concluding remarks, respectively.

2. Model

Gali and Monacelli (2005) present a DSGE model for a small open economy (SOE) operating in a global environment. The global economy is considered as a continuum of many small open economies, represented by a unit interval [0, 1], where each point *i* corresponds to a small open economy. Hence, it is possible to focus on the dynamics of a SOE without having a major impact on the global economy.

Important model features include the following:

- Under budget constraints, the representative household within the SOE aims to optimize utility from both imported and domestic consumption goods and leisure.
- The household has access to foreign financial instruments that allow households to optimize their consumption and saving decisions, ensuring intertemporal utility maximization.
- Firms in the SOE produce differentiated goods by combining labor with technology, with labor supplied by the households.
- The model employs the Calvo price-setting mechanism, where firms stagger their price adjustments.
- The optimal decisions made by both the household and firms, given their respective constraints, jointly determine the equilibrium in the SOE, thus capturing the interactions between consumption, production, and monetary policy under an inflation targeting setup.

- The natural level of output (Potential) highlighting the role of productivity (a_t) and world demand (y_t^*) in shifting the potential of the SOE is expressed as:

$$\bar{y}_t = \Omega + \Gamma a_t + \alpha\Psi\, y_t^* \quad (1)$$

- In SOE, the domestic output is defined as function of world output (y_t^*) and term of trade (s_t):

$$y_t = y_t^* + \frac{1}{\sigma_\alpha}\, s_t \quad (2)$$

- The deviation of domestic output y_t from its natural level $\bar{y}_t$ is the output gap x_t, which is expressed in terms of forward looking IS equation as:

$$x_t = E_t\{x_{t+1}\} - \frac{1}{\sigma_\alpha}\,(r_t - E_t\{\pi_{H,t+1}\} - \overline{rr}_t) \quad (3)$$

- The above equation illustrates how output gap depends on expected future output gap $E_t\{x_{t+1}\}$ and deviation of ex-ante real interest rate ($r_t - E_t\{\pi_{H,t+1}\}$) from natural interest rate ($\overline{rr}_t$).
- Furthermore, the proportionality of real marginal cost with the output gap led to a version of New Keynesian Phillips Curve (NKPC) as:

$$\pi_{H,t} = \beta E_t\{\pi_{H,t+1}\} + \kappa_\alpha x_t \quad (4)$$

- Here the domestic inflation is defined as the function of expected future domestic inflation and output gap. This is identical to that of a closed economy. The difference occurs only in the slope parameter κ_α, which incorporates the effect of trade openness. While the CPI inflation is expressed in terms of domestic inflation and terms of trade changes:

$$\pi_t = \pi_{H,t} + \alpha(s_t - s_{t-1}) \quad (5)$$

- In order to control inflation, the central bank monetary policy rule is defined on the basis of *stylized Taylor-type rule* as:

$$r_t = \rho + \phi_\pi \pi_t \quad (6)$$

- Altogether, this is a small open economy model derived from the structure of a closed economy's sticky-price model used in monetary policy analysis. However, in the open economy model, additional parameters account for the economy's degree of openness and the substitutability between domestic and foreign goods.

2.1. Shocks of interest

The model is driven by the two types of exogenous shocks: (a) domestic productivity (a_t) and (b) world demand (y_t^*), that are defined as AR(1) process:

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a \quad (7)$$

$$y_t^* = \rho_y y_{t-1}^* + \varepsilon_t^* \quad (8)$$

Here, ρ_a and ρ_y measure the persistence of shocks i.e. the extent to which the effects of a shock last over time. The value closer to one represents that shock has long lasting impact, whereas values closer to zero represents the quicker return to steady state. ε_t^a and ε_t^*, are independently identically distributed stochastic terms, which represents the unexpected changes in labor productivity and world demand.

A positive productivity shock ($\varepsilon_t^a > 0$), increases the potential output and reduces the marginal cost, which in turn increases the domestic output and reduces the inflation from steady state. In result, policy rate, which reacts to overall inflation, also decreases.

Similarly, a positive world demand shock ($\varepsilon_t^* > 0$), increases the domestic output due to higher foreign demand, but reduces the imported inflation burden through the favorable terms of trade. As a result, inflations fall, to which monetary policy reacts by reducing the policy rate.

2.2. Calibration

We calibrated this SOE DSGE model for Pakistan economy by estimating the values of parameters using econometric techniques, historical data and from relevant literature. While for Canada, we used the same values as given in the paper. **Table 1** presents the complete list of calibrated parameters.

Table 1: List of Calibrated Parameters

Sr. No.	Parameter	Definition	Canada[1]	Pakistan	References/Remarks
1	Beta (β)	Time preferences (Discount Factor)	0.99	0.98	Ahmed et al. (2025) - upcoming SBP working Paper
2	Sigma (σ)	Coefficient of Relative risk aversion (CRRA)	1.00	0.31	Ahmed et al. (2025) - upcoming SBP working Paper
3	Alpha (α)	Imports share in domestic consumption (Degree of Openness)	0.40	0.15	Estimated using the latest data from Consumer Price Index (CPI) basket (base year: 2015-16)
4	Gamma (γ)	Elasticity of substitution between goods produced in foreign economy	1.00	1.00	Gali & Monacelli (2005)
5	Eta (η)	Substitutability between domestic and foreign goods	1.00	0.78	Ahmed et al. (2018)
6	Phi (φ)	Disutility from supplying labor	3.00	0.70	Estimated by regressing the growth rate of real wages on the changes in per capita consumption (C_t) and labor supply (N_t)[2]
7	Theta (θ)	Price stickiness parameter	0.75	0.49	Ahmad et al. (2018)
8	Tau (τ)	Employment subsidy	0.76	0.70	Proxied by Business subsidies[3]
9	Mu (μ)	Optimal markup on MC	1.20	1.16	Estimated by using financial data of firms listed on the Pakistan Stock Exchange (PSX) between 2005 to 2019
11	Rhoa (ρ_a)	Persistent of domestic labor productivity shock (parameter of AR(1) for productivity)	0.66	0.23	Estimated using HP-filtered, seasonally adjusted labor productivity data (1978Q1–2021Q4).
11	Rhoy (ρ_y)	Persistent of world output shock (parameter of AR(1) for y^*)	0.86	0.86	Gali & Monacelli (2005)

[1] Taken from Gali & Monacelli (2005).
[2] The data is sourced from SBP and APO from 1970 to 2021.
[3] It is calculated as a six-year average (FY18-FY24) of proportion of total subsidies allocated to business, based on budget estimates.

12	Phipi (ϕ_π)	Response of monetary policy to inflation under Taylor rule	1.50	1.55	Ahmad et al. (2018)
13	Epsilon (ε)	Elasticity of substitution between Differentiated goods	6.00	7.20	Sharma and Behara (2022)

2.3. Explaining difference in parameters for Canada and Pakistan

1. **The discount factor (β) and CRRA (σ):** β (representing the preference of future consumption over current consumption) is slightly lower, and σ (showing how much households tolerate fluctuations in their consumption) is significantly lower for Pakistan, relatively. For Canada, these parameters are assumed from a benchmark for developed economies, whereas for Pakistan, Ahmad et al. (2025) statistically estimated these parameters using actual data.
2. **Degree of openness (α):** This parameter is relatively lower for Pakistan, reflecting its limited integration with world economy as Pakistan's import to global GDP ratio stands at only 0.05%.
3. **Elasticity of Substitution Between Goods produced in Foreign Economies(γ):** it is assumed that this parameter remains uniform across small open economies regardless of domestic characteristics.
4. **Elasticity of substitution between domestic and foreign good (η):** This parameter is relatively lower for Pakistan, indicating a lower scope for substitution. For Canada, the value is assumed based on benchmark, while Pakistan's value is taken from Ahmad et al. (2018), where it is derived from Bayesian estimation using actual data.
5. **Disutility from supplying labor (φ):** The value of φ for Pakistan is relatively lower, because the value is estimated from Pakistan's actual data rather than assumed benchmark.
6. **Calvo price stickiness parameter (θ):** The value of this parameter shows that prices in Pakistan adjust relatively more quickly. For Canada, this parameter is assumed based on the conventional calibration of an average period of one year between price adjustment. However, for Pakistan the value is estimated from survey data on actual price setting behavior, reflecting the higher frequency of price changes.
7. **The employment subsidy parameter (τ):** The business subsidies as a proxy for employment subsidies shows relatively lower government support for the unemployed in Pakistan.
8. **Optimal markup on marginal cost (μ):** The parameter μ models firm's pricing strategy. The value of this parameter is slightly low in Pakistan relatively. For Canada, this parameter is derived from elasticity of substitution (ε), such as $\mu = \frac{\varepsilon}{\varepsilon - 1}$. However, for Pakistan it is calculated directly from firms' financial data, representing a more realistic measure.
9. **Persistence of Domestic Productivity Shock (ρ_a):** The persistence of labor productivity shock is relatively lower in Pakistan.
10. **Persistence of World Demand Shock (ρ_y):** Global business cycle shocks are assumed to have similar persistence for small open economy such as Pakistan and Canada; thus, the value of parameter is identical.

11. **Response of monetary policy rule to inflation (ϕ_π):** This parameter is relatively higher for Pakistan. For Canada, this value is set following the standard Taylor rule, while for Pakistan, it is estimated from monetary policy reaction function using the actual data.

Building on these baseline parameters, ***Table 3*** provides the derived model parameters for both economies, attached as **Annexure – A1.**

3. Results

The Impulse Response Functions (IRFs) of key macroeconomic variables are computed using parameters in **Table 1**[4] for Pakistan and Canada. The magnitude of shocks applied to both countries correspond precisely to those used in the original study, i.e. one standard deviation of labor productivity and world demand shocks.

3.1. Domestic Labor Productivity Shock

In the simulation, the one standard deviation shock is applied to the domestic labor productivity, and its dynamic impact on output, inflation, interest rate and exchange rate are analyzed in **Figure 1** as given below:

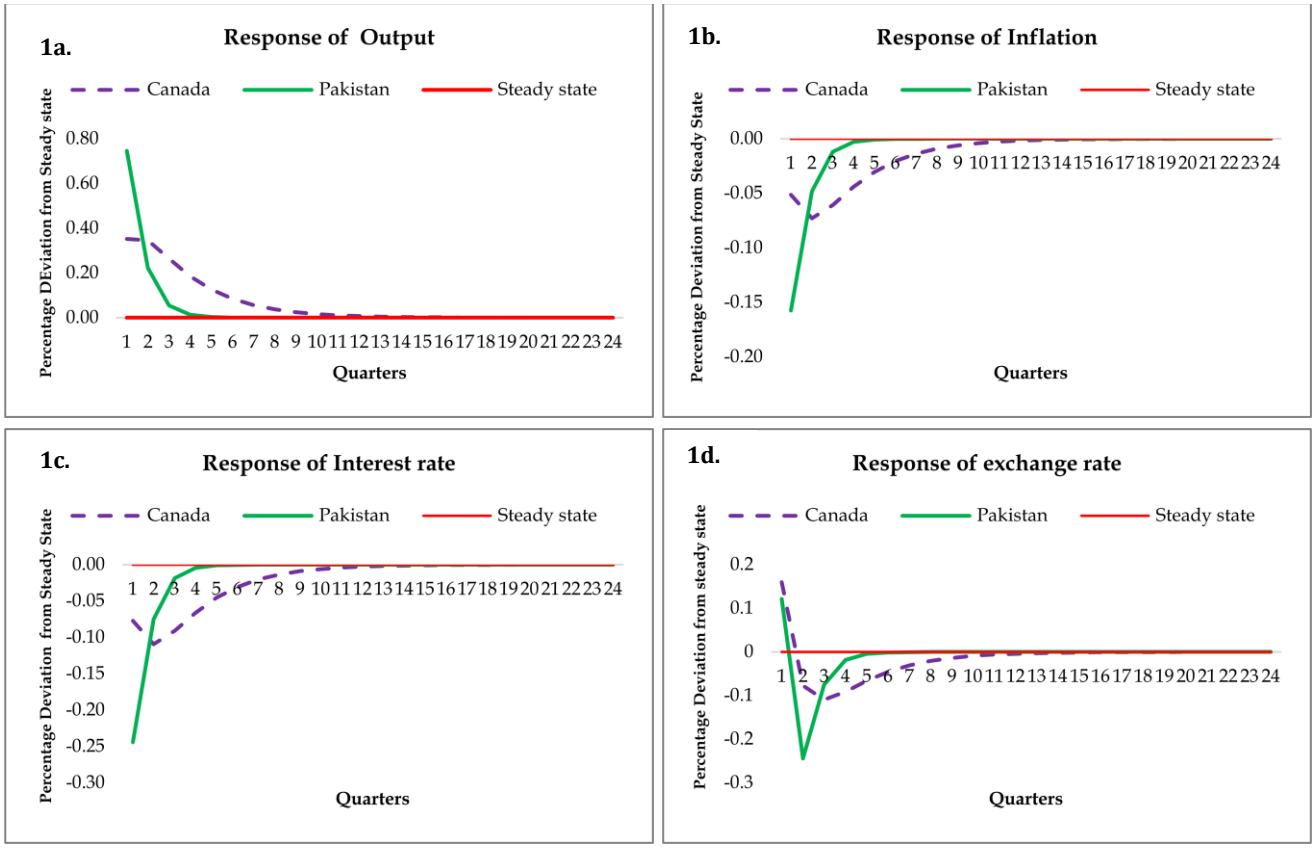

Figure 1: Response of Key Macroeconomic Variables to Domestic Labor Productivity Shock

[4] The computation of IRFs also involves the use of derived parameters, reported in Table 3 (Annexure – A1). These parameters are the functional transformations of the baseline parameters provided in Table 1.

Figure 1a reveals critical structural contrast between the two economies, particularly in terms of sensitivity, persistence, and deviation of output from the steady state in response to the productivity shock. Pakistan's output rises sharply relative to Canada, indicating a higher initial sensitivity to shock. This heightened sensitivity reflects structural characteristics such as underutilized production capacity, a more elastic labor supply, and a relatively low baseline level of productivity, translating into short-term gains in output.

However, Pakistan has a short-lived response, as output returns to the steady-state within five quarters, while for Canada it is initially smaller but much more durable, converging back to the steady-state in twelve quarters. This lack of persistence reflects deeper structural weaknesses in Pakistan, such as inadequate capital, weaker technological absorption, and lower financial inclusion.

Inflation declines in both economies due to the excess supply generated by productivity shocks; however, the magnitude and convergence differ **(Figure 1b)**. Pakistan has seen a more significant drop in inflation, which can be attributed to the higher speed of price in Pakistan compared to Canada, as reflected by price stickiness parameter. When combined with the lower persistence of shock, it results in a short-lived response of inflation, as it converges to steady state within six quarters. The similar pattern is followed by interest rate (**Figure 1c**). To make the supply and demand equal, interest rates must be adjusted to boost consumption and aggregate demand, while accounting for the production and inflation dynamics. Both Pakistan and Canada, experienced that adjustment in interest rate brings the inflation back to its steady state. However, the adjustment of interest rate in Pakistan is larger and short lived.

In contrast, Canada's response is more gradual, with a stronger interest rate adjustment initially, but a slow-paced return of inflation and output to their steady-state levels. This gradual response is indicative of the more resilient economic framework in Canada, where inflationary pressures are absorbed over time, allowing for a smoother transition back to equilibrium. Thus, the difference in the speed and scale of response between the two countries reflects differences in monetary transmission mechanism and structural characteristics.

These dynamics also interact with exchange rate movements, particularly in response to labor productivity shocks (**Figure 1d**). In such cases, the exchange rate initially depreciates before eventually appreciating. The behavior can be understood through the lens of Uncovered Interest Parity (UIP) condition. Assuming global interest rates remain stable, a reduction in domestic interest rates relative to global rates makes foreign assets more attractive, leading to capital outflows and a depreciation of the domestic currency. However, as inflation declines, domestic goods become more competitive in the international markets, increasing demand for the local currency and driving its appreciation in the future. This interplay between interest rate differentials and inflation dynamics explains the eventual reversal of the initial depreciation.

3.2. World Demand Shock

A one standard deviation shock is introduced to world demand in the simulation, which leads to subsequent responses in output, inflation, interest rate, and exchange rate as depicted in **Figure 2**, as given below:

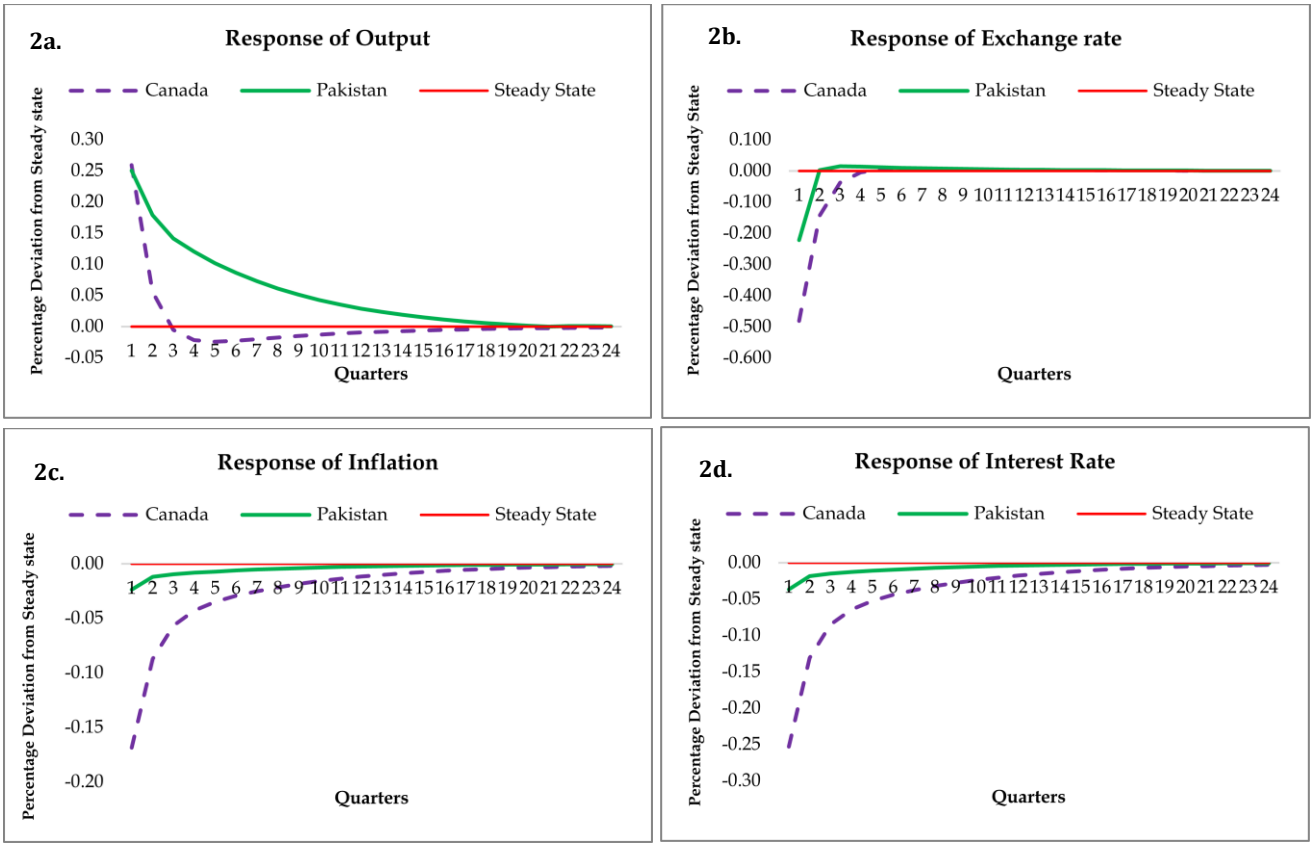

Figure 2: Response of key Macroeconomic Variables to World Demand Shock

Figure 2a depicts the contrasting impulse responses of Canada and Pakistan to a positive world demand shock. Initially, both economies show similar percentage deviation, indicating similar short-term reaction. However, this apparent symmetry is misleading when considering the underlying economic scale and structural differences between the two nations. After initial response, the countries diverge, with Pakistan's output remaining elevated longer due to factors such as lower disutility from supplying labor[5], and lower CRRA[6]. In contrast, Canada's output returns to the steady-state quickly, reflecting a more efficient labor market and higher labor supply disutility, hence contributing to the rapid adjustment.

An increase in the world demand boosts exports, leading both Pakistan and Canada to experience an appreciation in the exchange rate, albeit with varying magnitude and persistence (**Figure 2b**). Pakistan exhibits a smaller and short-lived response due to low-value exports and lower degree of economic openness. Moreover, the low CRRA implies that extra income generated through an external demand shock is quickly directed into consumption, absorbing the shock and shortening the appreciation of the exchange rate. In contrast, Canada's diverse and high valued export base coupled with deeper economic integration leads to a stronger and relatively persistent exchange rate appreciation.

[5] It reflects households' greater willingness to increase labor supply in response to higher demand.
[6] The lower coefficient of relative risk aversion (CRRA) implies that household tolerate the fluctuations in their consumption pattern easily. As the export led income rises during the shock, the households increase their domestic consumption rather than smoothing it over time, which keeps the domestic aggregate demand high along with foreign demand.

Following the exchange rate appreciation, both countries see a decline in inflation due to reduction in import bill (**Figure 2c**). However, Pakistan's response is muted because of low price stickiness, higher sensitivity of domestic inflation to output gap and high domestic demand (low CRRA), which offsets the import inflation reduction. Resultantly, the overall impact on CPI inflation is neutralized, contributing to the muted response relative to Canada.

The implication of these dynamics is evident in the response of interest rate depicted in (**Figure 2d**), where both Pakistan and Canada cut their interest rates. However, Pakistan shows a cautious approach to inflation which results in slower response. Given the interplay of higher domestic inflation in response to higher demand and decline in imported inflation amidst appreciation, as discussed above, the central bank perceives less inflationary pressure and adjusts interest rates gradually. However, it may prolong economic vulnerability such as prolonged output gap by delaying economy's return to equilibrium. Canada, on the other hand, moves quickly to stabilize inflation and output with decisive interest rate adjustments. A substantial and sustained appreciation of the exchange rate in Canada helps stabilize inflation, allowing for more focused and effective interest rate adjustments. This aids Canada's ability to anticipate and respond to shocks effectively.

3.3. Pakistan can reap significant gains by carrying out structural reforms

According to the analysis above, the country's ability to react to shocks is influenced by underlying structural parameters such as persistence of productivity shock, CRRA, price stickiness, disutility from supplying labor etc. However, even though several parameters are important yet by altering just one i.e. persistence of productivity shock can change the macroeconomic picture. In Pakistan, persistence of productivity shock is relatively low, but if policies such as sustained investment in human capital, physical and technological capital deepening, institutional creditability, and innovation, succeed in extending it, the cumulative impact of productivity shock would be magnified.

Table 2 compares cumulative responses over 12 quarters under two scenarios for Pakistan: one with lower persistence at $\rho_a = 0.23$, which represents Pakistan's own estimate, and another with higher persistence equivalent to the level seen in Canada $\rho_a = 0.66$**.**

Table 2: Cumulative Response to Labor Productivity Shock (12 Quarters)

Variables	$\boldsymbol{\rho_a = 0.23}$	$\boldsymbol{\rho_a = 0.66}$[7]
Output	1.04	2.80
Inflation	-0.22	-0.39
Interest rate	-0.34	-0.60
Exchange rate	-0.24	-0.39

The results in **Table 2** reveal several important insights:

[7] Equivalent to Canada's value given in Gali & Monacelli (2005).

I. **Output:** With lower persistence, the cumulative output gain is only 1.04 percent above steady state over twelve quarters (three years). In contrast, with higher persistence, the cumulative output gain would be more than double – 2.80 percent above steady state, highlighting the importance of structural reforms required to sustain productivity shock.

II. **Inflation:** Under low persistence, inflation falls by cumulatively 0.22 percent below the steady state over twelve quarters, whereas under higher persistence, the fall is larger – 0.39 percent, allowing the economy to experience both higher output and lower inflation simultaneously.

III. **Interest rate:** Similar pattern is followed by interest rate. It declines more sharply (0.34 versus 0.60, percent below steady state), when moving from lower to higher persistence, indicating the greater monetary space to sustain investment and consumption.

IV. **Exchange rate:** Cumulative appreciation in the exchange rate will be increased by 0.15 percent, in the higher persistence scenario, underscoring the importance of productivity persistency in improving the country's external competitiveness and attractiveness for capital inflows.

4. Conclusion

The analysis of this study reveals that Pakistan's economy has higher sensitivity of potential output to productivity changes, higher sensitivity of inflation to output gap, lower price stickiness, lower degree of openness, lower disutility from supplying labor, lower CRRA, and lower persistence of productivity shocks. These findings carry direct implications for policymakers.

The results suggest that if Pakistan could address the structural issue relating to persistence of productivity shock, the gain in output would more than double over the twelve quarters, while also allowing the economy to simultaneously experience lower inflation, greater monetary space and higher appreciation in exchange rate. To achieve such higher persistence, it is essential to focus on reforms such as consistent investment in human and physical capital, technology adoption, and building institutional capacity, so that the benefits of increased productivity are not short-lived.

In addition, Lower price stickiness calls for reforms to enhance market competitiveness and improve price stability. Similarly, limited openness and low value-added exports highlight the need for diversification to better capture benefits from global demand shocks. Another important finding is that the households in Pakistan easily tolerate the fluctuations in their consumption patterns, emphasizing the importance of promoting financial literacy and safe investment avenues, so that household could smoothen their consumption efficiently over time.

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Annexure

A1: Derived Model Parameters

Sensitivity of Domestic Output to Terms of Trade (σ_a):

$$\sigma_a = \frac{\sigma}{(1-\alpha)+\alpha\omega}$$

Where $\omega = \sigma\gamma + (1-\alpha)(\sigma\eta - 1)$

Discount rate (ρ):

$$\rho = \beta^{-1} - 1$$

Sensitivity of Natural Level of Output to Productivity (Γ):

$$\Gamma = \frac{1+\varphi}{\sigma_a + \varphi}$$

Part of Sensitivity of Natural Interest Rate to Expected Change in World Output (Θ):

$$\Theta = (\sigma\gamma - 1) + (1-\alpha)(\sigma\eta - 1) = \omega - 1$$

Sensitivity of Natural Level of Domestic Output to World Output (Ψ):

$$\Psi = -\frac{\Theta\sigma_a}{\sigma_a + \varphi}$$

Sensitivity of Inflation to Output Gap Under Phillips Curve (κ_a):

$$\kappa_a = \lambda(\sigma_a + \varphi)$$

Where $\lambda = \frac{(1-\beta\theta)(1-\theta)}{\theta}$

Constant representing the Natural Level of Output (Ω):

$$\Omega = \frac{\nu - \mu}{\sigma_a + \varphi}$$

Where $\nu = -\log(1-\tau)$ and $\mu = \frac{\varepsilon}{\varepsilon - 1}$

Table 3: Derived Model Parameters based on Calibration

Parameter	Definition	Values for Canada[8]	Values for Pakistan
Sigma (σ_a)	Sensitivity of domestic output to terms of trade	1.00	0.44
Rho (ρ)	Log of discount factor (Discount rate)	0.01	0.02
Tau (Γ)	Sensitivity of natural level of domestic output to productivity	1.00	1.49
Theta (θ)	Part of sensitivity of natural interest rate to expected change in world output	0.00	-1.25
Xi (Ψ)	Sensitivity of natural level of domestic output to world output	0.00	1.79
Kappa (κ_a)	Sensitivity of inflation to output gap in Philips curve	0.34	0.62
Omega (Ω)	Constant representing the natural level of output	-0.13	-0.17

[8] As given in Gali & Monacelli (2005).