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# Financial Stability and Monetary Framework under Interest-Free DSGE Settings for Pakistan

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## Abstract

Various small and large, conventional and interest-free, DSGE models have been developed, simulated, and compared. After a large conventional model, an interest-free NK model was prepared with household preferences, retail firms, and capital-producing firms. The deduction of *zakat* was suggested with appropriate incidence. The model was estimated using quarterly data for Pakistan between 1990 and 2009, a period characterized by the consolidation of monetary and macro-prudential policies besides the opening up of the banking sector. This large-scale model included financial accelerator, systemic risk, the inter-bank market, macro-prudential policy, and monetary policy. Both types, that is, interest-based conventional models and interest-free models, were estimated and compared. The welfare loss of four conventional and three interest-free models was computed and compared, where loss decreased with monetary policy and increased with money in utility. The lower value of welfare loss for the large conventional model exhibited effective financial stability policies in Pakistan, as compared to the basic model. It was found that interest-free monetary models couldn't reduce welfare loss, when compared with conventional models. The study also evaluated three interest-free rates of return as alternatives to interest rates theorized by Khan and Mirakhor (1989). It was found that the shift towards an interest-free regime for entrepreneurs, banking, inter-bank operations, central banking, and policies can be simulated with Pakistan's data. The Islamic model showed lesser convergence, so the fit of the model was reduced.

***Keywords*:** financial stability, DSGE Model, interest-free, monetary framework, Pakistan

## Introduction

Formal full-fledged Islamic banking started in Pakistan on March 20, 2002 when Al Meezan Investment Bank initiated operations after receiving the

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first Islamic commercial banking license from the State Bank of Pakistan (SBP). However, the field of Islamic economics kept facing a lack of data and applicable models. There is a dearth of Islamic general equilibrium models that provide comparisons with interest-based financial frameworks. Indeed, there is a lack of appropriate studies that evaluate the stability of financial institutions and financial markets, specifically from an Islamic perspective. The fact of the matter is that data for Islamic models is quite limited, as it is available only from 2005. Moreover, the data for macroeconomic variables also lacks the required variation between quarters beyond 2009. So, the reliability of economic estimations after 2009 is questionable. Hence, Islamic economists face many issues. None of the regulatory instruments of monetary policy and macro-prudential policy have been implemented yet under the principles of Islamic economics and could not be tested with data. In this environment, simulations fall short of reality. Meanwhile, the number of studies that test the interaction between monetary policy and macro-prudential policies is increasing globally, an area that requires more work in Pakistan.

For the sake of estimations and comparisons, the current study develops models, small and large, with and without monetary policy, with financial accelerator, banking sector, policies, and interest-free models with real profit rates. Models are evaluated and compared through multivariate convergence and welfare loss. Besides, IRFs are also compared and discussed for all sorts of models.

The current study attempts the estimation and comparison of interest-free and interest-based models of a) monetary policy and b) macro-prudential policy (financial stability). To the best of the researcher's knowledge, no such study has been conducted keeping in view the above objective using Pakistan's data. For the interest-free model, a few principles, instruments, and model dynamics were borrowed from Khan and Mirakhor (1989).

One large NK DSGE model was simulated with basic macroeconomic equations, a financial accelerator, the banking sector, monetary policy, and macro-prudential policy. Interest-free DSGE models are fewer in number, while those with policies and financial friction are quite absent. So, the proposed model is a genuine addition to DSGE settings for interest-free real sector models for a small, closed economy. The main elements of the large Islamic DSGE model include 1) share in profit and loss between the bank

and entrepreneur, 2) share in profit and loss between the bank and central bank against the investment of reserves in the equity of banks, 3) financial frictions and financial accelerator with an Islamic spirit of ROCE, that is, the rate of return to capital employed of non-financial companies, 4) calculation of *Zakat* instead of taxes, 5) development of the inter-bank market, 6) replacement of the rate of return on stocks (ROR_SE) as a general rate against the interest rate, and 7) computing the monetary policy with the rate of return to the equity of bank (ROE), with investments from the central bank under *mudarabah* contract. Measures, such as financial cost, are added as in Doojav and Batmunkh (2018), although they are little needed at the level adopted by conventional interest-based banking. In fact, under the Islamic paradigm, demand deposits are handed over to the central bank. So, the requirement for policies of financial stability should remain limited in the interest-free paradigm. However, the discussion on interest-free models, developed so far, should be quite important.

## Literature Review

So far, very few interest-free DSGE models have been developed in previous studies. Moreover, these studies have remained limited to monetary policy and neither worked out banking sector nor policy regimes. Among them is Saadat et al. (2016), who worked on the Taylor rule for Iran with money growth. Feizi (2008) offered the NK SOE model using the exchange rate as an alternative monetary policy instrument which is less useful. Hadian (2017), following Ireland (2001) and Walsh (1998), constructed the NK DSGE model with the "expected rate of return to the outcome of projects in the real sector" as a monetary instrument. Mirfatah et al. (2019) provided a DSGE model with money growth rate as a Taylor-type rule against interest rate. The DSGE model of Dahani and Aboulaich (2018) used interest rate as the rate of return on capital and *Zakat* as fiscal policy. The main issue with all these models is that they don't explain the banking part of the economy, without which an interest-free economy can't be envisaged, though monetary policy can be worked out. Furthermore, there are other issues as well that require detailed investigation, as given in the next section.

The suggestion of Hadian (2017) for using "expected rate of return to outcome of projects in the real sector" is a viable one, although it is not sufficient because more types of profit rates are required to address the diversity of even medium sized Muslim economies, where banks and

insurance companies operate while stock exchanges are vibrant under a central bank. Pakistan's financial market is diversified manifolds as it is governed by a developed securities and exchange commission. The current study, however, uses the real sector rate of return as proposed by Hadian (2017). Mirfatah et al. (2019) used money growth rate, which is also a usable option, yet mere growth rate is not sufficient as it has no direct link to the real sector. In the current study, the rate of return on capital employed of non-financial companies (ROCE) is used, which has a direct link to the real sector.

An Islamic central bank can't rely on the rate of growth of money as its sole instrument. Instead, the rate of return on bank equity and the capital employed of non-financial companies can provide a direct and better instrument for gauging monetary policy. Both types of profit rates are used for simulation purposes and, at present, are not aimed at providing any direct control to a central bank, as desired by central bankers. Instead, they fulfil the requirement of an interest-free economy that calls for real sector working. As the Islamic legitimacy of the policy interest rate issued by the central bank is questionable, so the current study utilized the policy leverage of the "rate of return on equity of the central bank's reserves", as suggested by Khan and Mirakhor (1989). This instrument remains under the direct control of the central bank. It is a matter of efficient collection of reserves and investment of (a part of) these reserves that should provide sufficient leverage for central bankers, while its extent would be much greater than a mere announcement of a policy rate. So, the leverage given by the "rate of return on equity of the central bank's reserves" would depend on the decision of the central bank to enforce a policy for reserves, invest a portion of reserves in banks or in projects, and also on the performance of commercial banks and sector firms. All these elements not only help provide leverage but also meet the requirements of an interest-free economic framework.

## The Model

The model blocks of the large model consist of household preferences (utility function), retail firms that produce goods (intermediate and final) with the Dixit-Stiglitz function, calvo pricing, calvo wage rate, and capital-producing firms. Besides, financial accelerator equations were added following Tufail and Ahmed (2019), while financial market functions following Ramanauskas and Karmelavicius (2018), Dib (2010), and

Hollander and Liu (2016). However, the peculiarities of Pakistan's financial market were not ignored. Systemic risk was added as a "negative financial accelerator", as used by Silva et al. (2018), in order to capture 'feedback effect of the real sector on the financial sector' through changes in the bank's equity position. The inter-bank market, as in Dib (2010), was devised because it is relevant for Pakistan. Macro-prudential policy was built following Doojav and Batmunkh (2018), wherein tools such as reserve requirements and capital adequacy ratios are structured. Monetary policy was framed as of Junior (2016). An interest-free model was developed following Khan and Mirakhor (1989).

## C1: Interest Free Model

The model of Khan and Mirakhor (1989) suggested the same role for banks as in conventional economics, that is, working as administrators of payment systems and as financial intermediaries.[1] The current study suggests a macro-financial model with small changes in four functions, while adding one new parameter for Islamic monetary policy. The four functions include 1) rate of return to banks from entrepreneurs, 2) return on deposits, 3) central bank's policy for reserves, and 4) earning profits from reserves by investing in equity shares of banks. The fifth change is that reserves are suggested to be used as interest free "monetary policy". The remaining model is based on the usual NK macro-economic DSGE framework.

The proposed interest-free model uses three rates of return namely 1) return to capital employed (ROCE), 2) rate of return on bank equity (ROE), and 3) rate of return to banks' investment in stock exchanges (ROR_SE). These three rates have different contexts. ROCE is the main instrument that replaces "Rk" (weighted average rate of return on bank advances to machinery). ROCE is used in financial accelerator. ROE is used by the central bank as a tool of monetary policy. The last, namely ROR_SE, replaces R, the general interest rate also acts as a discount rate for inter-temporal settings but with the minor change of deducting *mudarabah* at

[1] Khan & Mirakhor (1989) explain that "in an Islamic financial system, banks perform the same essential functions as they do in the traditional banking system but are constrained to carry out their transactions in accordance with the rules of the Islamic law—Shariah. They act as administrators of the economy's payments system and as financial intermediaries".

2.5% on savings. The details of the rates of return in the interest-free model are given below.

1. ROCE - Rate of Return to Capital Employed

a. It replaces the "weighted average rate of return on bank advances to machinery", that is, the Rk that is used in the estimation of financial accelerator and for the computation of premium against the risk-free rate.

b. As an alternate bank rate for banks, that is, profit per unit of investment (PPIU), replacing interest-based rates. ROCE is more plausible as a bank rate than the bank rate against advances, the actual interest rate paid by the borrowers.

c. ROCE remains double the interest rate, as a general rule. It is because it is calculated before the payment of interest and taxes. However, in the Islamic model, interest is not paid, while *mudarabah* is paid as tax by individuals on their savings, instead of corporate tax. Hence, ROCE is the most appropriate rate here.

2. ROE - Rate of Return on Bank Equity

It is used for money management (as a monetary policy rate to be used by the central bank) as ROE (+1). Khan and Mirakhor (1989) suggested this to be a monetary policy tool. Also, it requires that the use of reserves be allowed by depositors and banks through their formal willingness. As under the Islamic economic system, all the amount in the current account deposits has to be taken as reserves, bank leverage would be shifted towards the central bank, along with most of the responsibility for financial stability.

3. ROR_SE - Rate of Return to Investments in Stock Exchange

a. ROR_SE is used by risk-averse investors (most of the time).

b. R, the general interest rate, is used for discounting in inter-temporal settings. Being on the safe side, ROR_SE, which banks report as a return on investment in stock exchanges, is a safer tool and *halal* (legitimate). However, it can't be used without taxing the *mudarabah*.

The formula could be ROR_SE = (0.025) * (Y-C).

*Mudarabah* applies to savings, so S=Y-C. 0.025 is the rate of *mudarabah* (2.5%), assuming that every account holder is liable to pay

*mudarabah*. Another parameter can be added here for exact computation that could decrease *mudarabah* incidence for the rich only.[2] In this composition, ROR_SE can replace the general interest rate used in economics. However, timing should be $E_t$ROR-SE (+1) where the interest-free rate of return (IROR) is defined as follows:

$$R = E_t IROR(+1)$$

$$E_t IROR(+1) = ROR\_SE(+1) - ZT_t \quad (1)$$

$ZT = (zt)*(Y(+1) - C)$, where zt = 0.025 is rate of *mudarabah* deduction.

In data that is processed for quarterization, it can be used as follows:

$$ZT_t = ((zt)/4)*(Y(+1) - C) \quad (3)$$

Here, it is noteworthy that the income stream comes a year later. However, as per the rule of economics, consumption can be made before the commencement of income. The rate of return is applied a year later, when the entrepreneur pays out. The same methodology is applied in financial accelerator.

In fact, ROR_SE is the preferred one. ROCE is the actual rate of return paid by entrepreneurs to the banks. But individuals are risk averse and prefer short term financing or investing in banks, where banks charge for services. Risk-averse individuals prefer the stock market for a safe return. Even if individuals invest in entrepreneurs, they choose a risk-free rate but will have a little less leverage as compared to banks. So, a general discount rate would be established near ROR_SE and not near ROCE.

It should be interesting to note that where Mirakhor and Zaidi (1988) explain that "this can further be explained in terms of the Q theory of investment" along with marginal efficiency of capital, this is, in fact, a reference to the financial accelerator that was described by Bernanke et al. (1999) later on. This aspect suggests that some of the theoretical basis for concepts like financial frictions can be found in Islamic economic theory. As in Bernanke et al. (1999), who compute a 30% rise in output due to a shock in technological progress against the basic model, Mirakhor and Zaidi (1988) also expected, then in 1988, that "in an Islamic economic system,

[2] Business assets (*amwal-e-tijarat*), as per their market value, are zakatable, if one year is completed as fatwa of Jamia Islamia, Bannuri Town guides. Fatwa No. 144109200307. https://www.banuri.edu.pk/readquestion/karobar-ki-zakat-144109200307/26-04-2020

particularly with its emphasis upon work and moderation in consumption, saving would be enhanced". If one considers the deposit rate as the saving rate, as is a tradition in Pakistan's data collection methodology, then, after the introduction of an interest-free economy, a rise in savings should be expected.

ROCE can be calculated as follows:

Rate of Return to Bank; ROCE: $ROCE_t = \frac{\gamma^B \pi_t^F}{Adv_t^B}$ (4)

Where $ROCE_t$ is the rate of return for banks on advances to businesses (adv_b), $\gamma$ is profit sharing ratio for bank. While adv_b is mudarabah investment of bank in entrepreneur.

Profit per unit of investment by Bank: PPIU: $PPIU_t = \frac{\pi_t^F}{Adv_t^B}$ (5)

Then, ROCE can be defined as $ROCE_t = \gamma^e PPIU_t$ (6)

Rate of return for Entrepreneur: $ROCE_t = \frac{(1-\gamma^B)\pi_t^F}{Adv_t^B}$ (7)

Rate of Return on Deposits $ror_t^d = \frac{\gamma^d \pi_t^B}{D_t^B}$ (8)

Where $\gamma^d$ denotes ratio of profit/loss for bank, while $\pi_t^B$ is distributable profit of bank. $D_t^B$ denotes deposits of banks.

Rate of Return for Depositor:

$$ROR_t^B = \frac{\gamma^B \pi_t^B}{D_t^B + Cap_t^B + \phi^{CB} RR_t^{CB}} = \frac{\gamma^B \pi_t^B}{KE_t^B} \quad (9)$$

The rate of return of the depositor is the ratio of profit or loss for the depositor to its share of total capital from the bank (KE_B). The total capital of a bank includes deposits, the bank's equity capital, and the amount of reserves invested back by the central bank. The share of the depositor in profits is given by capital and the amount of reserves invested back by the

central bank. The share of the depositor in profits is calculated as:

$$\gamma^B PPDU_t = \frac{\gamma^B \pi_t^B}{KE_t^B} \tag{10}$$

The profit of the bank is determined by the rate of return of the entrepreneur, from which subtractions are made for payments to depositors and the central bank. Adv_BRR is the amount invested back by the central bank in banks against reserve requirements acquired from banks.

$$\pi_t^B = \frac{\gamma^e \pi_t^e}{Adv_t^{BRR}} Adv_t^{BRR} - \frac{\gamma^B \pi_t^B}{KE_t^B} D_t^B - \frac{\gamma^{CB} \pi_t^B}{KE_t^B} \phi^{CB} RR_t^B \tag{11}$$

If reserve requirement, RR is defined as RR = K_rr*d_b, where K_rr is some ratio of deposits, then profit of banker, against Adv_BRR is given by:

$$\pi_t^B = \frac{\gamma^e \pi_t^e}{Adv_t^{BRR}} Adv_t^{BRR} - \frac{\gamma^B \pi_t^B}{KE_t^B} D_t^B - \frac{\gamma^{CB} \pi_t^B}{KE_t^B} \phi^{CB} K\_rr * D_t^B \tag{12}$$

**C2: Balance Sheet of Islamic Banks**

The balance sheet of conventional banks is used (for simulation in Dynare) as if it was that of interest-free banks.[3] But before that, it is necessary to repeat the discussion of risk-free investment by banks and non-risky investment (on the asset side). The assets of a bank comprise discounted bills, government securities, T-bills, advances to banks, investment in the stock exchange in the form of the purchase of shares, advances to entrepreneurs, and reserves required by law. So its mathematical expression can be given as:

$$Disc_t^B + I_{B,t}^{GSec} + TBills + AdvtoBanks + I_{B,t}^{SE} + AdvtoBiz_t^B + TRR_t^B = Br_t^B + D_t^B + Cap_t^B \tag{13}$$

These investments on asset side may be segregated as risk free and risky ones.

[3] This had to be adopted because the data on Islamic banks was available after 2005, which is insufficient for simulation.

$$InvRiskFree + InvRisky + TRR_t^B = Br_t^B + D_t^B + Cap_t^B \quad (14)$$

Where

$$InvRiskFree = Disc_t^B + I_{B,t}^{GSec} + TBills + AdvtoBanks \quad (15)$$

While

$$InvRisky = I_{B,t}^{SE} + AdvtoBiz_t^B$$

So, risk-free investment is based on discounted bills, investment in government securities, T-bills, and advances to banks (in the inter-bank market). Risk-free assets are interest-based, in general. Discounting a bill, a note, or a check, therefore, involves interest (State Bank of Pakistan, n.d.).[4] The study then uses them as "mudarabah financing" in entrepreneurs for simulating the "could-be" real alternate and calculates the impact on the economy. Government securities cause crowding out and a credit crunch. In that manner, it forgoes a tax opportunity. But it is engulfing the tax revenue. So, the government should find some other way out instead of making an open offer for leakage from revenues. Short-term Treasury Bills (T-Bills) are issued by the government and are less risky. T-bills are interest-based (Kahf, 2018). There are reasons to divert funds deployed for T-bills towards the financing of entrepreneurs. But, inter-bank advances would also exist in the Islamic economy. In that manner, the balance sheet can be modified as follows:

$$AdvtoBanks + I_{B,t}^{SE} + AdvtoBiz_t^B + TRR_t^B = Br_t^B + D_t^B + Cap_t^B \quad (16)$$

The equation reads that, on the asset side, advances to banks, investments in stocks, advances to businesses, and total reserves required by the central bank are equal, on the liability side, to the amount borrowed from banks, deposits, and capital invested by banks.

### C3: Balance Sheet Constraint for Interest-free Banker

Balance sheet constraint for Interest-free banker would be:

[4] See State Bank of Pakistan's website. Question No. 38. Does discounting of bills is allowed under Islamic Shariah? https://www.sbp.org.pk/IB/FAQ.asp

$$I_{B,t}^{SE} + Adv_t^B + ER_t^B = D_t^B + MR_t^B + Br_t^B + Cap_t^B \quad (17)$$

If there are zero excess reserves while minimum reserves are generated against mudarabah deposits, and if there is net borrowing from the inter-bank market, then the balance sheet constraint of an interest-free banker should be: $I_{B,t}^{SE} + Adv_t^B = D_t^B + MR_t^B + Br_t^B + Cap_t^B$ (18)

If banks carry some excess reserves, then, it is assumed that banks are liable to submit all reserves to the central bank. So, total reserves comprise minimum and excess reserves. TR = MR +ER. The balance sheet is then calculated as:

$$I_{B,t}^{SE} + Adv_t^B = D_t^B + R_t^B + Br_t^B + Cap_t^B \quad (19)$$

**C4: Islamic Inter-bank Market**

There would be little space for an Islamic interbank market. But with the advent of specialized and regional Islamic banks, the need for interbank investment could rise. However, it could be dented by the central bank's extremely low profit/loss ratio and by a higher rate of return on long term advances for entrepreneurs. It may, or rather should, exist, somehow, at such "inter-bank profit/loss sharing ratios" that are higher than those of the central bank and lower than the return from entrepreneurs.

**C5: Central Banking in Islamic Perspective**

As theorized by Khan and Mirakhor (1989), central bank's investments in banks out of reserves, created against demand deposits, should bring some returns.

Rate of Return for Central Bank

$$RETURN_t^{CB} = \frac{\gamma^{CB}\pi_t^B}{KE_t^B}\phi^{CB}RR_t^B \quad (20)$$

KE is total capital of bank. In fact it is equity of bank, in new scenario, that includes capital of bank (previous year's equity), time deposits (mudarabah deposits) and amount of reserves invested by central bank.

Denoting rate of return to central bank as return on equity (ROE_CB), one can formulate ROE as:

$$ROE_t^{CB} = \frac{\gamma^{CB}\pi_t^B}{KE_t^B} \tag{21}$$

If ROE_CB is calculated as Profit Per Unit of Reserve (PPRU), then,

$$PPRU_t^B = \pi_t^B / KE_t^B \tag{22}$$

Where bank capital is defined as $KE_t^B = D_t^B + Cap_t^B + \phi^{CB} RR_t^{CB}$, so ROE_CB can be redefined as $ROE_t^{CB} = \gamma^{CB} PPRU_t^B$.

And so

$$ROE_t^{CB} = \gamma^{CB} PPRU_t^B = \gamma^{CB}\pi_t^B / KE_t^B \tag{23}$$

**C6: Log Linearized Equations of Islamic Model**

$$\varphi\widetilde{H}_t + \sigma_c\widetilde{C}_t = \widetilde{W}_t - \widetilde{P}_t$$

Labor Supply (A1)

$$\frac{\sigma_c}{\beta}[E_t\widetilde{C}_{t+1} - \widetilde{C}_t] = \frac{IROR_{ss}}{P_{ss}} E_t[IRO\widetilde{R}_{t+1} - \widetilde{P}_{t+1}]$$

Euler Equation (A2)

$$\widetilde{K}_{t+1} = (1-\delta)\widetilde{K}_t + \delta\widetilde{I}_t$$

Law of Motion of Capital (A3)

$$\widetilde{Y}_t = \widetilde{A}_t + \alpha\widetilde{K}_t + (1-\alpha)\widetilde{N}_t$$

Production Function (A4)

$$\widetilde{K}_t = CPU_t + \widetilde{Y}_t - IRO\widetilde{R}_{t+1}$$

Capital Demand (A5)

$$\widetilde{H}_t = CPU_t + \widetilde{Y}_t - \widetilde{W}_t$$

Labor Demand (A6)

$$CPU_t = (1-\alpha)\widetilde{W}_t + \alpha IRO\tilde{R}_{t+1} - \tilde{A}_t$$

Marginal Cost (A7)

$$\widetilde{\pi}_t = \beta E_t\widetilde{\pi}_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta}(CPU_t - \widetilde{P}_t)$$

Philips Curve (A8)

$$Y_{ss}\widetilde{Y}_t = C_{ss}\widetilde{C}_t + I_{ss}\widetilde{I}_t$$

Equilibrium Condition (A9)

$$\widetilde{A}_t = \rho_A \widetilde{A}_{t-1} + \varepsilon_t$$

Productivity Shock (A10)

$$\widetilde{\pi}_t = \widetilde{P}_t - \widetilde{P}_{t-1}$$

General Inflation Rate (A11)

$$Adv^B_{ss} Ad\widetilde{v}^B_t = \eta_k K_{ss} \widetilde{K}_t$$

LTV Ratio (A12)

$$Adv^B_{ss} Ad\widetilde{v}^B_t = D^B_{ss} \frac{1}{(r_{n,ss} - r_{D,ss})}[\widetilde{D}^B_t - (\widetilde{r}_{n,t} - \widetilde{r}_{D,t})] - D^B_{ss}\widetilde{D}^B_t)$$

Bank Advances/Deposits (A13)

$$Adv^B_{ss} Ad\widetilde{v}^B_t = +I^{iGSec}_{B,ss}[\frac{(1+r^{GSec}_{ss}) - (r_{n,ss} - r_{D,ss})}{(r_{n,ss} - r_{D,ss})}][I^{iGSec}_{B,t+1} + (1+\widetilde{r}^{GSec}_t) - 2(\widetilde{r}_{n,t} - \widetilde{r}_{D,t})]$$

Bank Advances/Govt Sukuk (A14)

$$R^k_{t+1} = \left[\frac{1-\delta}{1-\delta+\overline{R}^k}\right]P^k_{t+1} + \left[\frac{\overline{R}^k}{1-\delta+\overline{R}^k}\right]mpk_{t+1} - P^k_t$$

FA1: Financial Accelerator 1: Tobin's Q Equation (A15)

$$Z_t = \left[\frac{1-\psi_{efp}}{\psi_{efp}}\right]mpk_{t+1} - P^k_t$$

FA-2: Financial Accelerator 2: Capital Utilization Rate (A16)

$$mpk_t = -(K^s_t - N_t) + w_t$$

FA-3: Financial Accelerator 3: Marginal Product of Capital (A17)

$$Y_t = C_{SS}C_t + I_{ss}I_t + \frac{C^e}{Y}C^e_t + \frac{Z}{Y}Z_t + \frac{G}{Y}G$$

FA-4: Financial Accelerator 3: Resource Constraint (A18)

$$S_t = R^k_{t+1} - (R_t - \pi_{t+1})$$

FA-5: Financial Accelerator 4: External Finance Premium (A19)

$$S_t = -\chi_{efp}(n_t - q_t - K_t) + \varepsilon_t^{fd}$$

FA-6: Financial Accelerator 5: EFP Elasticity (A20)

$$EQF_t = \frac{K}{N}(R_{t+1}^k -_{t-1} R_t^k) +_{t-1} R_t^k + \theta_n EQF_t + \varepsilon_t^{EQF}$$

FA-7: Financial Accelerator 5: Net Worth (Equity of Non-financial Firms (A21)

$$C_t^e = EQF_t$$

FA-8: Financial Accelerator 6: Entrepreneurial Consumption (A22)

$K_t^s = K_{t-1} + Z_t$ FA-9: Financial Accelerator 7: Capital Services (A23)

$$PK_t = -(r_t - \pi_t) + \frac{1-\delta}{1+\delta+ROK} Pk_{t+1} + \frac{ROK}{1+\delta+ROK} mpk_{t+1} + \varepsilon_t^{Pk}$$

FA-10: Financial Accelerator 8: Price of Capital (A24)

***Equations of Islamic Variables***

$$\frac{[\{(\gamma^B - \omega^j(1-\gamma^B)\}PPIU_{t+1}^B - E_t\gamma PPDU_{t+1})}{Adv_t^B} = \frac{1}{Div_t^B} - \beta^B E_t \frac{1}{Div_{t+1}}[(\gamma^B - \omega^j(1-\gamma^B)]PPIU_{t+1}^B - \frac{1}{Div_t}(r_t + \mu_1 npl_t + \mu_2 car_t + \mu_3 mrr_t + \mu_4 err_t)$$

FOC of Bank Margins with Islamic Contract with Regulations (A25)

$ZT_t = zt * [Y_{t+1} - C]$ Zakat Deduction from Savings (A26)

$E_t IROR_{t+1} = ROR_{t+1}^{SE} - ZT_t$

Rate of Return [Replacement of Discount Rate] (A27)

$$roke_{ss} roke_t = \gamma^B[\pi_t^F - Adv_t^B]$$

Rate of Return to Capital Employed (A28)

$roke_t = \gamma^e PPIU_t$ Definition of Rate of Return (A29)

$$ror_t^B = \frac{\gamma^B \pi_t^B}{D_t^B + Cap_t^B + \phi^{CB} RR_t^{CB}} = \frac{\gamma^B \pi_t^B}{KE_t^B}$$

Rate of Return to Bank on Investments in Entrepreneur (A30)

$$\gamma_t^{IIB} PPIU_t^{IIB} - \gamma^{CB} PPIU_{t+1}^{CB} - Br_t^{IIB} = \phi_{RORIIB}\left[\gamma_t^{IIB} PPIU_t^{IIB} - \gamma_t^{IIB} PPIU_t^{IIB}\right]$$

FOC of Islamic Inter-bank Market (A31)

$$\frac{ROE_t^B}{ROE_{ss}^B} = \left(\frac{ROE_{t-1}^B}{ROE_{ss}^B}\right)^{\gamma R}\left[\left(\frac{\pi_t}{\pi_{ss}}\right)^{\gamma\pi}\left(\frac{Y_t}{Y_{ss}}\right)^{\gamma\pi}\right]^{1-\gamma Y} + S_t^m$$ Monetary Policy (A32)

$$S_t^m = \rho_M S_{t-1}^M - \varepsilon_t^M$$

Shock to Monetary Policy (A33)

$$car_t = \varpi_{car} car_{t-1} + (1 - \varpi_{car})(\varpi_y y_t + \varpi_{cr} Adv_t) + \varepsilon_{car,t}$$

Capital Adequacy Ratio (A34)

$$rr_t = \nu_{rr} rr_{t-1} + (1 - \nu_{rr})(\nu_y y_t + \nu_{cr} Adv_t) + \varepsilon_{rr,t}$$

Total Reserve Requirement (A35)

$$err_t = \nu_{rr} err_{t-1} + (1 - \nu_{rr})(\nu_y y_t + \nu_{cr} Adv_t) + \varepsilon_{rr,t}$$

Excess Reserve Requirement (A36)

$$mrr_t = \nu_{mrr} mrr_{t-1} + (1-\nu_{rr})(\nu_y y_t + \nu_{cr} Adv_t) + \varepsilon_{mrr,t}$$

Minimum Reserve Requirement (A37)

***Equation of Systemic Risk***

$$SR_{ss}^B SR_{t+1}^B = \varphi_{SRB} SR_{ss}^B SR_t^B + \frac{Adv_{ss}^B SR_{ss}^B}{E_{ss}^B}[Adv_{t-1}^B - E_{t-1}^B + SR_t^F] - \frac{Adv_{ss}^B SR_{ss}^B}{E_{ss}^B}[Adv_{t-1}^B - E_{t-1}^B - SR_{t-1}^F]$$

Bank's Systemic Risk (A38)

$$SR_{ss}^{F} SR_{t}^{F} = \frac{E_{ss}^{F}(1-\phi_{EEF})}{E_{ss}^{F}}[E_{t-1}^{F} - E_{t}^{F} - E_{t}^{F}]$$

Firm's Systemic Risk (A39)

$$EE_{i,t+1}^{B} = Adv_{i,t}^{B} - E_{j,t-1}^{F} + [E_{j,t}^{F} - E_{j,t-1}^{F}]$$

Firms Equity (A40)

Where

$$EE_{t+1}^{B} = \tilde{E}_{i,t+1}^{B} - \varphi_{EB}\tilde{E}_{i,t}^{B}$$

Auxiliary Variables (A41)

And

$$EE_{t}^{B} = \tilde{E}_{i,t}^{B} - \varphi_{EB}\tilde{E}_{i,t-1}^{B}$$

## Data, Variables and Calibration

A large interest-free model uses 42 variables with 42 equations. All series of variables are nominal and logged, de-seasoned and demeaned. Quarterization is performed through R-Studio. For de-seasoning, E-views [Census X-12], is used. The demeaning process is performed with a 1-sided HP-Filter and E-Views, from which the series HP1S-CYCLE is used for estimation in Dynare.

As the dataset has to be of long duration, quarterization is unavoidable, for which the Denton (1971) method was used. The Denton procedure imposes the condition that the sum of interpolated series must be equal to the annual series. Data of variables included GDP, private consumption, investment, capital (total capital employed), labour, wages, prices, interest rate, inflation, government expenditure, central Bank policy rate, cost per unit, advances to Private Sector Firms, return to capital-related loans to private sector firms, money supply, M2, equity of non-financial companies, deposits of banks, excess reserve requirement ratio, minimum reserve requirement ratio, interest rate for deposits, interest rate on bank advances to private Sector, non-performing loans' ratio, capital adequacy ratio, equity of banks, wage expenses of non-financial companies, investment of banks in government securities and T-bills, interest rate on govt. Securities, borrowing from inter-bank market, interest rate on inter-bank advances, safe interest rate, central bank policy rate treasury bills rate and risk premium on bank advances. An indicator series of GDP and private

investment was used from Hanif et al. (2013). Quarterized data is provided by Tahir et al. (2018), Hanif et al. (2013), Kemal and Arby (2004), and Arby (2008). Only Hanif et al. (2013) show variation between quarters, but it ranges from 1972–73 to 2009–10. GDP MP at the current factor cost series is issued by the State Bank of Pakistan, SBP, in the Handbook year 2020. Investment series provided by SBP as private gross fixed capital formation (GFCF) at current market prices in millions was quarterized with Hanif et al. (2013).

### D1: Calibration of Prior Parameters

Most of parameters were adopted from Choudhri and Malik (2014), and Tufail and Ahmed (2019).

**Table 1**

*Prior Parameters of the Model*

| Prior Indicator | Value | Description of Prior Parameter | Source |
|---|---|---|---|
| C_Y | 0.77 | Long Term ratio of Consumption to GDP | 30 years average of data |
| I_Y | 0.15 | Long term value of Investment to GDP | 30 years average of Pak data |
| Ce_Y | 0.01 | Parameter value of Entrepreneurial consumption to GDP | Average of entrepreneurial earning of Non-financial companies |
| Sigma | 1.01 | Parameter of relative risk aversion | (Tufail & Ahmed, 2019) |
| Phi | 2 | Marginal dis-utility for supply of labor | (Tufail & Ahmed, 2019) |
| Alpha | 0.49 | Share of capital in production function | (Tufail & Ahmed, 2019) |
| Beta | 0.992 | Discount factor | (Tufail & Ahmed, 2019) |
| Delta | 0.03 | Annual depreciation rate12% annual | Literature |
| Rhoa | 0.91 | Productivity's parameter | (Tufail & Ahmed, 2019) |
| Psi | 1.01 | Elasticity of substitution between intermediate goods | Literature |
| Theta | 0.70 | Price stickiness parameter | (Tufail & Ahmed, 2019) |
| thetaW | 0.75 | Wage stickiness parameter | (Junior, 2016) |
| psiW | 21 | Elasticity of substitution between differentiated labors | (Junior, 2016) |
| phi_inf | 3.8 | Response to inflation | Literature |

| Prior Indicator | Value | Description of Prior Parameter | Source |
|---|---|---|---|
| phi_x | 0.8 | Response to Output | Literature |
| eta_k | 0.45 | LTV cap for firms | Literature |
| nu_y | 0.2 | Reserve Requirement Rule, Output | Literature |
| nu_adv | 0.2 | Reserve Requirement Rule, Credit | Literature |
| nu_err | 0.8 | Reserve Requirement Rule, Smoothing | Literature |
| omega_car | 0.8 | CAR Rule, Smoothing | (Doojav & Batmunkh, 2018) |
| omega_y | 0.5 | CAR Rule, Output | (Doojav & Batmunkh, 2018) |
| omega_adv | 0.2 | CAR Rule, Credit | (Doojav & Batmunkh, 2018) |
| psi_R | 0.75 | Interest rate smoothing | Near estimation of (Doojav & Batmunkh, 2018) |
| Rhom | 0.4 | Money supply parameter | Literature |
| chi_efp | 0.041 | Elasticity of EFP with respect to leverage | (Tufail & Ahmed, 2019) |
| theta_efp | 0.99 | Survival rate | Literature |
| theta_b | 0.6 | Calvo Bank Rate | (Doojav & Batmunkh, 2018) |
| beta_b | 0.878 | Banking Beta. Banker's discount rate | (Ramanauskas & Karmelavicius, 2018) |
| ROK | 0.1 | Steady state value of return to capital | 1/beta |
| phi_eeqf | 0.9 | Parameter of firm's equity | Literature |
| phi_r_n | 0.9 | Auxiliary variable Parameter for bank rate | As suggested in Dynare Forum |
| keta_b | 0.2341 | Bank equity parameter | Literature |
| phi_PkI | 4 | Curvature of adjustment cost function | Literature |
| Sunpost | 0.1 | Parameter for indeterminacy | Literature |
| Thet | 0.97 | Entrepreneurial survival rate | Stock Exchange Data of Quitting Firms |
| Gam | 0.03981 | Capital buffer financial cost parameter | (Ramanauskas & Karmelavicius, 2018) |
| Omeg | 0.7 | Average risk weight | Literature |
| epsil_d | 0.0041 | Portion of population holding bank deposits | Ratio of bank account holders to population |
| Kappa | 2 | Elasticity of substitution between deposits and investment | Literature |

| Prior Indicator | Value | Description of Prior Parameter | Source |
|---|---|---|---|
| Pse | 0.54 | Elasticity of capital utilization | Literature |
| Z_y | 0.01 | Proportion of output lost due to Capacity utilization | Literature |
| Kb | 0.2667 | Parameter of Lending rate | Literature |
| phi_npl | 0.9 | Non-Performing Loan Parameter | Literature |
| epsilon_npl | 0.01 | Auxiliary variable for NPLs | Literature |
| mu_1 | 0.5 | Cost of Funding for NPL | (Doojav & Batmunkh, 2018) |
| mu_2 | 0.5 | Cost of Funding for CAR | (Doojav & Batmunkh, 2018) |
| mu_3 | 0.5 | Cost of funding for Reserve Requirement | (Doojav & Batmunkh, 2018) |
| mu_4 | 0.5 | Cost of funding for Capital to Asset Ratio | (Doojav & Batmunkh, 2018) |
| nu_err | 0.8 | ERR rule, smoothing | (Doojav & Batmunkh, 2018) |
| nu_y | 0.2 | ERR rule, output | (Doojav & Batmunkh, 2018) |
| nu_adv | 0.2 | RR rule, Bank Advances | (Doojav & Batmunkh, 2018) |
| omega_car | 0.8 | CAR rule, smoothing | (Doojav & Batmunkh, 2018) |
| omega_y | 0.5 | CAR rule, Output | (Doojav & Batmunkh, 2018) |
| omega_cr | 0.2 | CAR rule, Credit | (Doojav & Batmunkh, 2018) |
| phi_Eb | 0.92 | Parameter for Bank Equity | Literature |
| phi_SR | 0.9 | Parameter for Bank's systemic risk | Literature |
| phi_SR_F | 0.9 | Parameter for Firm's systemic risk | Literature |
| phi_rd | 2.4 | Parameter of deposit rate | Literature |
| upsil_b | 1 | Parameter for Inter-bank Borrowing | (Dib, 2010) |
| a_b | 0.18 | Share of Govt. Securities in banks' assets | Long Term Share of Govt Securities |
| nu_b | 0.05 | Elasticity of interbank risk premium w.r.t. ratio of interbank borrowing to lending banks' risk-weighted assets | (Dib, 2010) |
| mu_b | 0.2 | 20% Haircut rate | Literature |
| Eta_cp | 0.25 | Elasticity of price of capital (Pk) w.r.t. investment rate | Literature |

| Prior Indicator | Value | Description of Prior Parameter | Source |
|---|---|---|---|
| a_cp | 0.25 | Ratio of quarterly investment to capital stock | Literature |
| b_cp | 1 | Price of capital Q denoted as Pk | Literature |
| gam_ifb | 0.4 | Profit sharing ratio for bank (40%) | Assumed |
| Zt | 0.025 | Rate of mudarabah on Savings | Quranic Principle |
| gam_rd | 0.6 | Profit sharing ratio for customer on bank deposits (60%) | Assumed |
| gam_CB | 0.3 | Parameter for Central Bank's use of reserve for investment of in banks based upon Profit Per Unity of Reserves(PPRU) | Literature |
| Krr | 0.4 | Reserve requirement ratio on current account deposits (40%) | Literature |
| phi_CB | 0.4 | Ratio of central bank's investment out of reserves | Assumed |
| phi_PPIU | 0.9 | Parameter for Profit per Unit of Investment by Bank | Literature |

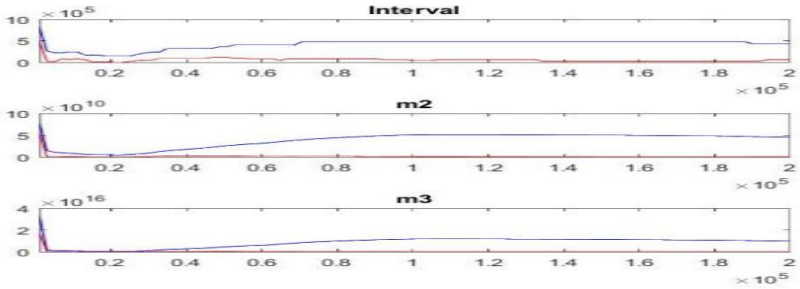
## Results and Discussions

### E1: Multivariate Convergence

Multivariate convergence, suggested by Brooks and Gelman (1998), is used as an evaluation criteria for DSGE models. Results, in fig 1, show that in 1st moment, Islamic model shows some convergence at least in the initial phase.

**Figure 1**

*Multivariate Convergence of Islamic DSGE Model*



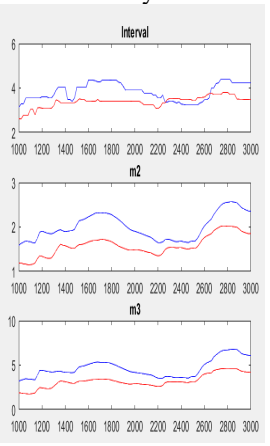
## E1.1 Multivariate Convergences of Other Models

Besides the large-scale Islamic DSGE model, all other models show convergence, though not to ideal levels. Yet the large conventional model exhibits more convergence. In specific, the basic model shows lesser convergence in the 2nd and 3rd moment, yet in the 1st moment, it shows better convergence. The second model, the basic conventional monetary policy model, shows good convergence in the first moment. The third model, basic conventional with money in utility, shows good convergence in the initial phase of the 1st moment and very good convergence in the initial phases of the 2nd and 3rd moments.

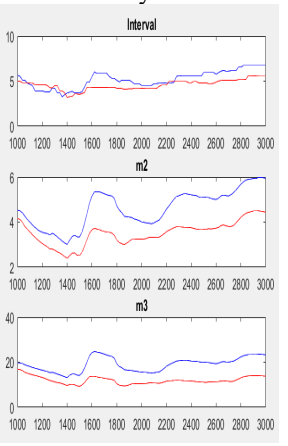
**Figure 2**

*Multivariate Convergence of Other Conventional Models*

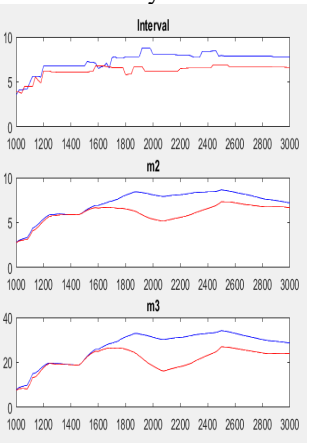
Basic Conventional Non-Monetary Model




Basic Conventional Monetary Model




Basic Conventional MIU Monetary Model




## E 1.2: Further Refinement in Convergence

As multivariate convergence is a matter of fitness of the model, we worked on it a little more. As JP Feifer, the team leader of the Dynare Forum, suggested to increase the number of draws to one million, because "if chains are not converged to the ergodic distribution, the results are meaningless".[5] So, it was tested in only first small model, the "Basic Conventional Non-Monetary Model", because of shortage of time. Results exhibit that both the blue and red lines converge and rise, making a chain in an ergodic

[5] See JP Feifer's comments in the Dynare Forum wherein a 'question on convergence diagnostics' he states that, "I would run chain with 1 million draws". https://forum.dynare.org/t/question-on-convergence-diagnostics/19460

distribution, in all three moments (m1, m2, and m3). This is a sufficient proof of the fitness of the model. It was not practiced in other models because it takes a very long time with one million draws. However, exhibiting successful convergence for one model should be considered for all.

**Figure 3**

*Multivariate Convergence to Ergodic Distribution for Model 1*

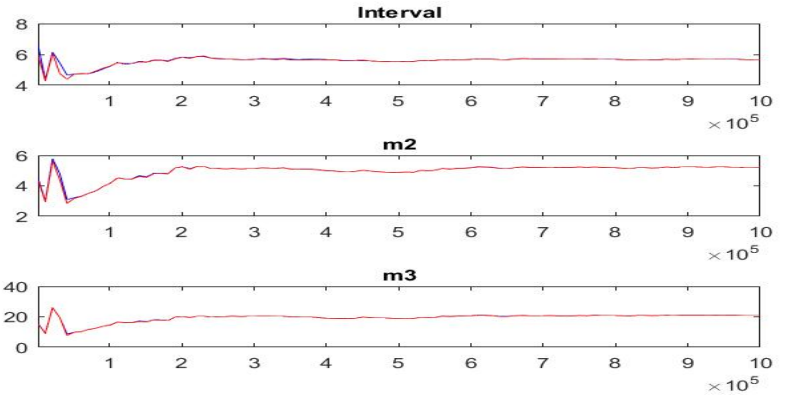
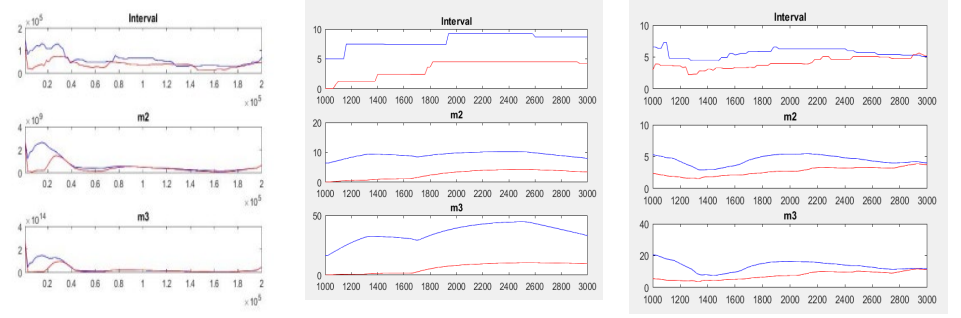



**Figure 4**

*Multivariate Convergence of Complete Conventional Model and Islamic DSGE Models*

| Complete Conventional Model | Islamic Monetary Policy (Money Growth and Profit Rate) | Islamic Monetary Policy (Money Growth and Profit Rate like Taylor Rule) |
|---|---|---|



With the same level of draws, the fourth model, the large conventional model, shows very good convergence from start to end in the 1st moment, yet a little less in the 2nd and 3rd moments. The fifth model, the Islamic monetary model (money growth and profit rate), shows very little convergence in all phases. The sixth model, Islamic monetary policy (money growth and profit rate as used in the Taylor rule), shows convergence at the end of all three moments.

**E3 Welfare Loss**

The welfare loss of four conventional and three Islamic models is computed by following Doojav and Batmunkh (2018), as given in Equation no. 51, with equal weights for output and inflation. JP Feifer, the Team Leader of Dynare Forum[6], referring to Gali[7], allows the computation of welfare loss for linear models. Welfare loss, based on the variance of variables, is also a sign of successful and complete computation of the DSGE models because it helps in the comparison of models. Dynare Forum suggests the comparison of models using variances of variables, so one can infer that the models' computation is successful and complete. Results of the models of the study show that welfare loss is reduced with monetary policy (model no. 2; as against the basic model, no. 1) while increasing with money in utility (model No. 3). Complete model No. 4 with banking and macro-prudential policy shows an equivalent value of welfare loss as the smaller monetary policy model No. 3. This exhibits that macro-prudential policies (CAR, MRR, and ERR), along with monetary policy, add to welfare gains as against basic model No. 1 and the model of monetary policy i.e. model No. 3.

Islamic models cannot reduce welfare loss, if compared with conventional models. This could be due to the model's design. A mere change of instruments may not reduce the welfare loss of Islamic DSGEs, hence, deep financial and monetary changes may be required.

[6] https://forum.dynare.org/t/how-to-analyze-welfare-loss-function/12615

[7] JP Feifer here refers to a model of Gali (2015), code of which can be retrieved from following link:
https://github.com/JohannesPfeifer/DSGE_mod/blob/master/Gali_2015/Gali_2015_chapter_4.mod

**Table 2**
*Computation of Welfare Loss*

| # | Model Title | $\omega_y Var Y^2$ | $\omega_\pi Var\pi^2$ | Total Welfare Loss |
|---|---|---|---|---|
| 1 | Basic Model without Monetary Policy | 0.042 | 0 | 0.042 |
| 2 | Basic Model with Monetary Policy | 7.12E-15 | 1.53E-78 | 7.12E-15 |
| 3 | Basic Model with Money in Utility and Monetary Policy | 2.14 | 6.57E-50 | 2.14 |
| 4 | Complete conventional model With accelerator, banking & macro-prudential Policy | 1.23E-06 | 5.84E-09 | 1.23E-06 |
| 5 | Islamic Monetary Policy (Money Growth and Profit Rate) | 4.69 | 3.46E-61 | 4.69 |
| 6 | Islamic Monetary Policy (Money Growth and Profit Rate like Taylor Rule) | 4.69 | 4.63E-62 | 4.69 |
| 7 | Islamic Monetary Policy (Profit Rate like Taylor Rule and usual Money Growth) | 4.69 | 4.76E-59 | 4.69 |

Variances of the models are retrieved from oo_var as suggested in a discussion of Dynare Forum by Mburr[8].

Three Interest-free monetary models are tested. The first model, no. 5, tests the money growth rate as a monetary policy tool, as suggested by Mirfatah et al. (2019), but our model adds the profit rate (as an exogenous variable) instead of the interest rate. Here employment gap is also added along with the output gap and inflation. The money growth rule is called the McCallum Rule. The second interest-free monetary formulation uses Money growth rate with lagged profit rate as an independent variable in a set of two equations, where the second equation uses profit rate as a Taylor type rule. Here, in the second equation, the profit rate (of non-financial companies) takes feedback from its own lag, inflation, employment gap, and output gap. It is noteworthy that all three interest-free models use two profit rates, one as the general rate (discount rate in the inter-temporal utility)

[8] See discussion of Dyanre Forum: https://forum.dynare.org/t/problem-about-welfare-loss-value/12804/4

and the other as the central bank's rate. In the second model, the future expected rate is used as the general rate. The third interest-free model uses the profit rate as a replacement for the central bank policy rate in Taylor rule setting without any other innovation. There is a minor difference in the welfare loss of all interest free models. However, interest free monetary models generate a higher level of welfare loss.

## E4. Posterior Parameters

Posterior parameters are generated in Dynare for the given prior values of parameters based on the fitness of the model against the data. Here, bayesian estimation is performed by Dynare. One aspect is to note that the value of zt, the parameter for mudarabah, is revised in the posterior as 0.0303 while it has to remain fixed at 0.025 because it is the rate of mudarabah (2.5% per year on savings) set by The Allah (Almighty) and cannot be changed by any human. So, it is suggested that Dynare provide an option where some of the parameters should not be revised and should remain constant. The author does not agree with this revision.

**Table 3**

*Prior VS Posterior Estimates of Large Islamic DSGE Model*

| Parameters | Prior mean | Posterior mean | 90% HPD | Interval | Prior Dist. | Pstdev |
|---|---|---|---|---|---|---|
| C_Y | 0.77 | 0.696 | 0.6303 | 0.7679 | Norm | 0.06 |
| Ce_Y | 0.015 | 0.0119 | 0.0096 | 0.0145 | Norm | 0.001 |
| I_Y | 0.15 | 0.1646 | 0.1416 | 0.1875 | Norm | 0.02 |
| sigma | 1.01 | 0.9798 | 0.9745 | 0.9951 | Gamm | 0.1 |
| phi | 2 | 1.899 | 1.6553 | 2.1521 | Gamm | 0.2 |
| alpha | 0.49 | 0.4265 | 0.3864 | 0.4607 | Beta | 0.05 |
| beta | 0.992 | 0.8128 | 0.633 | 1.0039 | Gamm | 0.09 |
| delta | 0.03 | 0.0289 | 0.0278 | 0.0298 | Beta | 0.003 |
| rhoa | 0.91 | 0.8442 | 0.7692 | 0.9332 | Gamm | 0.09 |
| psi | 1.01 | 1.1276 | 1.1241 | 1.134 | Gamm | 0.1 |
| theta | 0.7 | 0.6836 | 0.629 | 0.7446 | Beta | 0.075 |
| thetaW | 0.75 | 0.7589 | 0.545 | 0.9473 | Beta | 0.074 |
| psiW | 21 | 20.799 | 20.6425 | 20.9205 | Gamm | 0.2 |
| phi_inf | 3.845 | 3.8574 | 3.7056 | 4.0175 | Gamm | 0.2 |

| Parameters | Prior mean | Posterior mean | 90% HPD | Interval | Prior Dist. | Pstdev |
|---|---|---|---|---|---|---|
| phi_x | 0.8 | 0.7398 | 0.6312 | 0.8596 | Gamm | 0.08 |
| eta_k | 0.45 | 0.4564 | 0.426 | 0.4807 | Beta | 0.045 |
| psi_R | 0.75 | 0.8135 | 0.7728 | 0.8564 | Gamm | 0.09 |
| rhom | 0.4 | 0.4192 | 0.3501 | 0.5046 | Gamm | 0.09 |
| chi_efp | 0.041 | 0.0419 | 0.0398 | 0.0447 | Beta | 0.004 |
| theta_efp | 0.99 | 0.882 | 0.6745 | 1.0758 | Gamm | 0.09 |
| beta_b | 0.878 | 0.8695 | 0.7899 | 0.9193 | Gamm | 0.09 |
| ROK | 0.1 | 0.0746 | 0.0245 | 0.1283 | Beta | 0.02 |
| phi_eeqf | 0.9 | 0.924 | 0.7059 | 1.1308 | Beta | 0.09 |
| Phi_R | 0.9 | 0.832 | 0.8029 | 0.8555 | Beta | 0.09 |
| keta_b | 0.234 | 0.2517 | 0.2398 | 0.2621 | Beta | 0.02 |
| phi_PkI | 4 | 4.6354 | 4.4179 | 4.7865 | Gamm | 0.4 |
| sunpost | 0.1 | 0.0986 | 0.0859 | 0.1087 | Beta | 0.02 |
| thet | 0.97 | 0.9623 | 0.955 | 0.9653 | Beta | 0.09 |
| gam | 0.04 | 0.0355 | 0.034 | 0.0373 | Beta | 0.004 |
| omeg | 0.7 | 0.8924 | 0.8517 | 0.9318 | Gamm | 0.09 |
| epsil_d | 0.004 | 0.004 | 0.0035 | 0.0045 | Beta | 0.0004 |
| kappa | 2 | 2.4337 | 2.0725 | 2.7983 | Gamm | 0.2 |
| pse | 0.54 | 0.5214 | 0.4407 | 0.6192 | Beta | 0.054 |
| Z_y | 0.01 | 0.0097 | 0.0095 | 0.0099 | Beta | 0.001 |
| Kb | 0.267 | 0.2491 | 0.2316 | 0.2651 | Beta | 0.0267 |
| phi_npl | 0.9 | 0.781 | 0.6617 | 0.9124 | Gamm | 0.09 |
| epsilon_nnpl | 0.01 | 0.0098 | 0.0098 | 0.0099 | Beta | 0.001 |
| mu_1 | 0.5 | 0.406 | 0.3309 | 0.4583 | Gamm | 0.09 |
| mu_2 | 0.5 | 0.6172 | 0.4685 | 0.762 | Gamm | 0.09 |
| mu_3 | 0.5 | 0.4452 | 0.2187 | 0.6801 | Gamm | 0.09 |
| mu_4 | 0.5 | 0.4515 | 0.4118 | 0.5031 | Gamm | 0.09 |
| phi_PPIU | 0.9 | 0.9608 | 0.9573 | 0.9626 | Gamm | 0.09 |
| nu_y | 0.2 | 0.2061 | 0.1946 | 0.223 | Beta | 0.02 |
| nu_adv | 0.2 | 0.2202 | 0.1603 | 0.2777 | Beta | 0.02 |
| nu_err | 0.8 | 0.9954 | 0.9927 | 0.9968 | Gamm | 0.09 |
| omega_car | 0.8 | 0.882 | 0.7593 | 1.0039 | Gamm | 0.09 |

| Parameters | Prior mean | Posterior mean | 90% HPD | Interval | Prior Dist. | Pstdev |
|---|---|---|---|---|---|---|
| omega_y | 0.5 | 0.4102 | 0.377 | 0.45 | Gamm | 0.09 |
| omega_cr | 0.2 | 0.2114 | 0.1797 | 0.2402 | Beta | 0.02 |
| phi_Eb | 0.92 | 0.855 | 0.8512 | 0.8615 | Beta | 0.092 |
| phi_SR | 0.9 | 0.965 | 0.95 | 0.9932 | Beta | 0.092 |
| phi_SR_F | 0.9 | 0.778 | 0.7639 | 0.79 | Beta | 0.092 |
| phi_rd | 2.4 | 2.2746 | 2.2025 | 2.3694 | Gamm | 0.25 |
| upsil_b | 1 | 0.885 | 0.8652 | 0.8975 | Gamm | 0.1 |
| a_b | 0.18 | 0.165 | 0.1406 | 0.187 | Beta | 0.018 |
| nu_b | 0.05 | 0.053 | 0.0413 | 0.0652 | invg2 | 0.005 |
| mu_b | 0.2 | 0.2136 | 0.2117 | 0.2164 | Beta | 0.02 |
| Eta_cp | 0.25 | 0.208 | 0.2027 | 0.2108 | Beta | 0.025 |
| a_cp | 0.25 | 0.2531 | 0.2398 | 0.2705 | Beta | 0.025 |
| b_cp | 1 | 0.6895 | 0.6319 | 0.7968 | Gamm | 0.1 |
| gam_ifb | 0.4 | 0.4035 | 0.3821 | 0.4224 | beta | 0.04 |
| zt | 0.025 | 0.0247 | 0.0198 | 0.0303 | invg2 | 0.0025 |

## E5: Impact of Monetary Policy [interest free and interest based] on Macroeconomic Variables of Pakistan

Results of the simulation depicted in Fig. 9 suggest that ROE, the interest free rate of return for the central bank's policy, rises as a result of the shock to technology. But it goes from minus to zero and then stabilizes around zero. Though it is quite early to state the outcomes of interest-free models, it seems that it is a required result as the return to equity should not remain below zero, at least. The rise, as against the behaviour of the interest rate in the NK model, should cause a deterioration or instability of macroeconomic variables. It is why we need further work on the design of interest-free models in NK or RBC or other frameworks.

Besides, two conventional models; basic and financial accelerator, were assessed for comparison of the impact of monetary policy. Monetary policy is not assessed in the large model. It is because the scope of the study does not include the interaction of monetary and prudential policies. So, the results of basic and financial accelerator models, with monetary policy, are given below. It is noteworthy that Tufail and Ahmed (2019) assessed the same with financial accelerator, in the context of Pakistan, yet that study

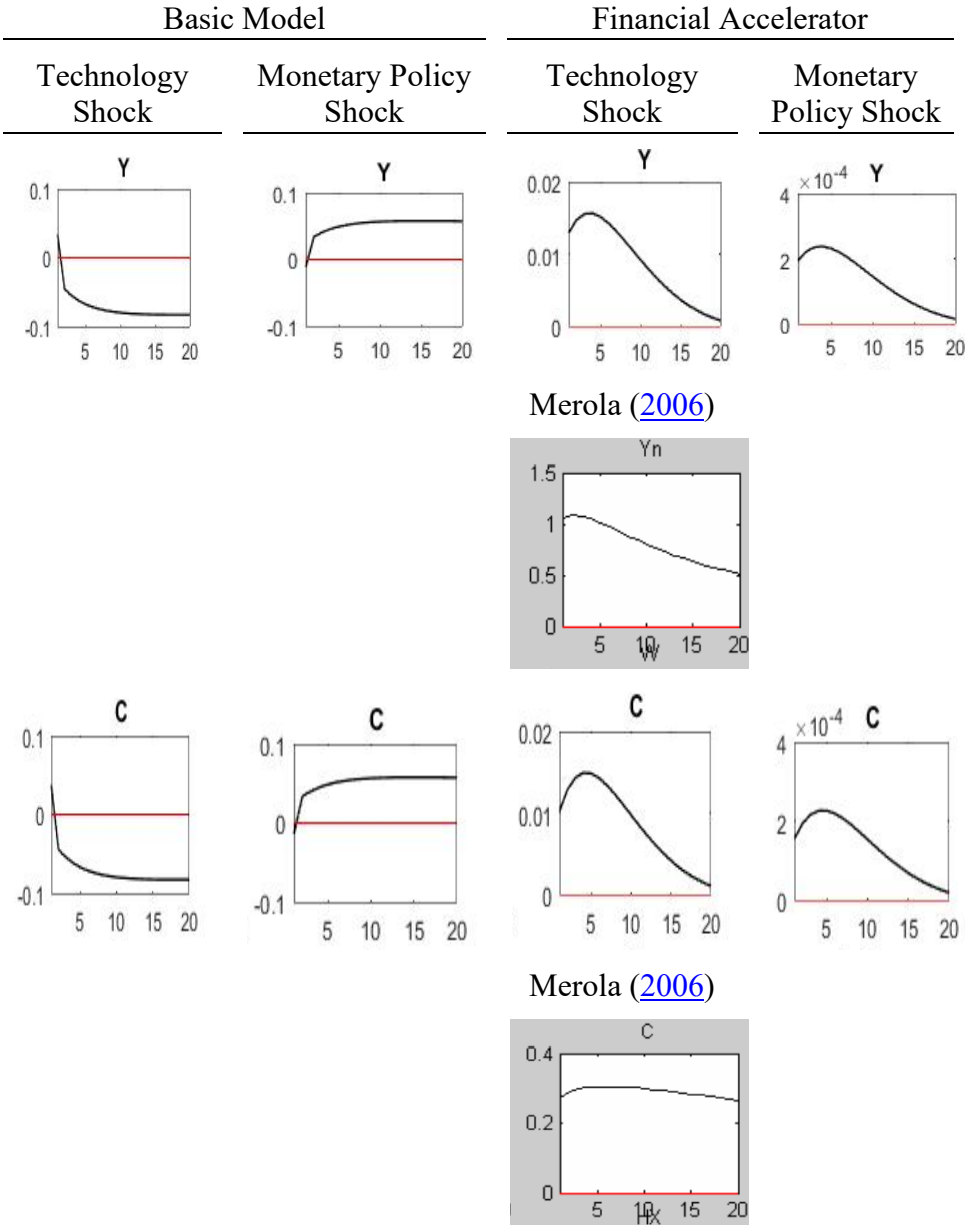
did not attempt to compare the impact of monetary policy in the case of financial accelerator, with the one without them, as worked out by Bernanke et al. (1999).

From the comparison of two shocks; technological and monetary policy, in Fig. 7, it is obvious that in both cases, with and without a financial accelerator, monetary policy has a positive impact on output, consumption, interest rate, capital, and wage inflation, but not on labour and wages. Most macroeconomic variables show a positive trend and a higher level of response due to technological advances in the financial accelerator model. This is in contrast to Tufail and Ahmed (2019), where, in the wake of monetary policy, output and other macroeconomic variables face a dip and then rebound, which is the usual behaviour of NK models.

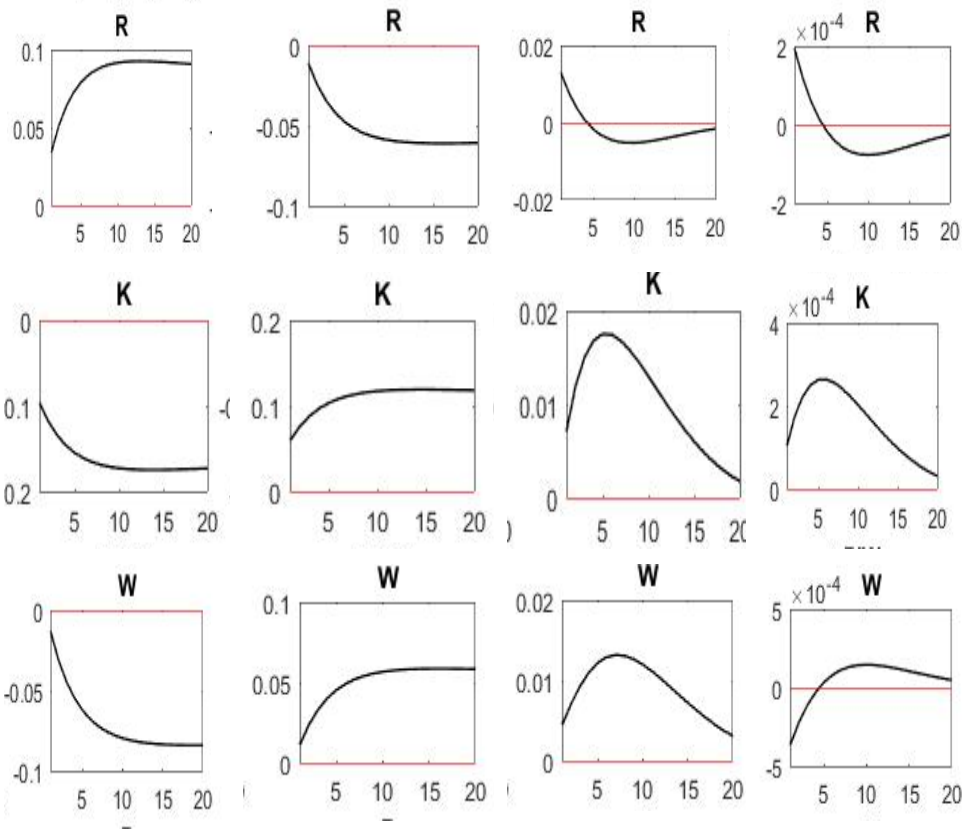
It is interesting to see, in Fig. 8, that the real economy (financial accelerator) reduces the impact of monetary policy while the non-real economic (basic) model keeps the macro-economic variables steady and stable after a sharp rise. It seems to be in line with the Keynesian negation of the quantity theory of money. Similar should be the Islamic economic view that a nominal increase in the quantity of money should lead nowhere. While comparing the results with other studies of financial accelerator, results for output, consumption, and wages are similar to those shown by Merola (2006) for the model without foreign currency denominated debt—technological shock in the non-tradable sector, which is also an NK financial friction model. So, the rising trend of output and other variables in the financial accelerator model against the typical NK behaviour of the basic model is justified. So, the same should be acceptable for Islamic models that are, in principle, real sector-based micro-founded financial accelerator models.

**Figure 5**

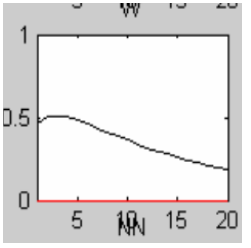
*Impact of Monetary Policy on Macro-Economic Variables*

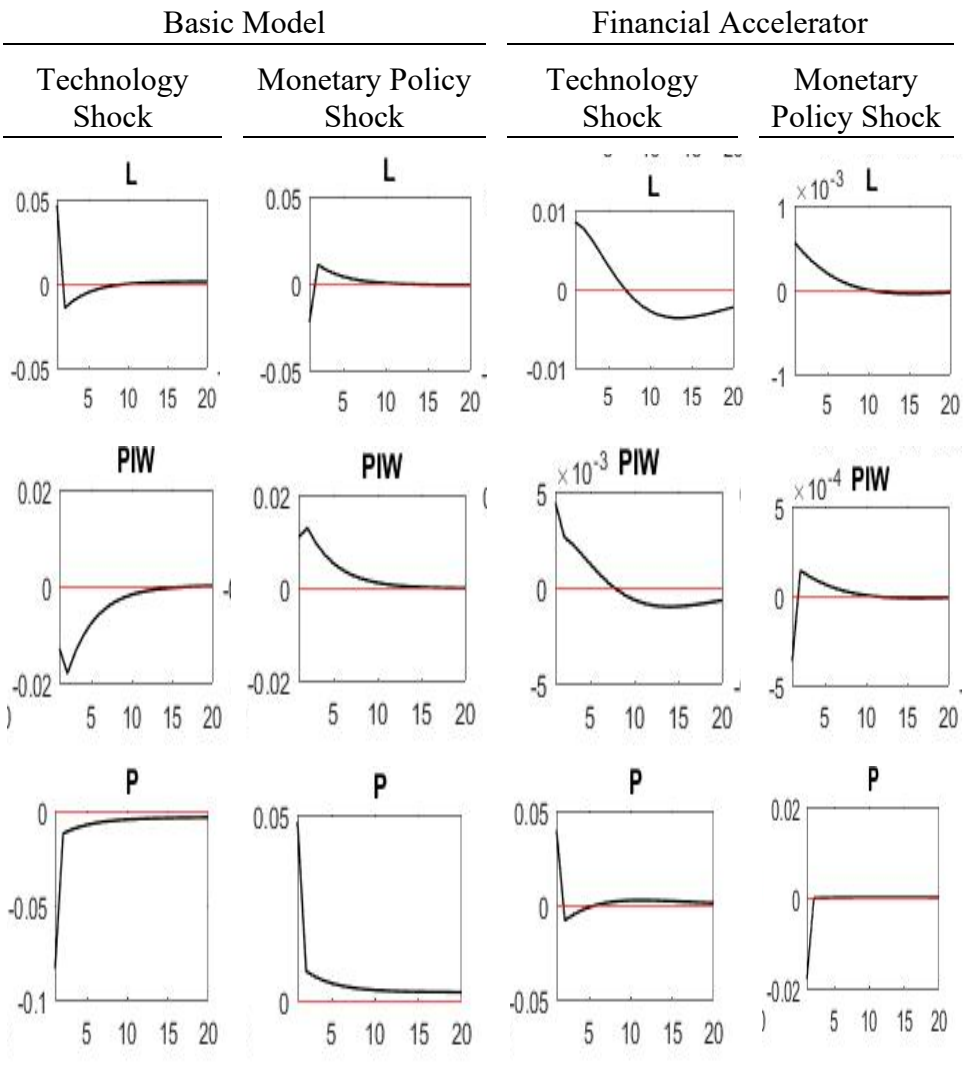


| Basic Model | | Financial Accelerator | |
|---|---|---|---|
| Technology Shock | Monetary Policy Shock | Technology Shock | Monetary Policy Shock |




Merola (2006)

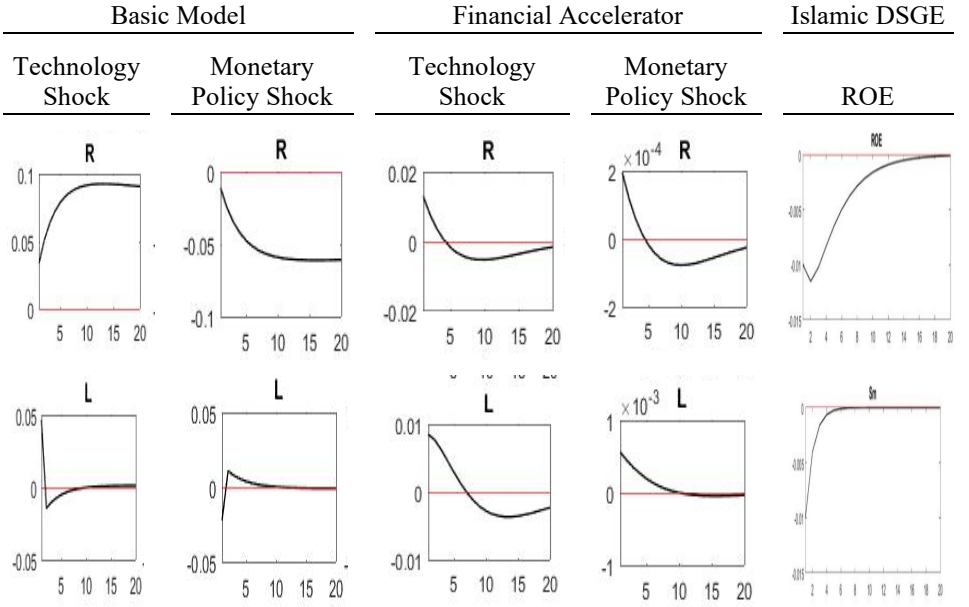





Dickens (2011), concluding Keynesian theory of monetary policy, suggests that interaction of investment multiplier, marginal efficiency of capital and interest rate, tend to generate unemployment. It is proven in fig 1 under technological shock in basic model. However, use of monetary policy instrument turns the labor into positive. But Fig 2 also shows that ROE, the Islamic rate of return to equity rises.

**Figure 6**

*Comparison of Models for Monetary Policy - Conventional VS Islamic Models*



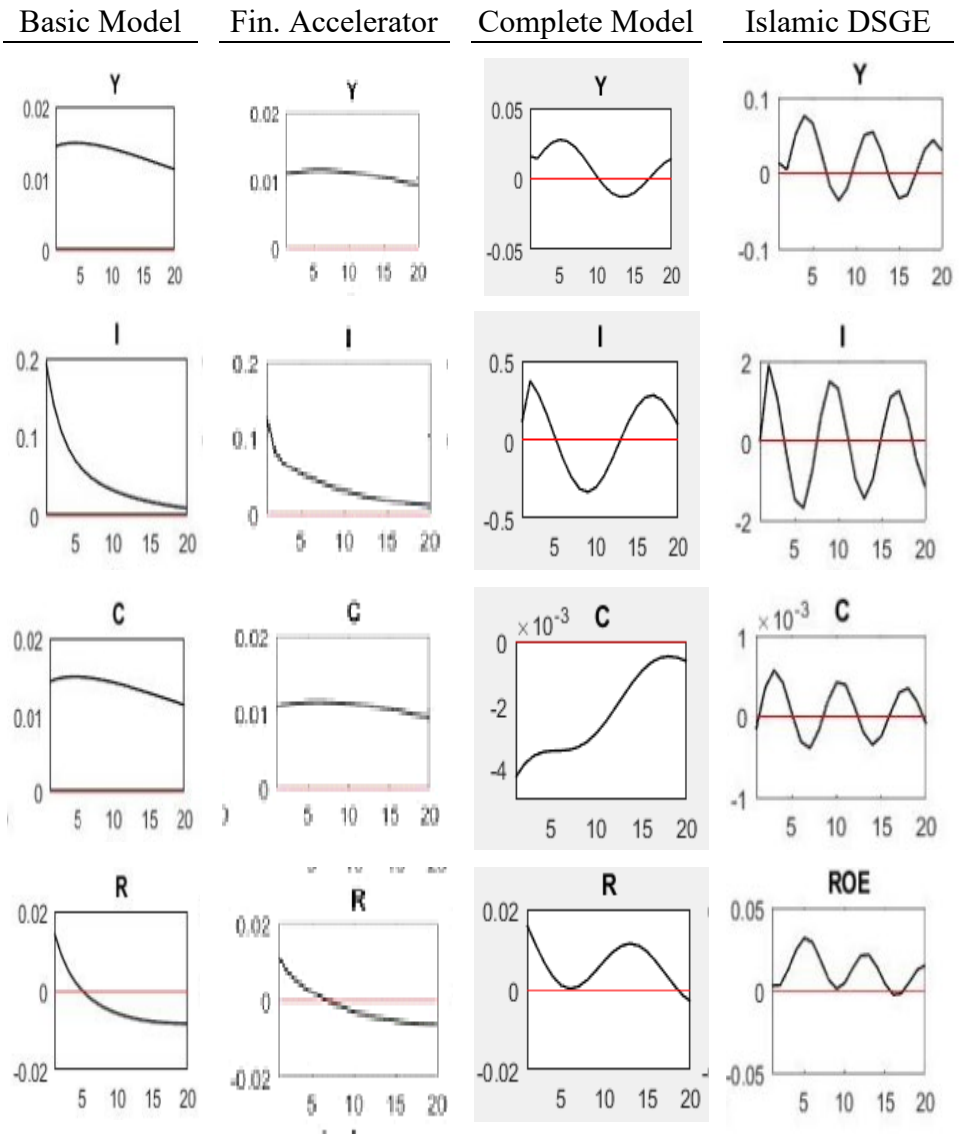

As per the study, where without monetary policy, interest rate rises, in the basic model, it keeps declining in the long run when monetary policy is conducted and employment is increased for more than 5 quarters. In the financial accelerator model, interest rate keeps downward trend. Here, credit provision by banks and the real economy pushes down the interest rate. Monetary policy moves the interest rate downward, so the impact on employment does not fade away until the 10th quarter. Both models exhibit that the Keynesian objective (dislodging the economy from a long run equilibrium position of unemployment to full employment) of monetary authority is achieved, as envisaged by Dickens (2011).

## E6: Shock to Technology

The basic conventional model, that follows Junior (2016), fits well with Pakistan's data. Its basic characteristics match the sticky wage new Keynesian model. The interest rate in the financial accelerator model follows Ortiz and Miyahara (2022), as a result of the TFP shock (see their Fig. 2).

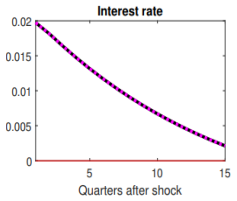
**Figure 7**

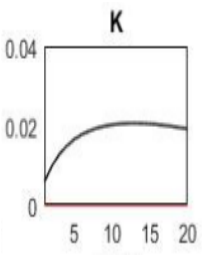
*Comparison of Models for Technology Shock*

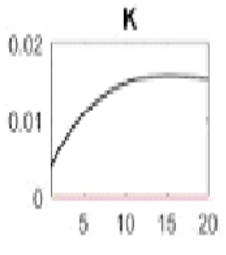


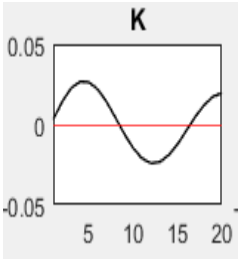

Ortiz and Miyahara (2022)

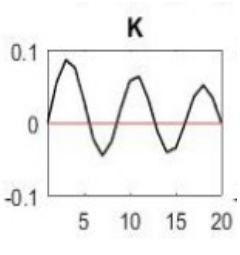
| Basic Model | Fin. Accelerator | Complete Model | Islamic DSGE |
|---|---|---|---|

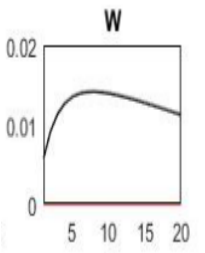


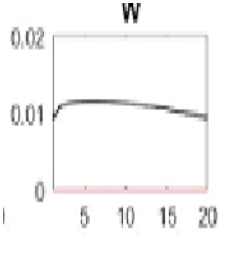



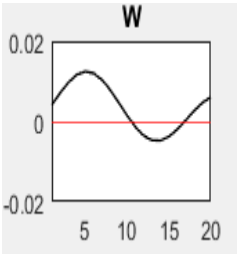



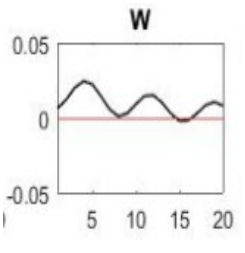



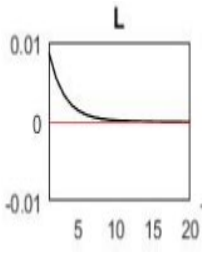



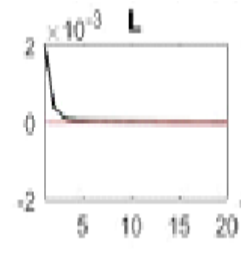



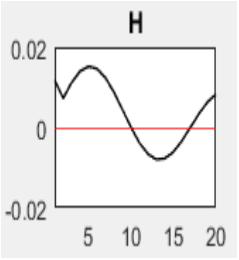



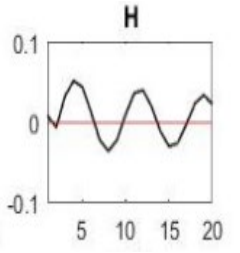



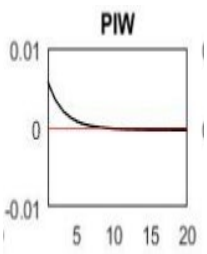



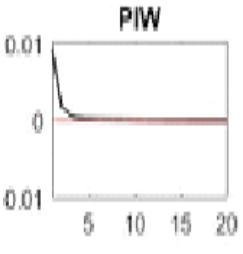



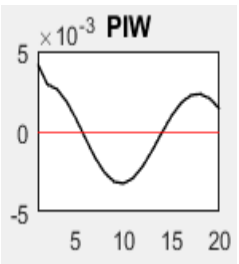



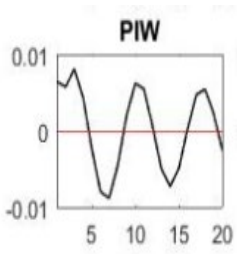



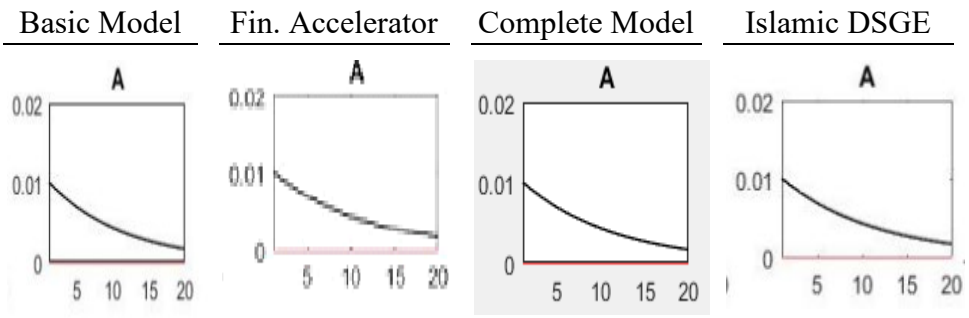



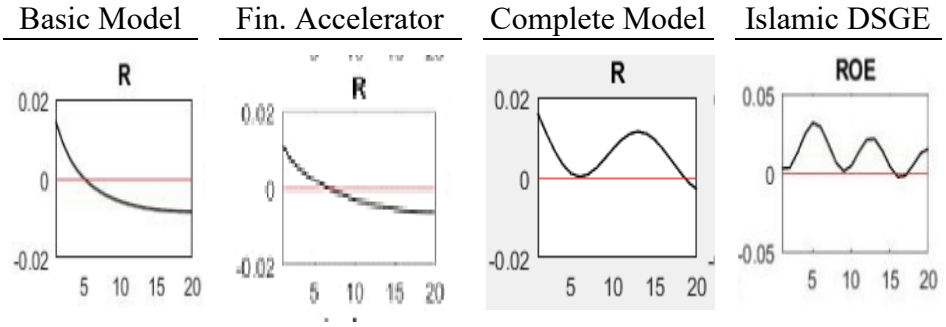



**E7. Interest Rate**

Interest rate keeps on declining in first two models while it adopts a cyclical pattern in the complete model, though keeps downward in the initial phase. It is, perhaps because of the financial intermediation that requires some longer term positive returns as in Ramanauskas and Karmelavicius (2018).

**Figure 8**

*Comparison of Models for Interest Rate*




ROE, the return on equity, the alternate to the policy rate, in Islamic model rises as against the conventional interest rate in conventional model that remains falling, in response to a 1% shock. Islamic DSGE setting gives a cyclical trend to the return on equity (ROE). It does not fall beyond zero level. Islamic one is more akin to the cyclical trend shown by Tufail and Ahmed (2019) for financial accelerator model for Pakistan.

**Conclusion**

The objective was to assess the macroeconomic impacts of shocks to the Islamic interest-free paradigm in a small closed economy in the NK sticky

wages and sticky prices DSGE setting. A large Islamic macro-financial DSGE model is developed, along with a complete conventional model, as well as a number of small models with and without monetary policy.

For the sake of comparison, the welfare loss of four conventional and three interest-free models was computed, where loss reduced with monetary policy while increasing with money in utility. The lower value of welfare loss for the large conventional model (with banking and policy), as compared to the basic model, exhibits effective financial stability policy. Interest-free monetary models cannot reduce the welfare loss if compared with conventional models. This could be due to the design of the model. The reason could be that a mere change of instruments may not reduce the welfare loss of Islamic DSGE models, so more work is required on interest-free DSGE models.

Multivariate convergence is also assessed for all models that show their fitness. Robustness of convergence of one of the models was assessed with a higher number of draws, which proved that chains exhibit an ergodic distribution and thus a higher level fitness.

The study also evaluated three interest-free rates of return as alternatives to interest rates: 1) return to capital employed of non-financial companies; 2) return to stock exchange investments by banks; and 3) a hypothetical rate of return to reserves as a policy rate, theorised by Khan and Mirakhor (1989). The large interest free banking model estimated with Pakistan's data was developed following the approach of Khan and Mirakhor (1989) in pursuing the reserves (of demand deposits) for investment in banks and then the rate of return to reserves as a monetary policy tool. A shift to an interest free regime of entrepreneurs, banking, central banking, and policies seems workable, given the model assumptions of NK with sticky wages and sticky prices. Zakat deduction is also suggested with appropriate incidence. The Islamic model shows a little less convergence, so the fitness of the model is reduced. Innovations in the interest-free model are many. First one is inclusion of the share in profit or loss between bank and entrepreneur, as suggested by Khan and Mirakhor (1989). It was not used in any model in DSGE settings, that too with the financial accelerator and banking. Another innovation is the sharing ratio of profit or loss between banks and central banks in exchange for reserves invested in bank's equity. Besides, financial frictions with Islamic spirit, wherein ROCE, the rate of return to capital employed, is a new idea. Another aspect is the development of an interbank

market for the Islamic DSGE model. The replacement of the rate of return on the stock exchange (ROR_SE (+1)), as a general rate against the interest rate for discounting in consumption and other related computations is also an innovation. In prior, it was hinted at using the ROR as an alternate rate, but its practical use, too, in the financial accelerator model of Islamic DSGE is quite suggestive for future calculations for Islamic financial models. Besides, computing the monetary policy with the return to equity of the bank (ROE) with investments from the central bank under the mudarabah contract is an innovation. The computation of the rate of return to equity of banks, as theorised by Khan and Mirakhor (1989), should be counted as a milestone for central banking. It should be an instrument for Islamic monetary economics, with the use in DSGE.

The study also devised a risky contract with a probability of default by the entrepreneur for Islamic macrofinance. The default amount has to be paid out of bank advances, and not out of the defaulting entrepreneur's assets. Conventional financial accelerator computes risky contracts, but, in case of default, despite the default, it has to be paid by entrepreneur, which results in the closure of the economic organization and the liquidation of business assets.

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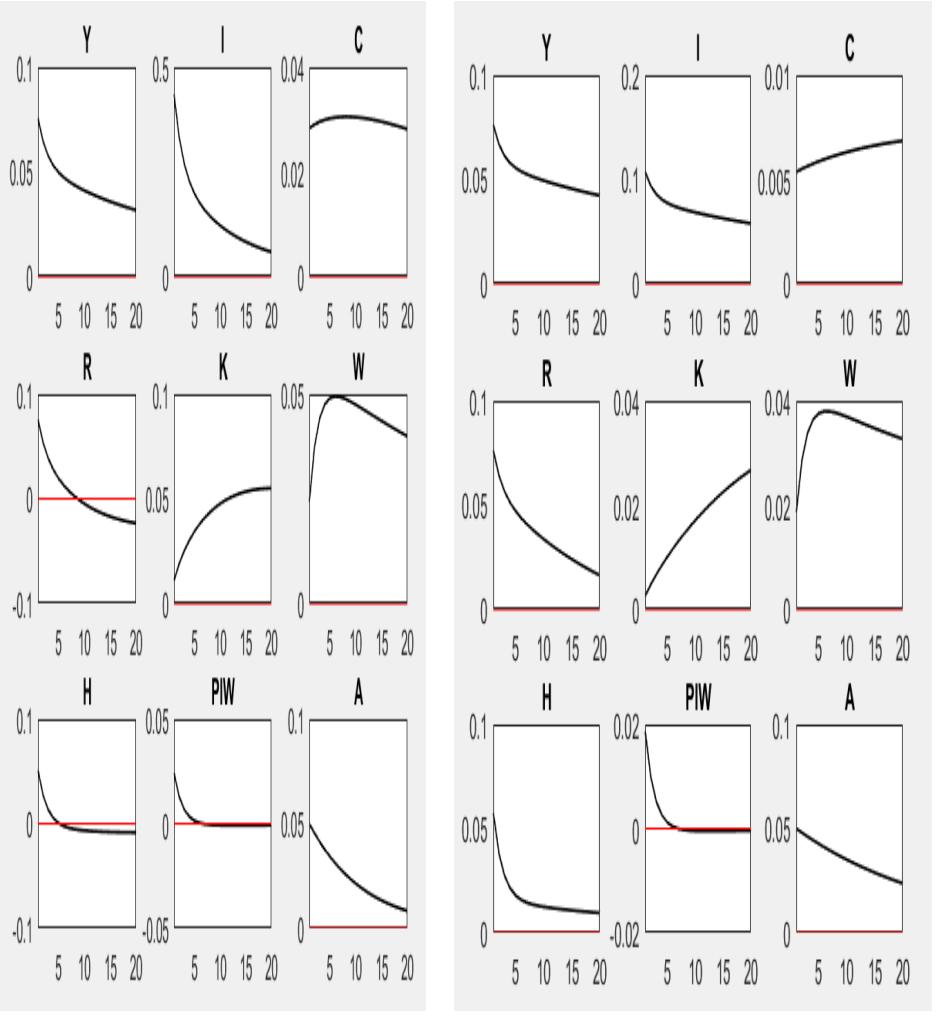
## Annex 1: Results of Conventional Non-Monetary Model

Observed and unobserved IRF of one of conventional monetary policy model are shown in the figure given below. Investment, consumption, interest rate, employment and technological progress show better response in the observed data of Pakistan.

**Figure 9**

*Observed vs Unobserved IRFs of Small Monetary Model*

Conventional Unobserved IRFs | Conventional Observed IRFs



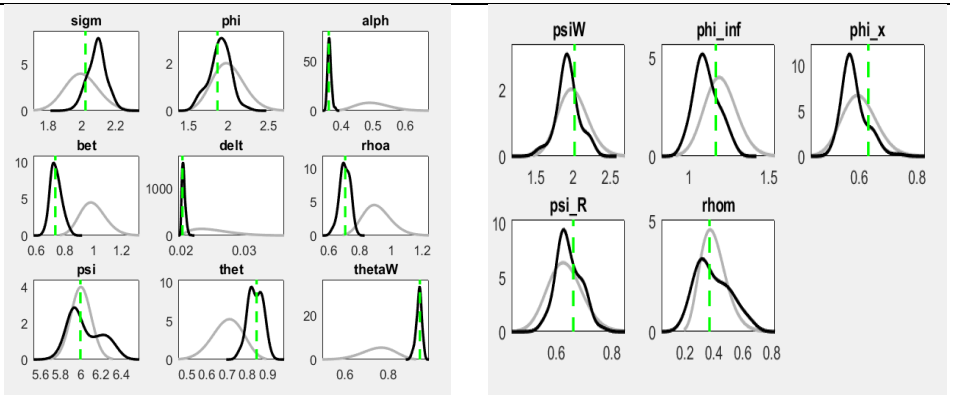
## Annex 2: Priors and Posteriors

Priors vs posteriors of conventional and interest-free models are given in the Fig below. Posteriors are shaped in a better way with one single peak point.

**Figure 10**

*Priors & Posteriors of Conventional & Islamic Monetary Model*

Priors & Posteriors: Conventional Monetary Model




Priors & Posteriors: Islamic Monetary Model