Uncovering Time Variation in Public Expenditure Multipliers: New Evidences

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Abstract

The paper provides fresh evidence on the dynamics of public expenditure multipliers and the factors explaining them. The findings of this paper will facilitate the policymakers in effectively framing fiscal policy to expedite economic stabilisation and uplift economic growth. The study proceeds with computing the time-varying public expenditure multipliers by employing the TVP-VAR model on the Indian quarterly dataset between the period 1997Q1 to 2019Q4. In the next stage, it pursues to examine the role of structural factors in explaining the time-variation in public expenditure multipliers. The empirical investigation reveals the heterogeneity in time-varying transmission and effectiveness of revenue capital and total expenditure shocks. The study further finds the adverse effects of fiscal instability and trade openness on public expenditure multipliers. In contrast, financial development and a larger propensity to consume enhance the public expenditure multiplier values. Withal structural factors have consequential effects on public expenditure multipliers in the long run and medium run. In the short run, the direction of structural factor's impact on public expenditure multipliers is in line with long run multipliers, although their impact turns insignificant.

JEL Classification: E62, C32, C11

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1. Introduction

The different macroeconomic schools cling to diverging views on the aptness of fiscal policy intervention for stabilising economic activity and boosting economic growth. The propagators of the free-market economy postulate the neutrality of fiscal policy on real economic variables. In contrast, Keynesian economists advocate the use of fiscal policy for stabilising business cycle fluctuations. With Keyne's renowned general theory of employment, fiscal policy has become a prominent area of research in macroeconomics.

A large strand of literature has documented the Keynesian impact of fiscal policy shocks on economic output via different transmission channels (see Aiyagari, 1992; Baxter et al., (1993); Edelberg et al., 1999). However, the Keynesian effects of fiscal policy expansion can be curtailed by the crowding out of private consumption at humungous levels of public debt in the economy (See Sutherland (1997)). In light of this, Perotti (1999) empirically discovers the positive effects of fiscal consolidation on private consumption expenditure in OECD economies and attributed this queer finding to the shrivelled fiscal stress which sequel the fiscal consolidation in these economies. The studies persuaded by the works of Sutherland (1997) and Perotti (1999) unanimously find the detrimental effect of fiscal stress on fiscal multipliers.

With fiscal stress, the studies have simultaneously discovered the fiscal multipliers to be contingent on financial development and trade openness (see Kirchner et al., 2010; Ilzetzki et al., 2013; Hory, 2016; Koh, 2017; Borsi, 2018; McManus, 2021). Furthermore, in their seminal work, Auerbach (2012) brings light to the counter cyclicality of fiscal multipliers. Kirchner et al. (2010) and Glocker et al. (2019), complementing Auerbach (2012), unveil the time variation in fiscal multipliers.

The aforementioned studies discussing the dynamics of fiscal multipliers and factors affecting them are concerned with advanced economies. On the contrary, non-linearities of fiscal multipliers have been inadequately investigated in emerging economies. The emerging economies differ from advanced economies in terms of fiscal space, trade openness, central bank autonomy and consumption patterns. Therefore, it becomes imperative to inquire whether the non-linearities in fiscal multipliers and their sources spotted in advanced economies will uniformly resemble the emerging economies or not? In light of this, the study scrutinises the dynamics associated with fiscal multipliers in the Indian scenario.

The paper builds upon the work of Hory (2016) and Koh (2017), who cross-sectionally analogies the PE multipliers in advanced and emerging economies and probe the factors which explain the disparity between them. In contrast, this study assimilates the time variation of PE multipliers in an emerging economy and contemplates the factors which explain this time variation. The paper's research design complies with the work of Kirchner et al. (2010), Berg (2016) and Glocker et al. (2019). These studies employ the Time-Varying Parameter Vector Autoregressive (TVP-VAR) model and its extensions to capture the time variation in PE multipliers and Bayesian regression subsequentially to analyse how different economic factors explain the time variation.

The studies centring on PE multipliers in the Indian economy are predominantly confined to their linear estimation. Given that the adequate literature suggests the PE multipliers being time-varying and contingent on different economic conditions, its linear estimation may lead to deceptive results and unavailing policy decisions. The TVP-VAR model will yield more precise values of PE multipliers than their linear counterparts as it reckons with the nonlinearities commencing from prevailing economic conditions at each point of time while estimating them. To the best of our knowledge, this study will be the first in the emerging economies context to estimate the time-varying PE multipliers and capture their driving forces. It will assist the policymakers in India and other emerging economies' alike India in identifying and improving the economic conditions and factors which culminate the PE multipliers.

The novelty of Kirchner et al. (2010), Berg (2016) and Glocker et al. (2019) resides in computing the time variation in the government's total expenditure multiplier and identifying the factors explaining it. Glocker et al. (2019) pointed toward future research extensions on the disparity in time-varying transmission and the effectiveness of the different components of PE shocks. The various studies on transmission and effectiveness of fiscal stimulus with one accord find them to be conditioned on the choice of fiscal instrument used for giving the stimulus. In particular, the fiscal stimulus via capital expenditure shock is found to have a more pronounced effect on economic activity than the revenue expenditure shock. With this, we can envisage the time-variation in transmission and effectiveness of PE shock to differ with the composition, i.e. between revenue, capital and total expenditure shock

The paper extends Kirchner et al. (2010) and Glocker et al. (2019) work and adds to global literature on fiscal multipliers by addressing the disparity in time-varying effectiveness of revenue, capital and total expenditure shocks and their determining factors. Withal the study inspects how dynamics concerning the time-variation in PE multipliers are conditioned on the period at which they are calculated (i.e. short run and long run). This study further stands novel by empirically estimating the marginal propensity to consume for domestic goods and examining its impact on the multipliers.

The study carries out the econometric analysis in two stages. The first stage employs the (TVP-VAR) model with stochastic volatility to comprehend the dynamic transmission of revenue, capital and total expenditure shocks. With the TVP-VAR model, we fetch the time-varying impulse responses of PE shocks and then use them to compute the time-varying PE multipliers. Similarly, we compute marginal propensity to consume for domestic goods ($\mathrm{MPC}^{\mathrm{DG}}$) which is subsequentially utilised in examining its impact on multipliers.

In the second stage, Bayesian regression has been used to investigate the impact of structural factors on the long-run and short-run PE multipliers. Given that there are enormous studies concerning the effect of structural factors (fiscal stability, automatic stabilisers, $\mathrm{MPC}^{\mathrm{DG}}$, financial development and trade openness) on PE multipliers, the study investigates how these factors explain the time-variation of PE multipliers in the Indian scenario.

The empirical results manifest the time-variation in transmission and effectiveness of the PE shock to significantly vary with its composition. The total expenditure multiplier follows the inverted U shape; it peaks in the global financial crisis (GFC) and slackens thereafter. At the same time, the capital expenditure multiplier keeps up a similar pattern with the total expenditure multiplier till 2013 and resurges afterwards. In contrast, the revenue expenditure multiplier remains time-invariant till GFC and declines thereafter.

Fiscal instability and trade openness downsize the PE multipliers, whereas financial development and MPC^{DG} amplifies them. The effects of fiscal instability, trade openness, and MPC^{DG} on PE multipliers are congruous to the literature. Whereas the effect of financial development on PE multipliers is in line with Koh (2017) and contrary to the studies on developed economics by Kirchner et al. (2010), Borsi (2018) and McManus (2021). The structural factors hold significant effects on PE multipliers in the long and medium run. In contrast, the effects of structural factors on PE multipliers turn insignificant in the short run.

The remaining paper is structured as follows: the second section details data and econometric methodology. The third section uncovers time variation in transmission and the effectiveness of public expenditure shocks. The fourth section tests convergence diagnostics. The robustness of computes PE multipliers and $\mathrm{MPC}^{\mathrm{DG}}$ is verified in the fifth section. The sixth section studies the driving forces of PE multipliers. The seventh section validates regression results with robustness checks. The last section concludes the study.

2. Data and Methodology

2.1 Data

The quarterly dataset of variables covering the period 1997Q1 to 2019Q4 has been used for carrying out the econometric analysis. Table 1. specifies the description and sources of the variables.

2.2 Time-Varying Parameter Vector Autoregressive Model with Stochastic Volatility

The TVP-VAR model with stochastic volatility developed by Primiceri (2005) advances the linear VAR model by allowing the coefficients and variance-covariance matrix to vary over time. The econometric specification of the TVP-VAR model with stochastic volatility, as given in Primiceri (2005), is as follows

$$X_t = A_{0,t} + A_{1,t}X_{t-1} + A_{2,t}X_{t-2} + \ \dots\dots A_{P,t}X_{t-P} + u_t$$

$$u_t \sim N(0, \Sigma_t)$$

X_t is the vector of endogenous variables and $A_{i,t}$ is the time-varying coefficient matrix for ith lag. The coefficient parameters are stacked as $\Theta_t = vec(A_t')$ where $A_t = [A_{0,t}, A_{1,t}, \ \dots\dots A_{p,t}]$ and $vec(.)$ is the column stacking operator. The error term u_t follows the normal distribution with mean zero and time-varying variance-covariance matrix Σ_t. The error term structure can be written as $u_t = S_t e_t$, where $E(e_t e_t') = I \ and \ E(e_t e_{t-k}') = 0$ for all values of t and k. Here matrix S_t satisfies the equation $S_t S_t' = \Sigma_t$.

Table 1. Description of Variables

Variable	Definition	Source
Gross Domestic Product(GDP) Private consumption Expenditure (CON) Imports (Imp)	These variables are taken at the constant price at the base year (2011). They have been seasonally adjusted using the Census XII method and then taken in logarithmic form.	RBI Handbook of Indian Economy
Revenue Expenditure Total Expenditure Capital Expenditure	The monthly data of these variables is taken and then aggregated at the quarterly level. These variables have been deflated using the Whole Sale Price Index (WPI). Further, They have been seasonally adjusted using the Census XII method and then taken in logarithmic form.	The data has been taken from the CIEC database, and the primary data source is CAG reports.
Inflation	The Inflation rate is calculated using the WPI	Authors calculation. The data for WPI at base year is taken from the RBI Handbook of Indian Economy
Weighted Average Call Money Rate (Interest)	The monthly data of this variable is taken and then averaged at the quarterly level.	RBI Handbook of Indian Economy
Debt-GDP Ratio	Debt is deflated with WPI and seasonality adjusted using the Census XII method. After that, its ratio is taken with GDP at a constant price.	Authors calculation. The data on Public Debt is taken from CIEC. Its primary source is Ministry of Finance reports.
Credit-GDP Ratio	The Credit-GDP ratio Gap is taken	Bank for International Settlements
Imports-GDP Ratio	Proxy for Trade Openness	Authors Calculation
Government Expenditure-GDP Ratio	Proxy for Automatic Stabilisers	Authors Calculation
Marginal Propensity to Consume	Computed in TVP-VAR setup.	Authors Calculation

Note: This table details the description of variables and sources from where they are collected.

The variance-covariance matrix structure Σ_t is decomposed with the triangular reduction as $F_t^{-1} \Sigma_t F_t'^{-1} = D_t$. Here D_t and F_t^{-1} are diagonal and lower triangular matrix comprising variance and covariance parameters. The elements of $D_t^{1/2}$ are stacked in vector σ_t. $\phi_{i,t}$ is a column vector with the non-zero element of (i+1)-th row of F_t^{-1}.

The vector of the VAR coefficient parameter Θ_t, covariance terms $\phi_{i,t}$ and log of variance terms σ_t follows the driftless random walk.

$$\Theta_t = \Theta_{t-1} + \omega_t \tag{2}$$

$$log\ \sigma_t = log\ \sigma_{t-1} + \varsigma_t \tag{3}$$

$$\phi_{i,t} = \phi_{i,t-1} + \vartheta_{i,t}\text{s} \tag{4}$$

The vector of shocks $[u_t, \omega_t, \varsigma_t, \vartheta_{i,t}]$ is normal and independently distributed with mean zero and variance-covariance matrix V_t. Here V_t is the block diagonal matrix with Σ_t, Ω, Ξ and Ψ_i as blocks. The study uses information criteria from linear VAR to decide the lag length for estimating the model. The specification and ordering of variables under X_t in equation (1) is reported in Table 2. The first three specifications are used to estimate PE multipliers, and the last two specifications compute MPC^{DG}.

2.2.1 Structural Identification

The paper adheres to Blanchard et al. (2002) and imposes the following restrictions for the structural identification of the government expenditure shocks. The shock in other variables does not affect PE contemporaneously. GDP responds instantly to PE shock and with lags to the other variables. Whereas Inflation responds contemporaneously to shock in PE, GDP and with a lag to other variables. At last, all the variables impact the interest rate contemporaneously. The similar restrictions have been imposed to identify the CON and Imp shocks.

Table 2: Model Specification

Specification	Ordering of Variables
Specification 1	[REV, GDP, Inflation, Interest]
Specification 2	[TOT, GDP, Inflation, Interest]
Specification 3	[CAP, GDP, Inflation, Interest]
Specification 4	[CON, GDP, Inflation, Interest]
Specification 5	[Imp, GDP, Inflation, Interest]

Note: Variables in different specifications of X_t are arranged in the order mentioned in the second column of the Table

3.2.2 Estimation of TVP-VAR Model

Given the high dimensionality of the parameters σ_t, ϕ_t, θ_t, Ω, Ξ, Ψ_i in the TVP-VAR model, Bayesian Methods are employed to estimate the model. The study employs Normal and Inverse Wishart data-based priors and uses Gibbs sampling for the posterior estimation of the parameters.

The prior distribution of the parameters of the TVP-VAR model is based on the OLS estimate of the time-invariant VAR model. The past studies in the literature calibrate the prior on OLS estimate of linear VAR from the initial training sample. This training sample is later discarded in the posterior simulation. However, given the small sample size of the Indian economy, the study follows Canova et al. (2009) and utilises the entire sample to calibrate the prior and carry out the posterior simulation.

$\hat{\Theta}, \hat{V}_{\Theta}$ $\hat{\phi}_i$ and $\hat{V}_{\phi_i}$are based on the OLS estimates of the time-invariant VAR. The study sets $\underline{\Omega}$ = $\underline{\rho_1}\lambda_1\hat{V}_{\Theta}$, $\underline{\Xi}$ = $\underline{\rho_2}\lambda_2 I_n$, and $\underline{\Psi_i} = \underline{\rho_{3i}}\lambda_3\hat{V}_{\phi_i}$. Here, $\underline{\rho_1}$ and $\underline{\rho_2}$ equals no of rows of $\underline{\Omega}$ and I_n plus one respectively and $\underline{\rho_{3i}}$ equals i+1 for i = 1, 2, …., n-1. Table 3. mentions the prior distribution of the parameters, whereas the details of prior hyperparameters λ_1, λ_2, and λ_3 are discussed in the robustness section.

Table 3 Prior Distribution of the Parameters

Parameters		Distribution
Θ_0	~	$N(\hat{\Theta}, \hat{V}_\Theta)$
$log\ \sigma_0$	~	$N(log\ \hat{\sigma}_0, I_n)$
$\phi_{i,0}$	~	$N(\hat{\phi}_i, \hat{V}_{\phi_i})$
Ω	~	$IW(\underline{\Omega}, \underline{\rho_1})$
Ξ	~	$IW(\underline{\Xi}, \underline{\rho_2})$
Ψ_i	~	$IW(\underline{\Psi_i}, \underline{\rho_3})$

Note: N(a, b) refers to the Normal distribution with mean a and variance-covariance matrix b. IW(c, d) refers to the Inverse-Wishart distribution with scale matrix c and degrees of freedom d.

The Gibbs sampler takes out sixty thousand draws in total and drops the initial fifty thousand draws as the burn-in sample. With the leftover, every tenth draw is taken to avoid the autocorrelation in the chain, and the remaining thousand draws are used for further analysis. The Gibbs sampling and estimation procedure are given in the Appendix.

3. Uncovering the Time-Variation

3.1 Time-Varying Transmission of Public Expenditure Shocks

The time-varying impulse responses facilitate us in examining the dynamics associated with the transmission of PE shocks to other economic variables. The median impulse responses of the thousand draws have been reported in Figure 1. All the PE's respond positively to their respective shocks till the third quarter and converge to zero afterwards. The response of PE to their respective shocks stays nearly time-invariant.

The revenue expenditure shock boosts aggregate demand and raises inflationary concerns in the economy. In contrast, the capital expenditure shock enhances productive capacity and curtails inflation in the economy. The contrasting effects of revenue and capital expenditure shocks on inflation are reflected in the second row of Figure 1. Inflation's response to the revenue expenditure shock remains nearly time-invariant. On the contrary, the adverse effects of capital expenditure on inflation have continuously intensified post-2002.

The total expenditure shock negatively impacts inflation in the initial quarters. However, the negative impact turns positive post fourth quarter and settles to zero post tenth quarter. The response of Inflation to the total expenditure shocks follows the inverted U shape; it peaks around 2008 and falls thereafter.

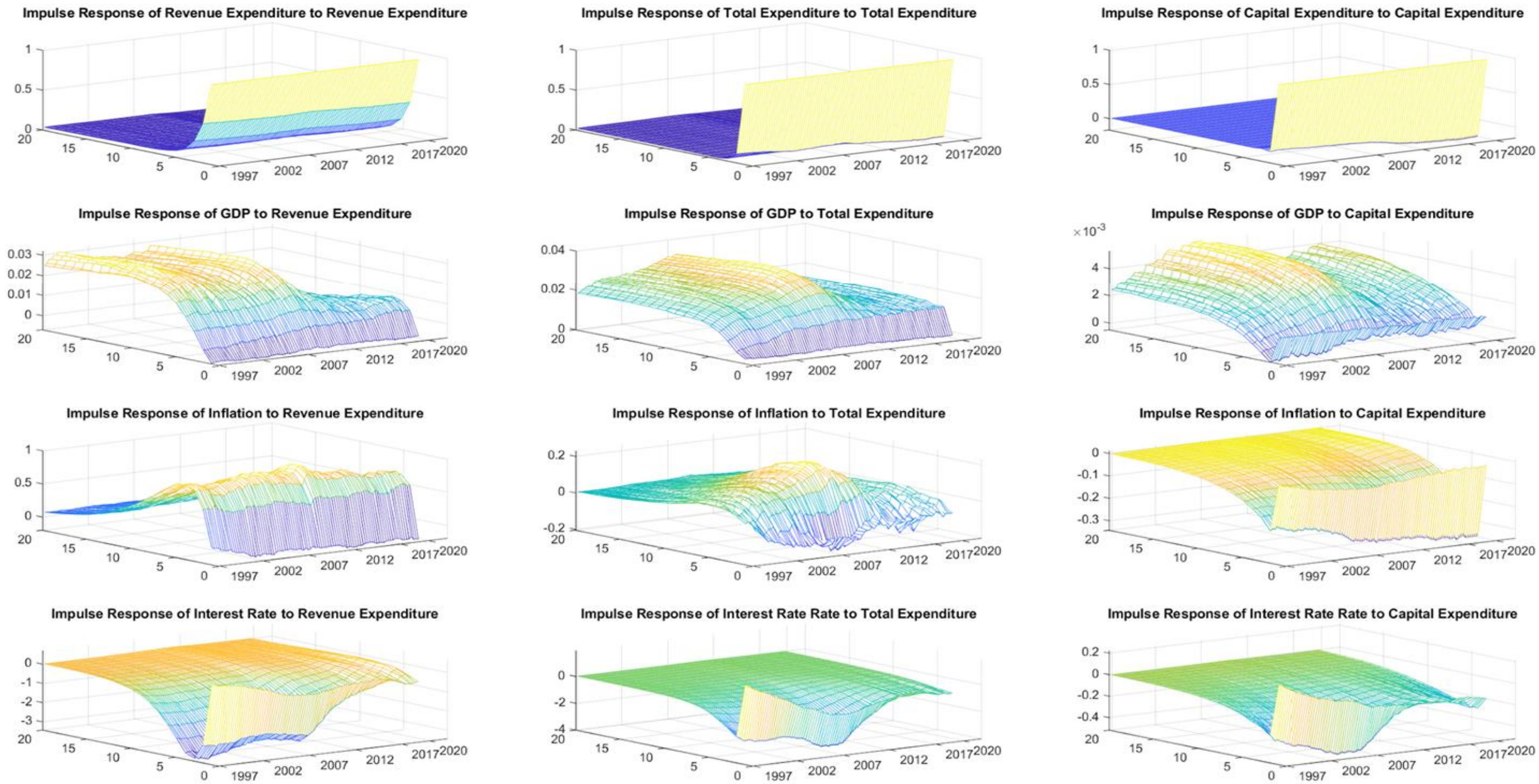
Despite the inflationary effects of revenue and total expenditure shocks, the Interest rate reacts accommodatively to the PE shocks. However, the negative response of the Interest rate to the expenditure shocks, which is reported in the third row of Figure 1. has significantly declined post-2008 crisis. The fall in interest rate responses can be attributed to the changing attitude of the central bank towards inflation.

The positive impact of PE's stimulus on GDP has been reported in the last row of Figure 1. The revenue and total expenditure boost to GDP have significantly decayed after the GFC. In contrast, the GDP response to the capital expenditure shock follows revenue and total expenditure till 2012 and resurges afterwards.

3.2 Time-Varying PE Multipliers and MPC^{DG}

The time-varying positive response of GDP to PE shocks has been transformed into time-varying PE multipliers $PEMLT_t$ using $(\frac{\sum_{i=1}^{n} Y_{ht}}{\sum_{i=1}^{n} G_{ht}}) \times \left(\frac{Y}{G}\right)_t$. Here Y_{ht} and G_{ht} are the h$^{\text{th}}$ quarter responses of GDP and PE to PE shock during the period t. $\left(\frac{Y}{G}\right)_t$ is the mean ratio of GDP and PE between 1997Q2 and t.

Figure 1. Time-Varying Impulse Responses of Public Expenditure Shocks



Note: The time-varying responses of GDP, inflation and call money rate with shock to revenue, total and capital expenditure are reported in the first, second and third columns of Figure. The X-axis in the Figure graphs ranges between 0 to 20 quarters and represents the time horizon of impulse responses. Y-axis ranging between the years 1997 and 2020 reflects the period at which impulse responses are computed. Z-axis reports the value of impulse responses. The time-varying impulse responses are estimated with Gali et al. (2010) priors. Refer robustness section.

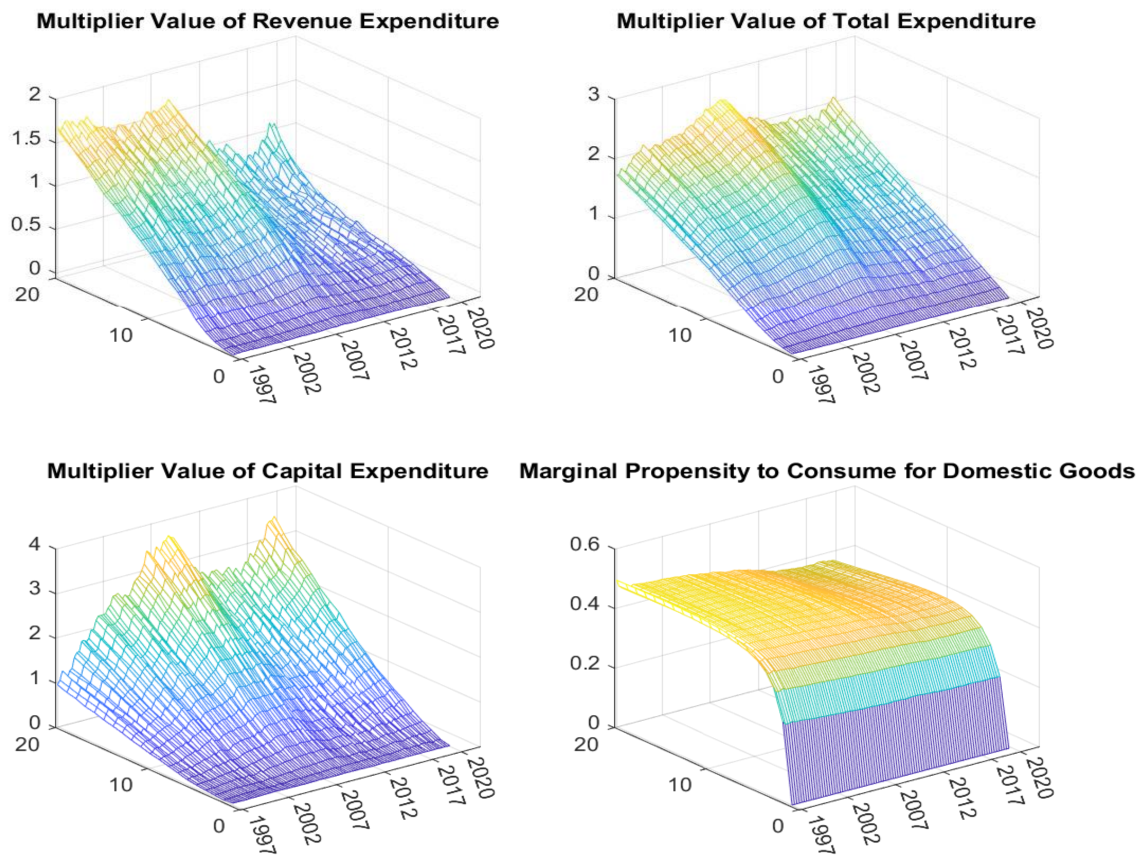
As per the national accounting practice, private consumption expenditure contains some proportion of the Imports expenditure. Therefore, in order to identify MPC^{DG}, Marginal propensity to import (MPM) has been subtracted from the marginal propensity to consume (MPC). In line with $(PEMLT_t)$, study computes $MPC_t \; and \; MPM_t$ using $(\frac{\sum_{i=1}^{n} C_{ht}}{\sum_{i=1}^{n} Y_{ht}}) \times \left(\frac{C}{Y}\right)_t$ and $(\frac{\sum_{i=1}^{n} I_h}{\sum_{i=1}^{n} Y_h}) \times \left(\frac{I}{Y}\right)_t$. Here Y_h, C_h and I_h is the h^{th} quarter response of GDP, CON and IMP to the GDP shock during period t. $\left(\frac{C}{Y}\right)_t$ and $\left(\frac{I}{Y}\right)_t$ is the mean value of average propensity to consume and import between the period 1997Q2 and t. $PEMLT_t$ and MPC_t^{DG} are computed for each of the thousand impulse responses, and their median values are reported in Figure 2.

The inverted-U shape has been observed in the total expenditure multipliers at 20 quarters between 1998 and 2019. It peaks around 2008 and falls thereafter. The capital expenditure multiplier follows the total expenditure multiplier till 2017 and resurges afterwards. Whereas, revenue expenditure stays almost time-invariant till 2007 and falls thereafter. In the initial years, the revenue expenditure multiplier exceeds the capital expenditure multiplier till 2004. However, this inequality reverses post-2004, and the capital expenditure multiplier becomes greater than the revenue expenditure multiplier.

The revenue expenditure multiplier at the 20$^{\text{th}}$ quarter hovers around 1.8 between the late nineties and GFC. It significantly falls post-2007, from 1.8 to less than 1 in 2019. In comparison, relatively less time variation has been observed in the total expenditure multiplier at the 20$^{\text{th}}$ quarter. It rises from 1.8 in the late nineties to 2 during GFC and falls thereafter to 1.9 in 2019.

The capital expenditure multiplier has also varied substantially with time; its 20$^{\text{th}}$ quarter value rises from 0.8 in the late nineties to a maximum of 3.8 in 2008 and falls thereafter to 2.5 in 2012.

It resurges post-2012 and reaches 3.5 in 2019. The long-term declining trend has been observed in MPC^{DG} at the 20th quarter. It falls from 0.49 in 1998 to 0.36 in 2019.



Note: $PEMLT_t$ is reported in the first three graphs of the Figure, and the last graph reports MPC_t^{DG}. The X-axis in the graphs of Figure, ranging from 0 to 20, represents the quarters at which multipliers, and MPC^{DG} are calculated. Y-axis ranging from 1997 to 2020 represents the period at which the value of multipliers, and MPC^{DG} is calculated. Z-axis reports the value of multipliers and MPC^{DG}.

4. Convergence Diagnostics

The study employs Geweke's, Raftery and Lewis diagnostics to examine the convergence of the parameters to their stationary distribution. Raftery and Lewis intend to estimate the required minimum no of draws to achieve the convergence in MCMC. This method is based on the researcher's quantile of interest to be estimated with certain accuracy and probability of achieving that accuracy. The Raftery and Lewis precision draws for the 50th quantile of TVP-VAR coefficients and volatility parameters with a tolerance limit of ±0.01 and probability 0.95 of achieving it has been less than 1000 (number of draws taken for posterior simulation for all the models).

With the precision draws, Raftery and Lewis-I statistics (dependence factor) reflect the rise in no of draws attributing to autocorrelation in MCMC. The value of the dependence factor greater than 5 indicates the presence of worrisome auto-correlation in the chain arising due to poor mixing, influential initial values, or correlated parameter draws in the chain. The study finds Raftery and Lewis-I statistics to be less than 5 for the coefficient and volatility parameters in all the models. It nullifies the influence of initial draws on the future draws of parameters.

Geweke's Relative Numerical Efficiency (RNE) has been around 1 for all the models' parameters. It indicates that the number of draws taken is sufficient to provide numerical accuracy similar to that of independent and identically distributed posterior sample draws.

Geweke's Convergence Diagnostic CD = $\frac{Mean(X_1)-Mean(X_2)}{\sqrt{\frac{(std(X_1))^2}{n}+\frac{(std(X_2))^2}{m}}}$ value for all the parameters in all the models lies between the interval (-2,2) with p-values greater than 0.05. Here X_1 and X_2 are the first and last 20 twenty percent of the MCMC draws, whereas CD values between -2 and 2 reflect the similarity in the two sets of parameter draws. The results concerning convergence diagnostics have been reported in the Appendix.

5. Robustness of Computed PE Multipliers and $\mathrm{MPC}^{\mathrm{DG}}$

The study is in line with Kirchner (2010) and follows Cogley et al. (2001) by imposing the stationarity conditions to ensure stability and robustness in the estimates of PE multipliers and $\mathrm{MPC}^{\mathrm{DG}}$. With the absence of stationarity conditions, unstable draws may exaggerate the time-variation in the estimated parameters and computed PE multipliers. Therefore, we discard the unstable draws that do not satisfy the eigenvalue inequality conditions.

With stability checks, we also examine the sensitivity of the results to the alternate choices of the prior hyperparameters λ_1, λ_2, and λ_3. The prior hyperparameters are innocuously selected in line with the literature before carrying out posterior simulations. However, with limited datasets, posterior inferences become sensitive to the choice of prior hyperparameters (see Glocker et al. (2019)). Therefore, it becomes essential to ensure the robustness of results with different choices of hyperparameters.

Glocker et al. (2019), in their work, kept the value of λ_1 = 0.01, $\lambda_2 = 0.01$ in line with Stock et al. (1996), Cogley et al. (2001) and Primiceri (2005). In the standard literature λ_3 is set as 0.1 however, at this value Glocker et al. (2019) find their empirical results to be volatile and unstable therefore, they set $\lambda_3 = 0.01$. In line with Glocker et al. (2015), Gali et al. (2015) also set a lower value of λ_3=0.01. Whereas contrasting with Glocker et al. (2015), Gali et al. (2015) lowered the value of λ_1 to 0.005. In our study, we carry out the estimation for different choices of prior hyperparameters and check the contingency of PE multipliers and $\mathrm{MPC}^{\mathrm{DG}}$ on the values of prior hyperparameters. The details of prior hyperparameters used in the study are given in Table 4.

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Table 4. Prior Hyperparameters

Hyperparameter Values	Source	Label
$\lambda_1 = 0.005$, $\lambda_2 = 0.01$, and $\lambda_3 = 0.01$	Gali et al. (2015)	Prior A
$\lambda_1 = 0.01$, $\lambda_2 = 0.01$, and $\lambda_3 = 0.01$	Glocker et al. (2015)	Prior B
$\lambda_1 = 0.0025$, $\lambda_2 = 0.005$, and $\lambda_3 = 0.005$	Author's choice for	Prior C
$\lambda_1 = 0.01$, $\lambda_2 = 0.05$, and $\lambda_3 = 0.05$	robustness checks	Prior D

Note: This table shows the choices of prior hyperparameters used for computing the PE Multipliers.

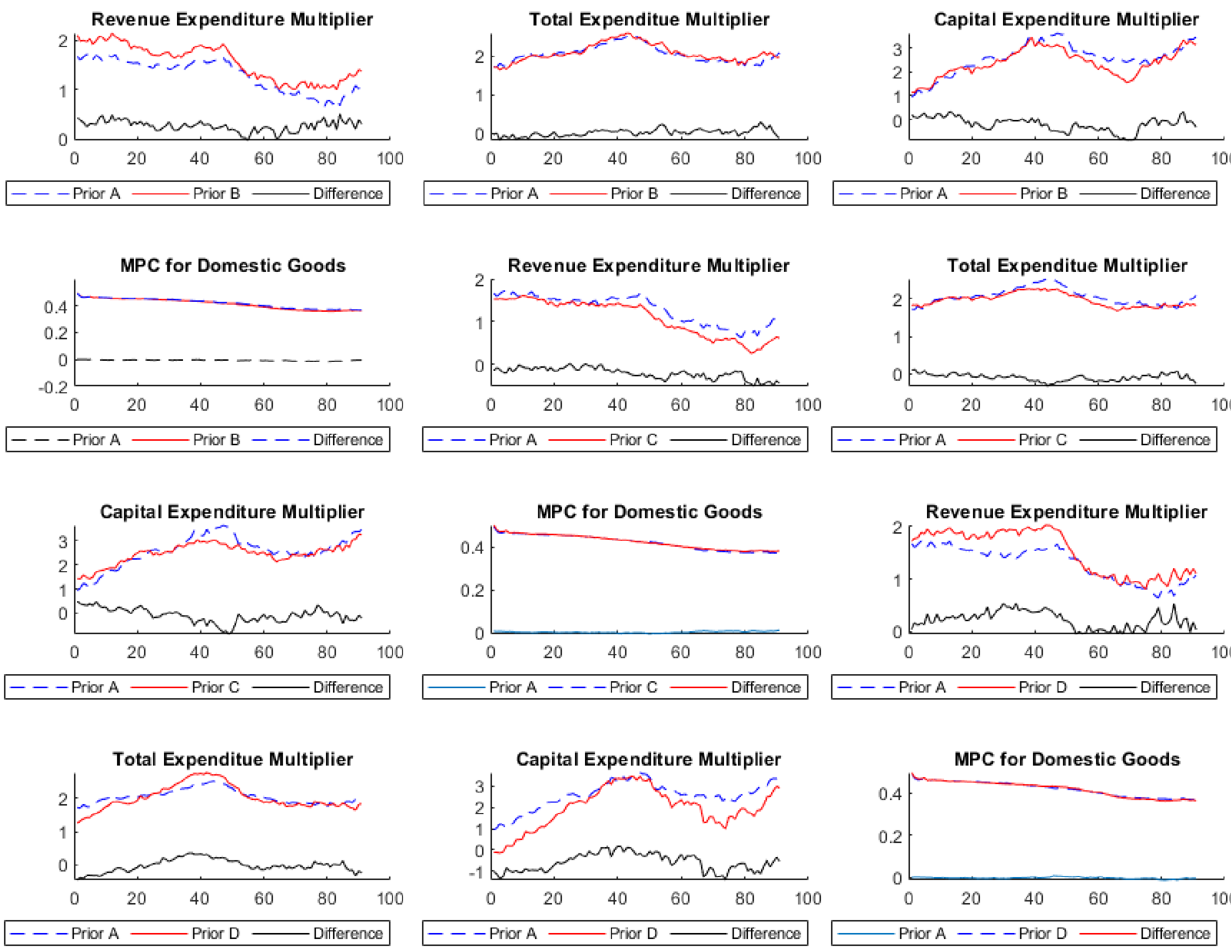

Figure 3 Sensitivity of PE Multipliers

Note: The Figure shows differences in the value of PE multipliers and MPC^{DG} at 20^{th} quarters when computed with the different choices of prior hyperparameters.

The differences between the PE multipliers and $\mathrm{MPC}^{\mathrm{DG}}$ at 20 quarters with different choices of prior hyperparameters (Prior A, Prior B, Prior C and Prior D) have been reported in Figure 3. $\mathrm{MPC}^{\mathrm{DG}}$ is highly robust across all the choices of prior hyperparameters. Although insignificant difference has been observed in PE multipliers estimated with prior hyperparameters Prior A, Prior B and Prior C. In contrast, the PE multipliers become a little volatile with higher values of λ_2 and λ_3. The variation in the value of the PE multiplier with higher values of λ_2 and λ_3 has been observed in Glocker et al. (2015) as well.

6. Driving Forces of the Public Expenditure Multipliers

This section discusses the role of structural factors in explaining the time-variation in short-run (4 and 8 quarters), medium-run (12 quarters) and long-run (16 and 20 quarters) PE multipliers. The study employs regression analysis to examine the impact of fiscal stability, financial development, trade openness, automatic stabilisers, and $\mathrm{MPC}_t^{\mathrm{DG}}$ on the PE multipliers. However, the PE multipliers are computed in the TVP-VAR setup; hence, a regression on them may yield biased results. Therefore, one should account for the uncertainty arising from the computation while doing regression analysis. Kirchner et al. (2010) and Glocker (2019) address this issue by running regression on each of the posterior draws of PE multipliers and taking the median of regression coefficients to conclude the impact of different factors on the PE multipliers.

In our study, besides PE multipliers, the independent variable $\mathrm{MPC}^{\mathrm{DG}}$ is also computed in the TVP-VAR setup. Therefore, uncertainty arises from two different sources (PE multiplier and MPC^{DG}). Hence, running regressions on the different combinations of PE multiplier and MPC^{DG} will be cumbersome. However, Gweeke's convergence diagnostic confirms the similarity of parameters across the MCMC draws used for analysis. Furthermore, Raftery and Lewis number of precision draws being less than the number of draws taken for posterior simulation confirms the accuracy of ±0.01 in the median of parameter draws with the probability of 0.95. Gweeke's, Raftery and Lewis convergence confirmations mitigate the biases arising from uncertainty in PE multipliers and $\mathrm{MPC}^{\mathrm{DG}}$.

The paper employs Bayesian regression with the dependent variable as the median of PE multipliers and independent variables as Debt-GDP ratio, Automatic Stabilisers, Median of MPC^{DG}, Credit-GDP ratio and Imports-GDP ratio. The independent Normal-Gamma distribution is a prior distribution in Bayesian regression, whereas posterior simulations are carried out using Gibbs sampling. The regression results concerning the impact of structural and policy factors on PE multipliers have been reported in Table 5 and Table 6.

6.1. Impact of Fiscal Stress on Public Expenditure Multipliers

According to the new Keynesian economists, consumers are forward-looking and base their consumption choices on their current income as well as future income. With fiscal stimulus during times of high fiscal stress, they expect tax hikes in the near future and raise their current savings to smoothen their future consumption, which neutralises the accelerating effects of fiscal stimulus on economic activity. This ricardian behaviour of consumers during times of high fiscal stress is more prevalent in advanced economies than in emerging ones (see Hory(2016)).

Fiscal stress with higher debt and interest payment deteriorates the fiscal space and leads to inefficient fiscal management, which in turn dampens the effectiveness of fiscal stimulus in the economy. The higher level of fiscal stress also raises sustainability concerns and narrows the external financing possibilities. With limited external financing possibilities, the domestic financing of fiscal stimulus crowds out private consumption and investment, which curtails the effectiveness of fiscal boosts (See Priftis et al., 2021 and Broner et al., 2022). Besides this, fiscal sustainability concerns weaken the demand for government bonds which reduces their price and raises interest on them. The financing of fiscal stimulus via issuing government bonds further intensifies the supply-demand mismatch and increases the interest rate. The surge in overall borrowing costs crowds out private investment and weakens the effectiveness of fiscal stimulus on the economy.

The study complying with literature has proxied fiscal stress with the Debt-GDP ratio. The paper finds the Debt-GDP ratio to have a significant ruinous effect on the medium and long-run PE multipliers. At the same time, the impact of Debt-GDP on short-run PE multipliers is negative but insignificant. The empirical results concerning the role of Debt-GDP in explaining the PE multipliers are in line with Gupta et al. (2005), Huidrom (2020), Kirchner et al. (2010), and Hory (2016).

6.2. Impact of Automatic Stabilisers on Public Expenditure Multipliers

Automatic stabilisers are meant for stabilising aggregate demand hence negatively influence the fiscal multipliers by crowding out the aggregate demand surge via fiscal boosts in the economy Batini et al. (2014). As discussed in Batini et al. (2014), the study has proxied automatic stabilisers by the Government Expenditure-GDP ratio and finds its impact on PE multipliers to be insignificant in the empirical results. The insignificant impact of automatic stabilisers can be attributed to their low levels in the Indian economy.

6.3 Impact of the MPC^{DG} and Trade Openness on the Public Expenditure Multipliers

Fiscal policy stimulus boosts income levels and raises consumption expenditure on domestic goods, which further resurges the aggregate demand and makes fiscal policy more effective. The larger the positive response of consumption to the rise in income, the greater the fiscal multiplier values will be. The formula for the fiscal multiplier in the standard textbook is given as follows

$$\text{Fiscal Multiplier} = \frac{1}{1-MPC+MPM} = \frac{1}{1-MPC^{DG}}$$

Higher the value of MPC^{DG} higher the multipliers. The study empirically validates the strengthening effects of MPC^{DG} on medium and long-run PE multipliers. However, in the short-run positive impact is significant on total expenditure multiplier at 8 quarters and capital expenditure multiplier at 4, 8 quarters.

As per the Mundell Fleming model, the aggregate demand surged via fiscal stimulus is partially met by the higher import levels in the open economies. The leakages in terms of imports diminish the fiscal multiplier values (Batini et al. (2014)). The study following the literature takes the Imports-GDP ratio as the proxy for trade-openness and finds its significant negative impact on the long-run revenue and capital expenditure multipliers. The impact was negative but insignificant for the short-run and medium-run PE multipliers. The empirical results regarding the impact of MPC^{DG} and Imports-GDP ratio on PE multipliers complies with Ilzetzki et al. (2013), Kirchner et al. (2010), Hory (2016), and Koh (2017).

6.4 Impact of Credit Constraints and Financial Development on the Public Expenditure Multipliers

The studies in the literature have diverging views concerning the impact of credit constraints on fiscal multipliers. In the standard New Keynesian model, Ricardian consumers alter their consumption bundles with the fiscal stimulus to bear the burden of higher taxes in future. The crowding out of private consumption weakens the accelerating effects of fiscal stimulus in the economy. At the same time, financial development and easing of credit constraints facilitate the consumers to smoothen their consumption which dampens the multiplier values of fiscal shocks (see Takyi et al. (2020)). However, the negative impact of financial development on fiscal multipliers is more prevalent in advanced economies (see Kirchner et al. (2010), Borsi (2018), Hory(2016) and McManus (2021))

In contrast, the absence of consumption smoothing behaviour in emerging economies prevents the crowding out of consumption with fiscal stimulus and nullifies the curtailing effect of financial development on the multipliers (see Khalid (1996), Ghatak et al. (1996), Hory (2016) and Singh (2017). Furthermore, financial development enhances the borrowing opportunities for credit-constrained consumers, which possibly crowds in the consumption expenditure succeeding fiscal stimulus and results in higher multiplier values. In line with this, the study empirically finds the positive impact of financial development on PE multipliers. However, the positive impact stands significant in the medium run as well as the long run. In the short run, the impact of the Credit-GDP ratio turns out to be insignificant for all the PE multipliers.

6.5 Summary

In a nutshell, the structural factors (Debt-GDP ratio, MPC^{DG}, Credits-GDP ratio and Imports-GDP ratio) substantially affects the PE multipliers in the medium-run and long-run. In the short-run, the direction of the structural factor’s impact on the short-run PE multiplier is in line with long-run PE multipliers. However, the magnitude of impact turns out to be insignificant. The structural factors uniformly explain the dynamics of revenue, total and capital expenditure multipliers. Financial development and MPC^{DG} surges the PE multipliers, whereas the fiscal stress and trade openness diminishes them.

Table 5. Bayesian Linear Regression with Dependent Variables as PE Multipliers at 16 and 20 Quarters

	Revenue Expenditure Multipliers		Total Expenditure Multipliers		Capital Expenditure Multipliers	
	Multiplier at 16 Quarter	Multiplier at 20 Quarters	Multiplier at 16 Quarter	Multiplier at 20 Quarters	Multiplier at 16 Quarter	Multiplier at 20 Quarters
			Structural Factors			
Intercept	3.8005***	3.8657***	2.8931***	3.8105***	6.4499***	5.2608***
	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
Debt-GDP Ratio	-0.7115***	-0.6556***	-0.5791***	-0.6632***	-1.0265***	-1.1201***
	(0.002)	(0.008)	(0.009)	(0.004)	(0.001)	(0.002)
Government Share	0.0034	0.0020	-0.0017	-0.0022	-0.0036	-0.0095
	(0.620)	(0.565)	(0.441)	(0.421)	(0.393)	(0.291)
MPC^{DG}	0.1501***	0.1757***	0.1720***	0.1654***	0.5061***	0.5854***
	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
Credit-GDP Ratio	0.0048*	0.0004	0.0097***	0.0101***	0.0071**	0.0069*
	(0.930)	(0.543)	(0.998)	(0.999)	(0.966)	(0.917)
Import Share	-0.0150**	-0.0169**	-0.0026	-0.0056	-0.0206**	-0.0236**
	(0.042)	(0.032)	(0.371)	(0.255)	(0.022)	(0.034)
Trend	-0.0046*	-0.0155***	0.0056**	-0.0057**	0.0422***	0.0005
	(0.086)	(0.000)	(0.958)	(0.000)	(1.000)	(0.587)

Note: a. MPC^{DG} in regression is computed at the same quarter as PE multipliers.

b. The value in brackets shows the probability of regression coefficients being positive.

c. If the probability value is greater than 0.9, 0.95 and 0.99, then the regression coefficient is positive and significant at 10 percent, 5 percent and 1 percent levels.

d. If the probability value is less than 0.1, 0.05 and 0.01, then the regression coefficient is negative and significant at 10 percent, 5 percent and 1 percent levels.

e. *, **, *** indicates significance at 90, 95 and 99 percent levels

f. MPC^{DG} and PE multipliers in the Table are computed with Prior hyperparameters (Prior A). Results are robust with the choice of parameters listed in Table 4. Refer to Section 7.

Table 6. Bayesian Linear Regression with Dependent Variables as PE Multipliers at 4, 8 and 12 Quarters Computed with Prior hyperparameters A

	Revenue Expenditure Multipliers			Total Expenditure Multipliers			Capital Expenditure Multipliers		
	Short-Run		Medium-Run	Short-Run		Medium-Run	Short-Run		Medium-Run
	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters
Structural Factors									
Intercept	0.2192	1.3652**	2.4931***	0.2041	1.3233**	2.2385***	-0.0549	1.5590***	3.9852***
	(0.665)	(0.989)	(1.000)	(0.653)	(0.987)	(1.000)	(0.461)	(0.994)	(1.000)
Debt-GDP Ratio	-0.0776	-0.4033**	-0.6062***	-0.0994	-0.3562**	-0.5010**	-0.0379	-0.2519	-0.6585***
	(0.359)	(0.036)	(0.006)	(0.328)	(0.058)	(0.015)	(0.429)	(0.138)	(0.005)
Government Share	0.0005	0.0019	0.0034	-0.0001	-0.0015	-0.0022	0.0007	0.0019	-0.0044
	(0.515)	(0.570)	(0.624)	(0.487)	(0.443)	(0.411)	(0.529)	(0.569)	(0.352)
MPC^{DG}	0.0314	0.0849**	0.1102***	0.0988	0.1665***	0.1822***	0.1140	0.3087***	0.4095***
	(0.631)	(0.968)	(0.999)	(0.848)	(1.000)	(1.000)	(0.884)	(1.000)	(1.000)
Credit-GDP Ratio	0.0008	0.0042*	0.0056**	0.0035	0.0072***	0.0090***	0.0031	0.0048**	0.0063**
	(0.631)	(0.929)	(0.964)	(0.879)	(0.994)	(0.998)	(0.848)	(0.950)	(0.969)
Import Share	-0.0004	-0.0050	-0.0085	0.0008	-0.0009	-0.0018	0.0029	0.0002	-0.0103
	(0.606)	(0.260)	(0.147)	(0.546)	(0.450)	(0.407)	(0.650)	(0.511)	(0.123)
Trend	-0.0004	-0.0052**	-0.0080***	-0.0002	0.0006	0.0036*	0.0004	0.0096***	0.0241***
	(0.480)	(0.021)	(0.004)	(0.466)	(0.599)	(0.901)	(0.574)	(1.000)	(1.000)

Note: a. MPC^{DG} in regression is computed at the same quarter as PE multipliers.
b. The value in brackets shows the probability of regression coefficients being positive.
c. If the probability value is greater than 0.9, 0.95 and 0.99, then the regression coefficient is positive and significant at 10 percent, 5 percent and 1 percent levels.
d. If the probability value is less than 0.1, 0.05 and 0.01, then the regression coefficient is negative and significant at 10 percent, 5 percent and 1 percent levels.
e. *, **, *** indicates significance at 90, 95 and 99 percent levels
f. MPC^{DG} and PE multipliers in the Table are computed with Prior hyperparameters (Prior A). Results are robust with the choice of parameters listed in Table 4. Refer to Section 7.

7. Robustness of Regression Results

Given the potential for bias in regression results due to the uncertainties surrounding the computation of PE multipliers and MPC^{DG}. The study confirms the robustness of the results with Kirchner et al. (2010) and Glocker (2019) procedure for conducting regression analysis. The paper carries out regression analysis with each decile of the thousand computed PE multipliers and MPC^{DG} draws at 20^{th} quarter. The coefficients of regression analysis conducted with each decile of PE multipliers and MPC^{DG} are reported in Figure 4.

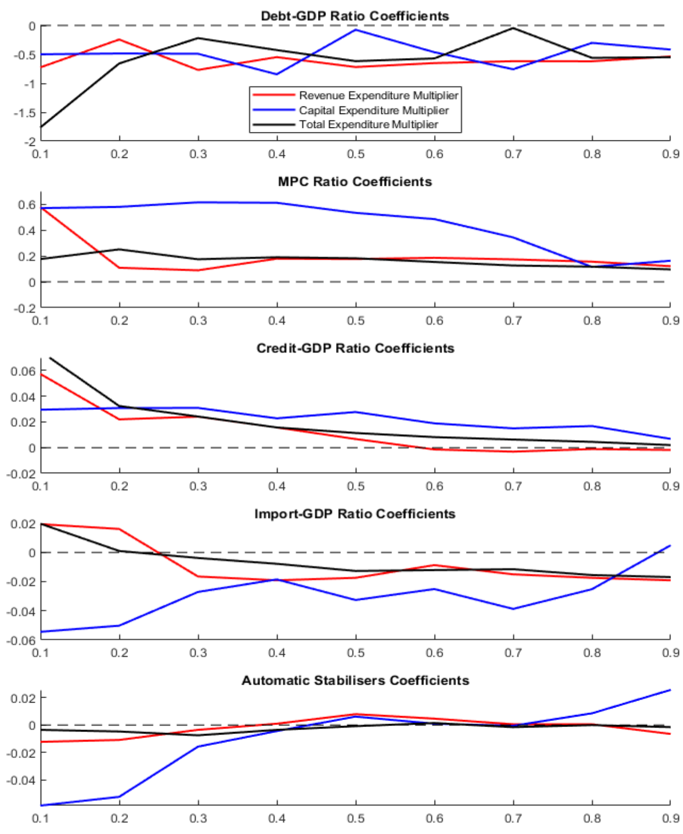

Figure 4 Coefficients of Regression Analysis with each decile of computed PE Multipliers and MPC at 20 quarters

Note: X-axis and Y-axis in the graphs of Figure reports Decile and Quantile Values

The detrimental effects of Debt-GDP ratio and Imports-GDP ratio stand robust with the regression analysis on PE multipliers and $\mathrm{MPC}^{\mathrm{DG}}$ computed at each decile. Similarly, the Credit-GDP ratio and $\mathrm{MPC}^{\mathrm{DG}}$ robustly amplifies the PE multiplier values. Although the size of their impact decays at larger deciles.

Withal study further validates results by conducting regression analysis on PE multipliers and $\mathrm{MPC}^{\mathrm{DG}}$ computed with different choices of prior hyperparameters mentioned in Table 4. These regression results are reported in the Appendix. The positive and negative impact of $\mathrm{MPC}^{\mathrm{DG}}$ and trade openness on PE multipliers are robust with all the choices of prior hyperparameters listed in Table 4. The accelerating effects of the Credit-GDP ratio stand robust and significant for the medium run as well as long run total and capital expenditure multiplier computed with all the choices of prior hyperparameters mentioned in Table 4. Whereas the positive impact of financial development on medium and long run revenue expenditure multiplier stands significant with prior hyperparameters (Prior A and Prior C) and insignificant with prior hyperparameters (Prior B and Prior D). In the short run, the insignificant impact of the Credit-GDP ratio on PE multipliers stands robust with all the choices of prior hyperparameters.

The detrimental effects of the Debt-GDP ratio are robust on PE multipliers computed with prior hyperparameters (Prior A, Prior B and Prior C). In the case of PE multipliers estimated with the prior hyperparameter (Prior D), the higher value of Debt-GDP ratio upsides the capital expenditure multiplier and downsides the revenue and total expenditure multiplier. However, its impact stands insignificant.

8. Conclusion

The key contribution of the paper lies in examining the role of structural factors (Debt-GDP ratio, MPC^{DG}, Credit-GDP ratio, Import-GDP ratio) in explaining the dynamics of revenue, capital and total expenditure multipliers in the Indian scenario. The study carries out the empirical analysis in two stages. In the first stage, the TVP-VAR model with stochastic volatility has been employed to compute the time variation in short-run and long-run PE multipliers. Furthermore, the same model has been then used to compute the time-varying MPC^{DG} as well. The study affirms the time dependency of PE multipliers unveiled by Kirchner et al. (2010) and Glocker (2019). It further compliments these studies by revealing the asymmetries in time dependency of revenue, capital, and total expenditure multipliers. The capital and total expenditure multiplier have been found to exhibit the inverted U shape. In contrast, a declining trend has been observed in the revenue expenditure multiplier post-GFC.

The Bayesian regression with independent Normal Gamma prior is then used in the second stage to scrutinise the drivers of time variation in the PE multipliers. The empirical results reveal that fiscal stress and trade openness diminishes the effectiveness of the PE stimulus in the economy. In contrast, MPC^{DG}, and financial development have been found to uplift the PE multipliers values. The effect of structural (Debt-GDP ratio, MPC^{DG}, Credit-GDP ratio and Imports-GDP ratio) factors hold significance on PE multipliers only in the long run. Given the paper's empirical results, we conclude that policy suggestions and decisions based on average PE multipliers may lead to misleading outcomes therefore, policymakers must consider structural factors while proliferating PE stimulus packages.

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Appendix

A.1 Gibbs Sampling Procedure

The TVP-VAR model equations are as follows

$$X_t = A_{0,t} + A_{1,t}X_{t-1} + A_{2,t}X_{t-2} + \ \dots \dots + A_{P,t}X_{t-P} + u_t \qquad (A.1)$$

$$u_t \sim N(0, \Sigma_t)$$

$$\Theta_t = \Theta_{t-1} + \omega_t \qquad (A.2)$$

$$\omega_t \sim N(0, \Omega)$$

$$\log \sigma_t = \log \sigma_{t-1} + \ \varsigma_t \qquad (A.3)$$

$$\varsigma_t \sim N(0, \Xi)$$

$$\phi_{i,t} = \phi_{i,t-1} + \vartheta_{i,t} \qquad (A.4)$$

$$\vartheta_{i,t} \sim N(0, \Psi_i)$$

The Gibbs procedure for sampling parameter draws is as follows

Step 1: Initialize $X_t, \Theta^T, \phi^T, \ \Omega, \ \Xi, \Psi,$ and s^T based on OLS estimates of linear VAR.

Step 2: The Gibbs sample procedure proceeds by drawing σ_t using the Kim et al. (1998) algorithm. The TVP-VAR model in equation (1) can be rewritten as

$$F_t^{-1} \left(X_t - \ A_{0,t} + A_{1,t}X_{t-1} + A_{2,t}X_{t-2} + \ \dots \dots + A_{P,t}X_{t-P}\right) = D_t^{1/2} e_t$$

$$X_t^{**} = D_t^{1/2} e_t \qquad (A.5)$$

Here X_t^{**} equals $F_t^{-1} (X_t - \ A_{0,t} + A_{1,t}X_{t-1} + A_{2,t}X_{t-2} + \ \dots \dots + A_{P,t}X_{t-P})$. Given Θ_t and F_t^{-1}, X_t^{**} becomes observable. The equations (A.5) and (A.3) form the non-linear state-space model. Hence we transform it into a linear state-space system by squaring the fifth equation and then taking the log.

$$X_t^{***} = 2h_t + e_t^* \tag{A.6}$$

Here $X_t^{***} = \log X_t^{**2}$ $h_t = \log \sigma_t$ and $e_t^* = \log(e_t^2)$. Equations (A.3) and (A.6) form the linear state-space model. However, e_t^* now follows the log chi-square distribution. Therefore, we approximate the log chi-square distribution by the mixture of seven normal distributions to convert the system into a gaussian linear state-space system. This strategy has been discussed in Kim et al. (1998). The details about the mixture of seven normal distributions with component probabilities q_j mean $m_j - 1.2704$, and variance v_j^2 is given in Table A.1.

Table A.1 Mixture of Seven Normal Distributions

j	q_j	m_j	v_j^2
1.0000	0.0073	-10.1300	5.7960
2.0000	0.1056	-3.9728	2.6137
3.0000	0.0000	-8.5669	5.1795
4.0000	0.0440	2.7779	0.1674
5.0000	0.3400	0.6194	0.6401
6.0000	0.2457	1.7952	0.3402
7.0000	0.2575	-1.0882	1.2626

Let $s^T = [s_1, ..., s_T]'$ be the vector of indicator variable choosing a distribution from the mixture of seven normal distributions. Given the value of $s_t = j$, Carter et al. (1994) algorithm used to draw h_t from the distribution of $(e_t^* | s_t = j)$. Here, $e_t^* | s_t = j \sim N(m_j - 1.2704, v_j^2)$. More precisely h_t is drawn from $N(h_{t|t+1}, H_{t|t+1})$. Here, $h_{t|t+1} = E(h_t | h_{t+1}, X_t, \Theta^T, \phi^T, \Omega, \Xi, \Psi, s^T)$ and $H_{t|t+1} = VAR(h_t | h_{t+1}, X_t, \Theta^T, \phi^T, \Omega, \Xi, \Psi, s^T)$ are the conditional mean and variance obtained from the backward recursion equations.

Step 3: In the third step, the Gibbs sampler draws ϕ^T. We can rewrite equation A.1 as

$$F_t^{-1} X_t^* = D_t^{1/2} e_t \qquad \text{(A.7)}$$

Here X_t^* equals $(X_t - A_{0,t} + A_{1,t}X_{t-1} + A_{2,t}X_{t-2} + \ldots\ldots + A_{P,t}X_{t-P})$. Since F_t^{-1} is a lower triangular matrix with one on the diagonal. The system of equations in A.7 can be written as

$$X_{i+1,t}^* = -X_{[1,i],t}^* \phi_{i,t} + \sigma_{i+1,t} e_{i+1,t} \qquad i = 2\ldots n \qquad \text{(A.8)}$$

Here $\sigma_{i,t,}$ $e_{i,t}$ are the ith element of σ_t and e_t. $X_{[1,i],t}^*$ is the row vector $[X_{1,t}^*, \ldots\ldots X_{i,t}^*]$. Given Θ^T and σ^T, X_t^* becomes observable, and equations A.8 and A.4 form the Gaussian linear state-space model where states are $\phi_{i,t}$. Since $\phi_{i,t}$ and $\phi_{j,t}$ are independent of each other, the Carter et al. (1994) algorithm applied to draw $\phi_{i,t}$ from $N(\phi_{i,t|t+1}, \Phi_{i,t|t+1})$. Here, $\phi_{i,t|t+1} = E(\phi_{i,t} | \phi_{i,t+1}, X_t, \Theta^T, \sigma^T, \Omega, \Xi, \Psi)$ and $\Phi_{i,t|t+1} = VAR(\phi_{i,t} | \phi_{i,t+1}, X_t, \Theta^T, \sigma^T, \Omega, \Xi, \Psi)$.

Step 4: In this step, we draw the regression coefficients Θ^T. Given F_t^{-1}, D_t, Ω, Ξ and Ψ_i, equation (A.1) and equation (A.2) form the linear state-space model. Kalman filter and backward recursion, as given in Carter et al.(1994), are used to draw Θ_t. Θ_t is drawn from $N(\Theta_{t|t+1}, P_{t|t+1})$, where $\Theta_{t|t+1} = E(\Theta_t | \Theta_{t+1}, X_t, \sigma^T, \phi^T, \Omega, \Xi, \Psi)$ and $P_{t|t+1} = VAR(\Theta_t | \Theta_{t+1}, X_t, \sigma^T, \phi^T, \Omega, \Xi, \Psi)$.

Step 5: In this step, we draw parameters Ω, Ξ, Ψ from their distributions $p(\Omega | X_t, \Theta^T, \phi^T, \sigma^T)$, $p(\Xi | X_t, \Theta^T, \phi^T, \sigma^T)$, and $p(\Psi | X_t, \Theta^T, \phi^T, \sigma^T)$ respectively. Given X_t, Θ^T, ϕ^T, and σ^T the parameters Ω, Ξ, Ψ, have Inverse Wishart distribution from which draws are obtained directly (Gelman et al. (1995).

Step 6: This step draws s^T. We sample $s_{i,t}$ from discrete density $p(s_{i,t} = j|X_{i,t}^{***}, \sigma_{i,t}) \propto q_j f_N(X_{i,t}^{***}|2\sigma_{i,t} + m_j - 1.2704, v_j^2)$.

Step 7: Go to step 2.

A.2 Convergence Diagnostics

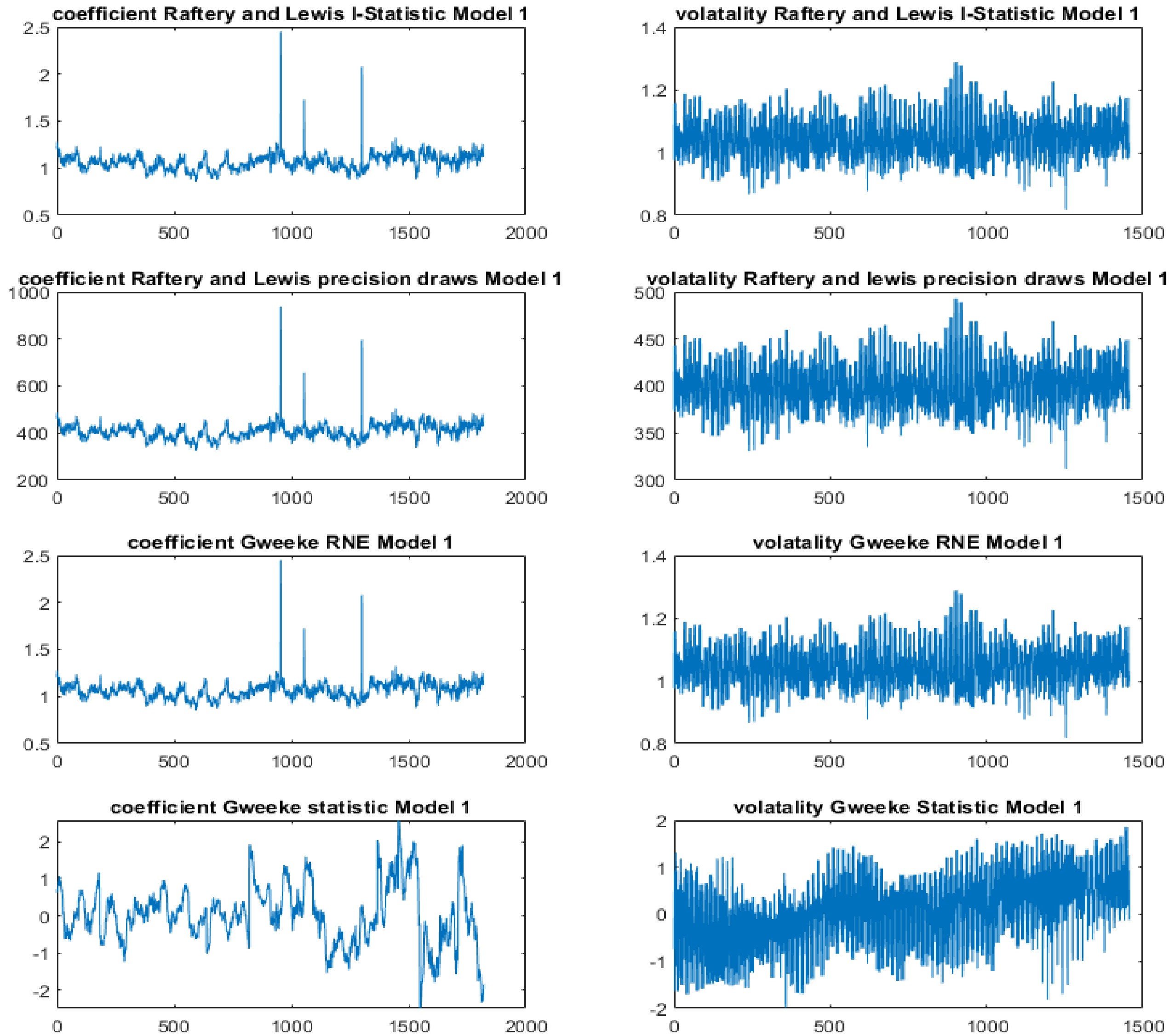

Figure A.1 Gweek's, Raftery and Lewis Convergence Diagnostic for Coefficient and Volatility Parameters in Model 1

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value.

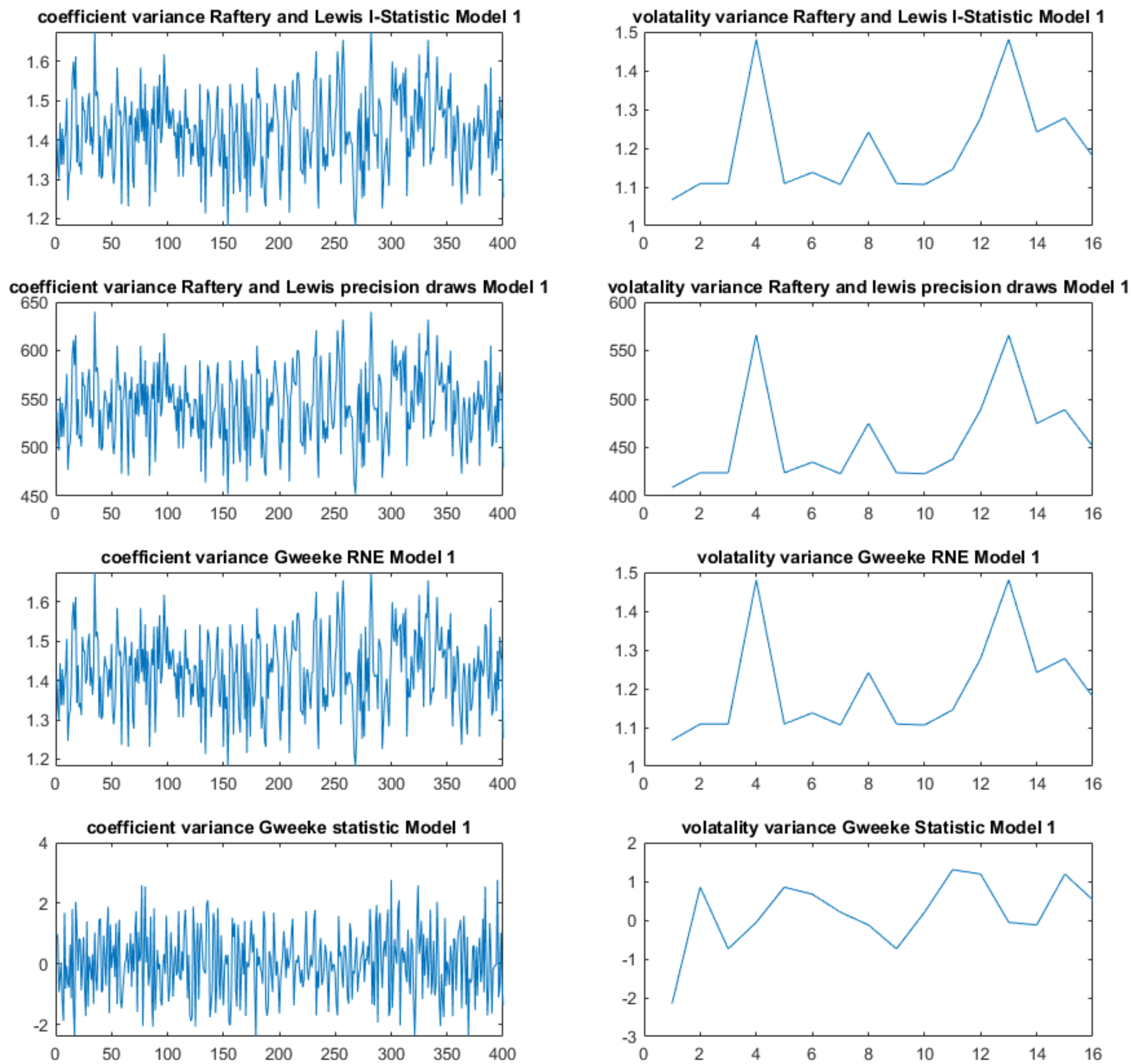

Figure A.2 Gweek's, Raftery and Lewis Convergence Diagnostic for Variance of Coefficient and Volatility Parameters in Model 1

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value.

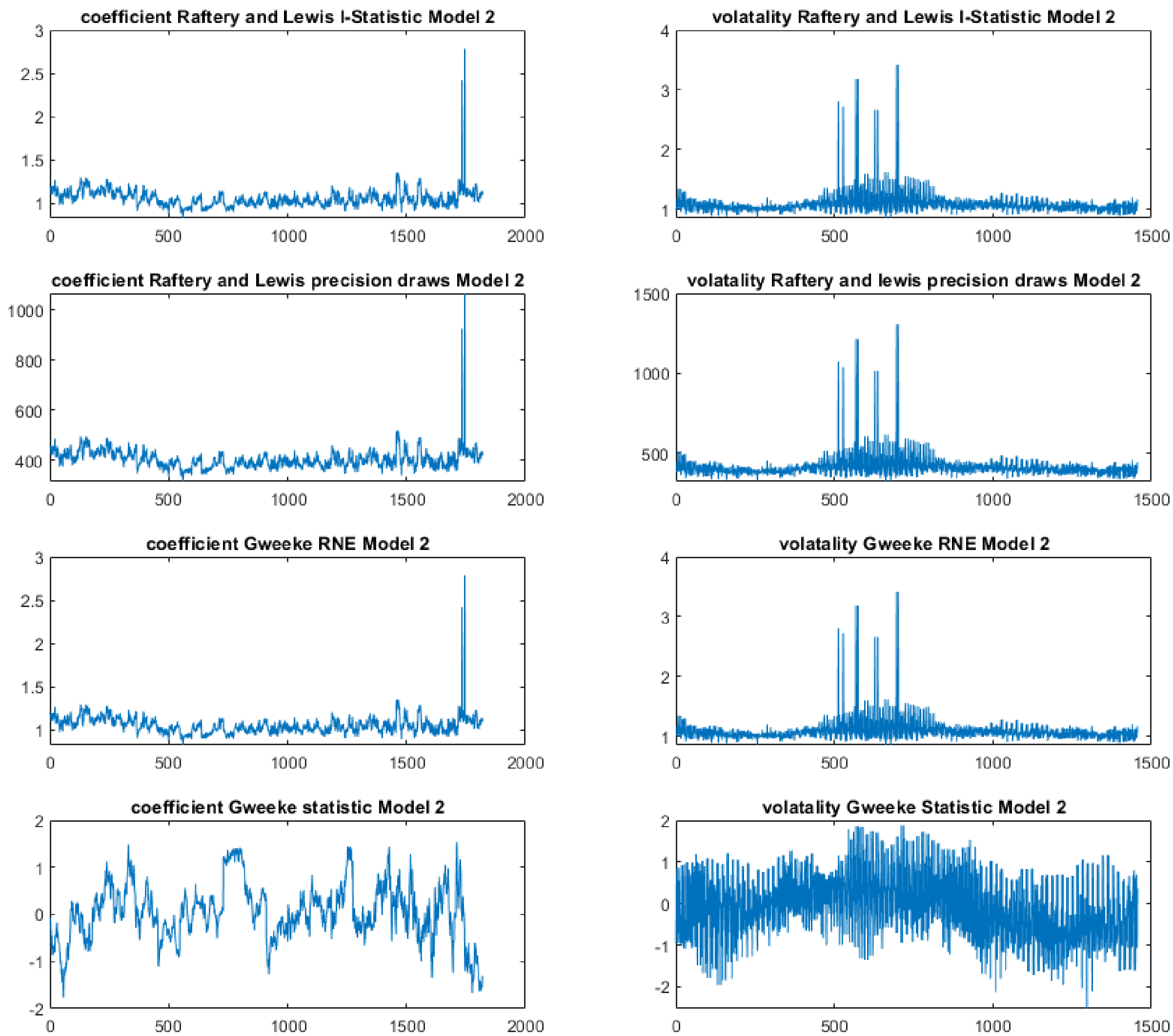

Figure A.2 Gweek's, Raftery and Lewis Convergence Diagnostic for Coefficient and Volatility Parameters in Model 2

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value.

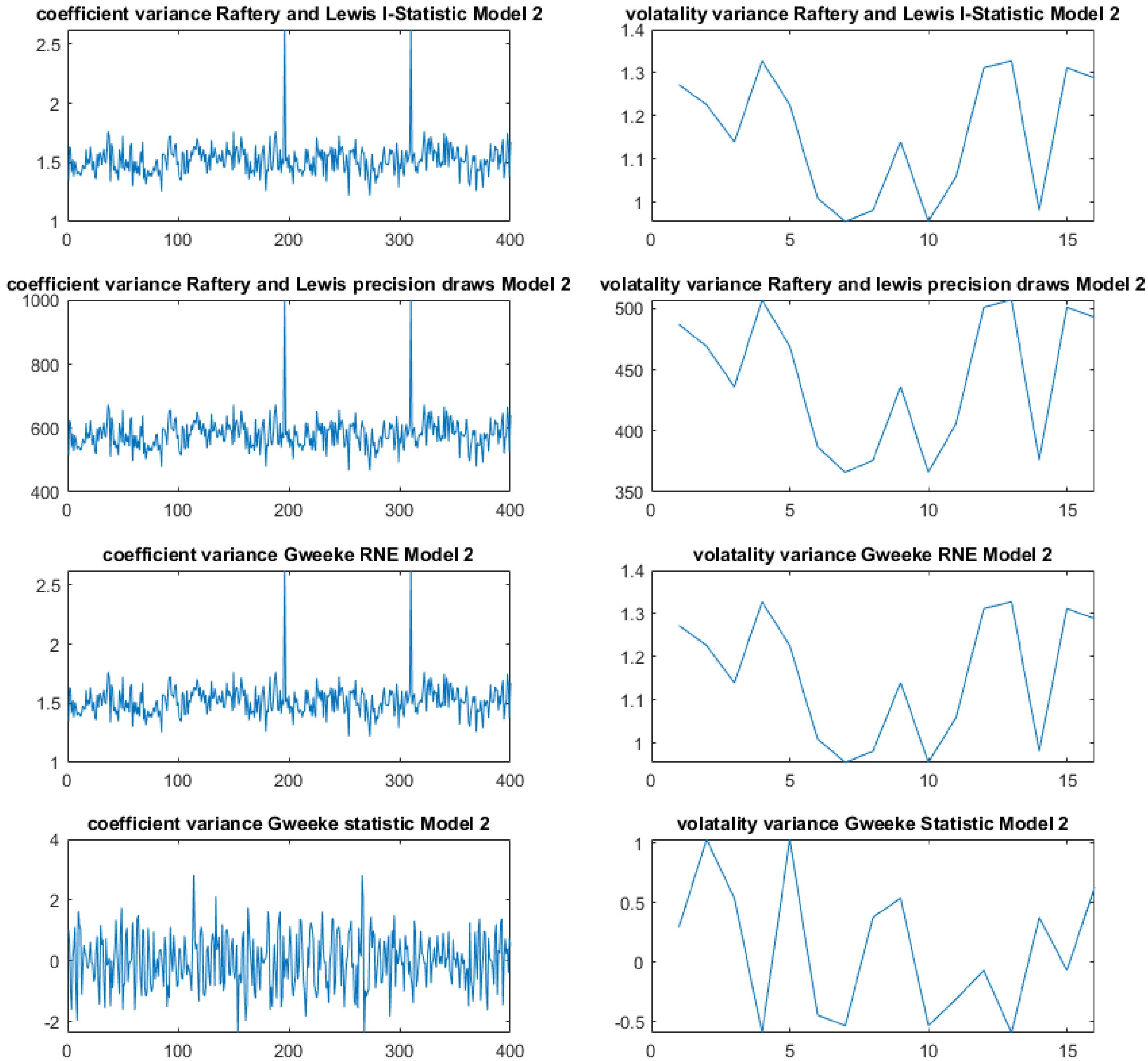

Figure A.3 Gweek's, Raftery and Lewis Convergence Diagnostic for Variance of Coefficient and Volatility Parameters in Model 2

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value.

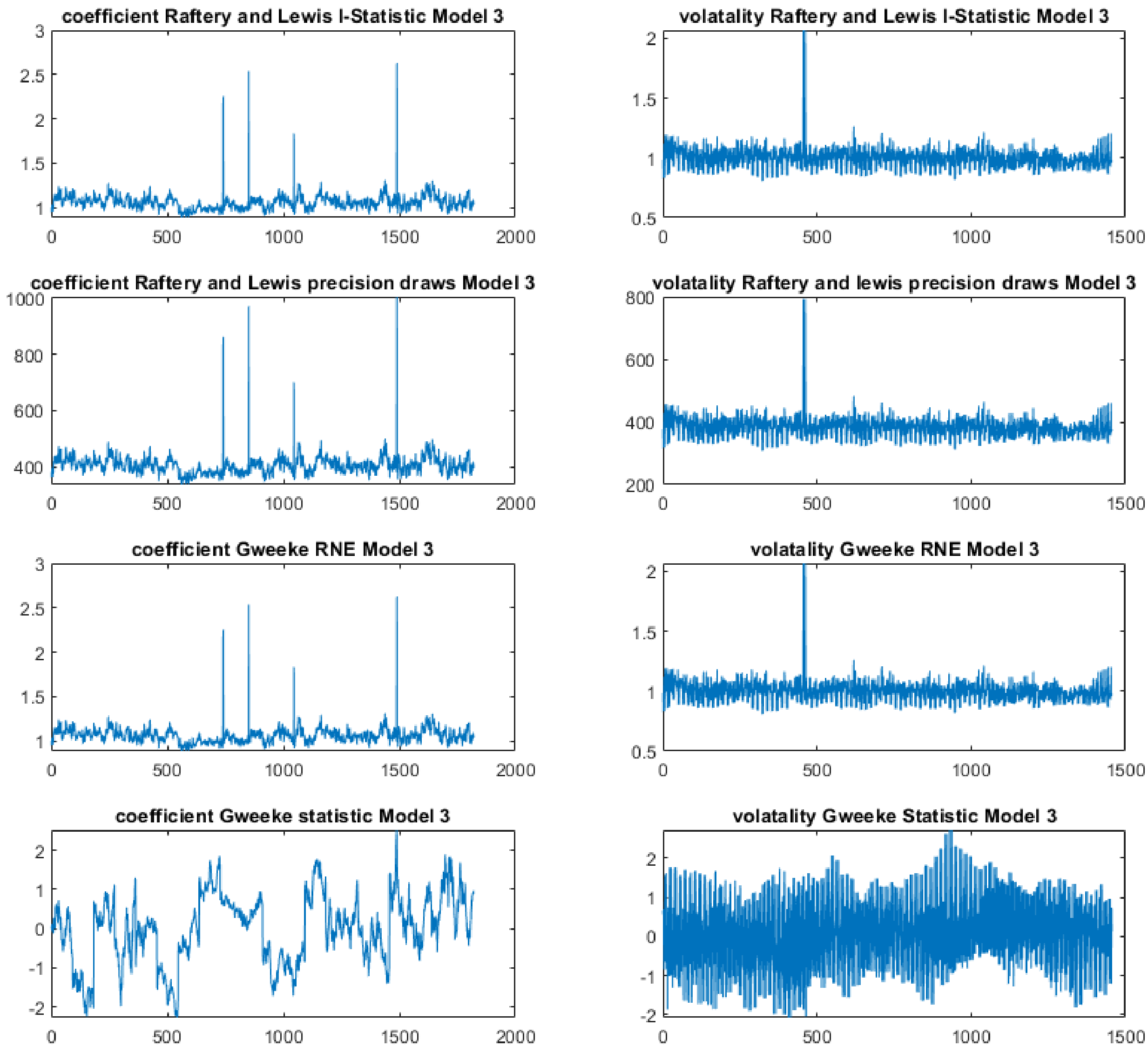

Figure A.4 Gweek's, Raftery and Lewis Convergence Diagnostic for Coefficient and Volatility Parameters in Model 3.

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value.

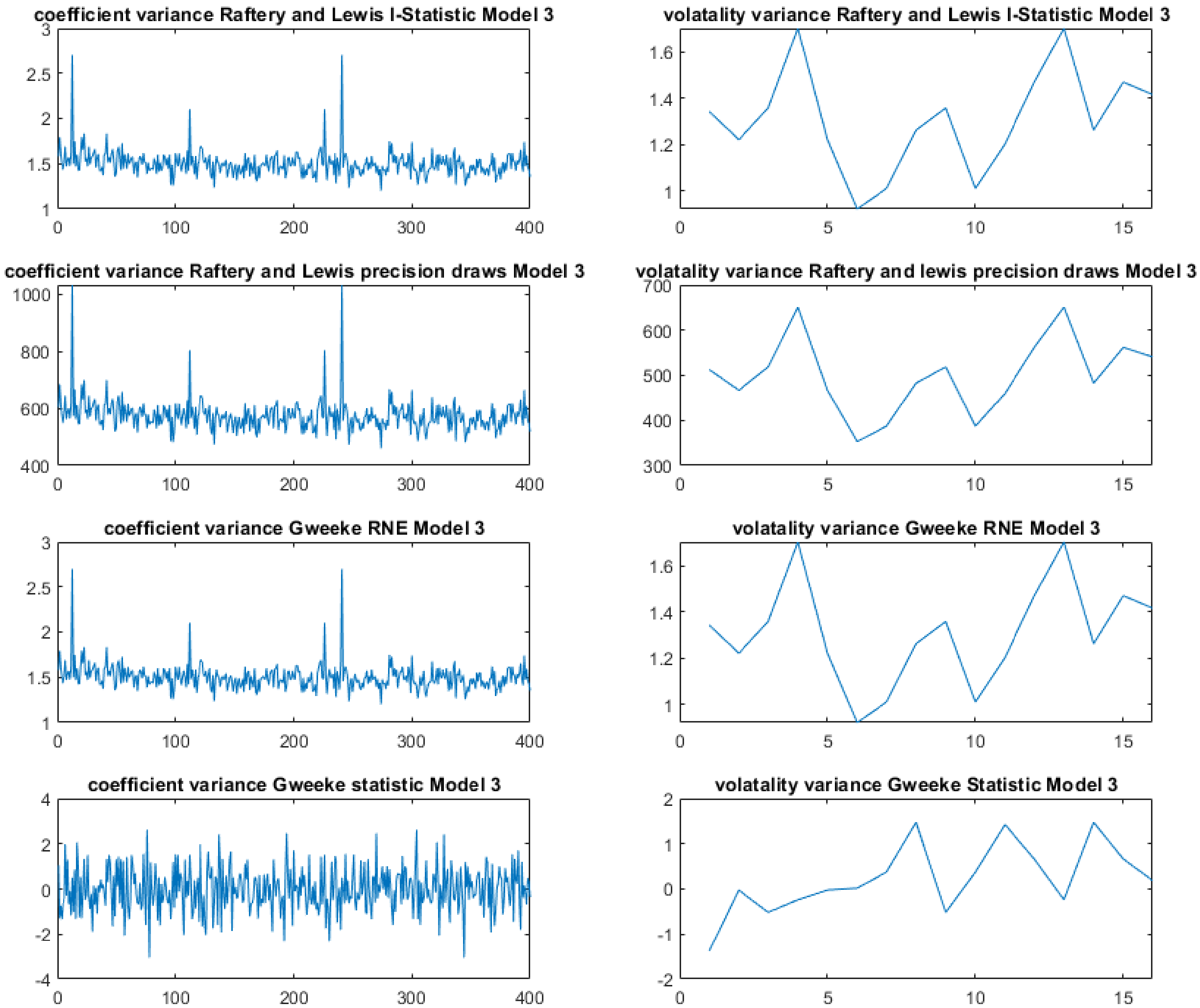

Figure A.5 Gweek's, Raftery and Lewis Convergence Diagnostic for Variance of Coefficient and Volatility Parameters in Model 3

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value.

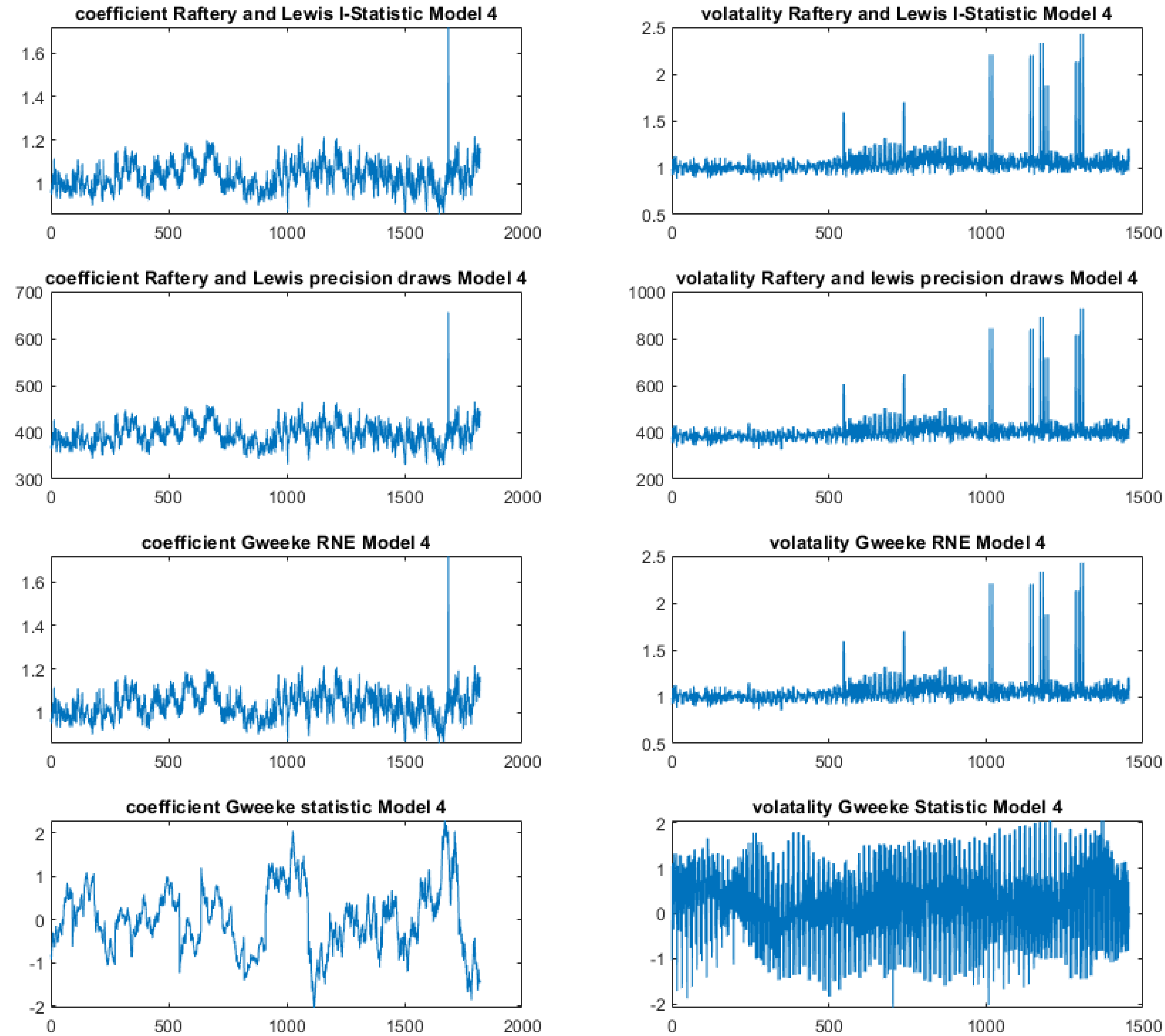

Figure 6 Gweek's, Raftery and Lewis Convergence Diagnostic for Coefficient and Volatility Parameters in Model 4.

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value

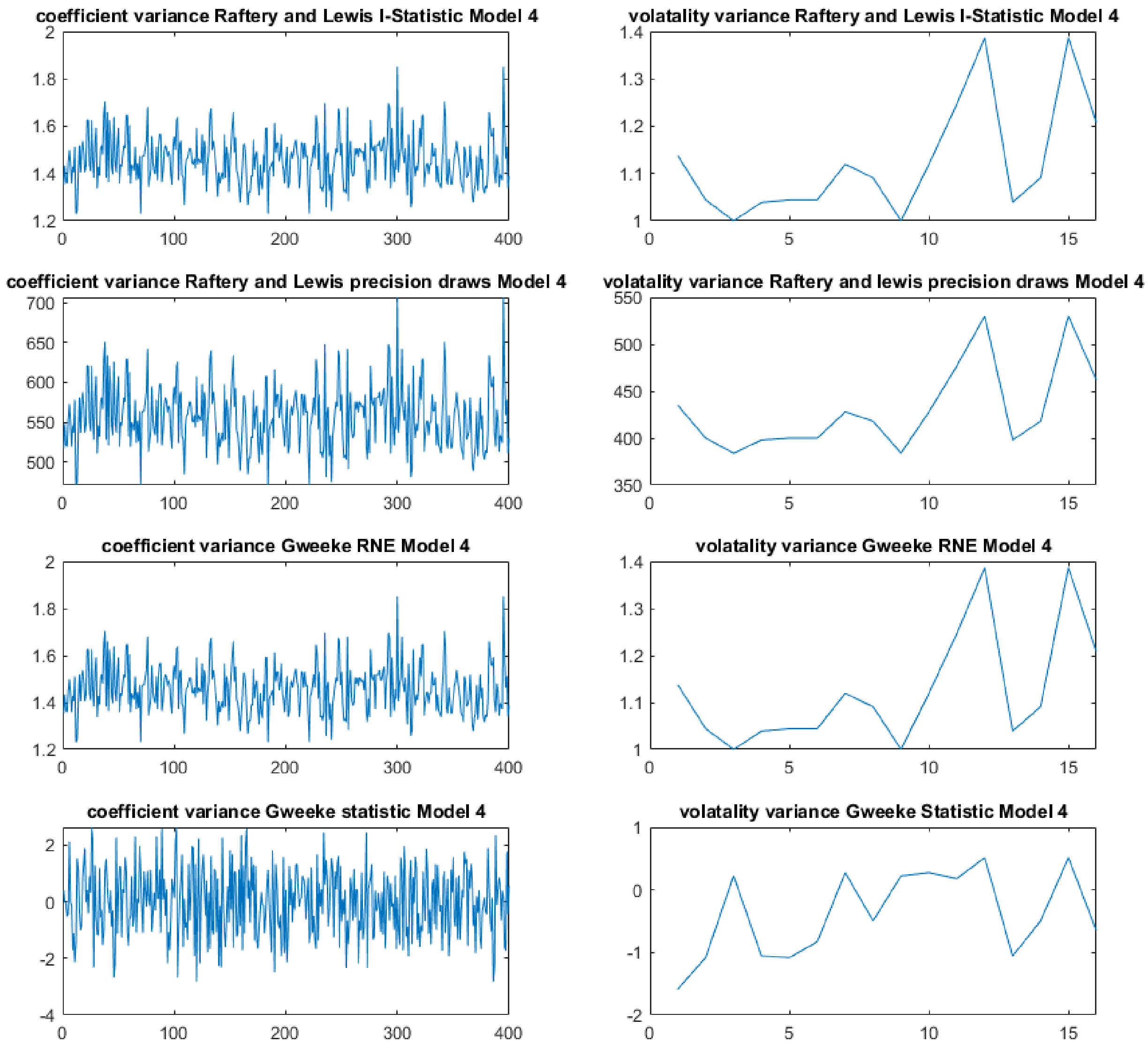

Figure A.7 Gweek's, Raftery and Lewis Convergence Diagnostic for Variance of Coefficient and Volatility Parameters in Model 4

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value

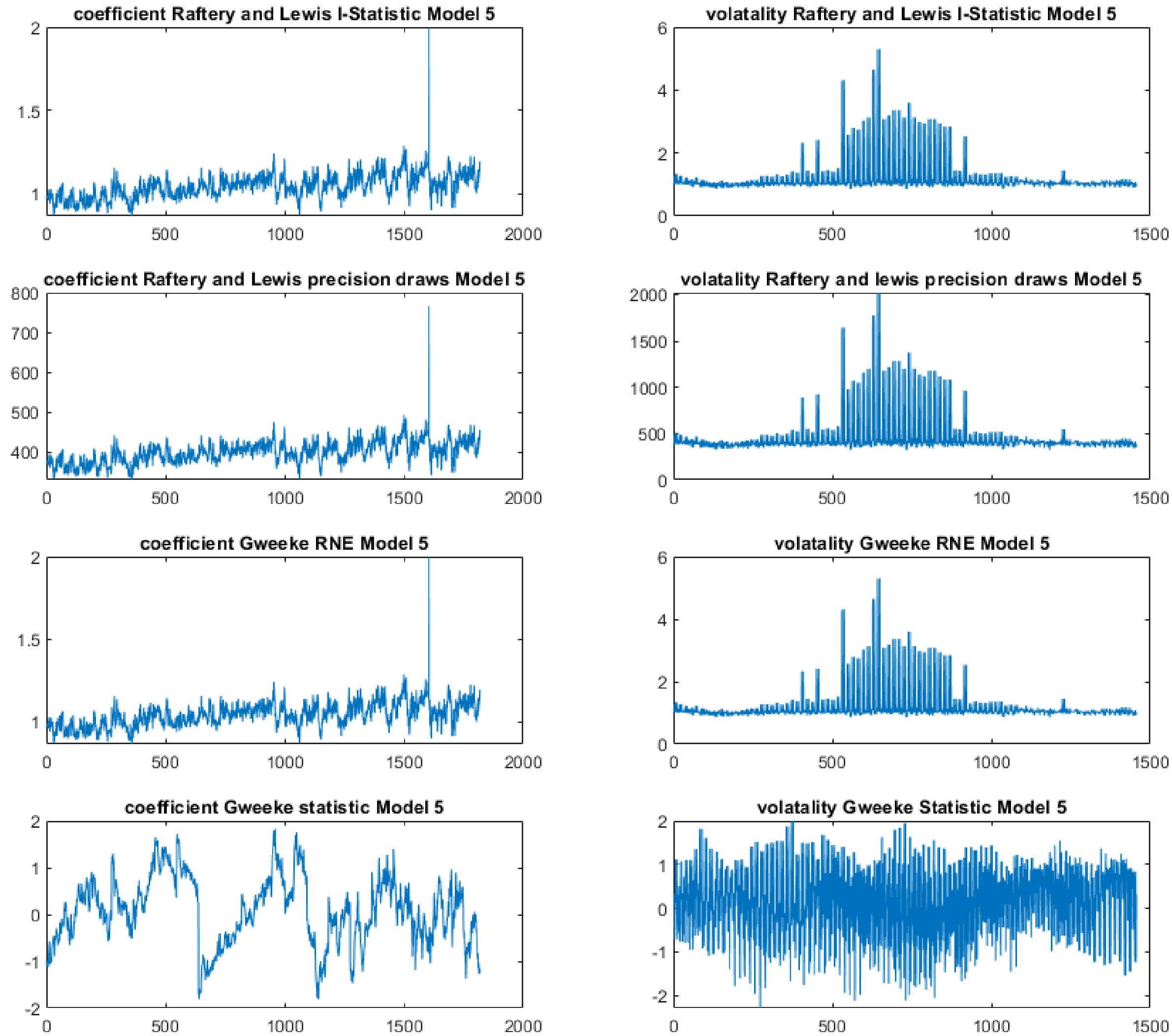

Figure A.8 Gweek's, Raftery and Lewis Convergence Diagnostic for Coefficient and Volatility Parameters in Model 5.

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value

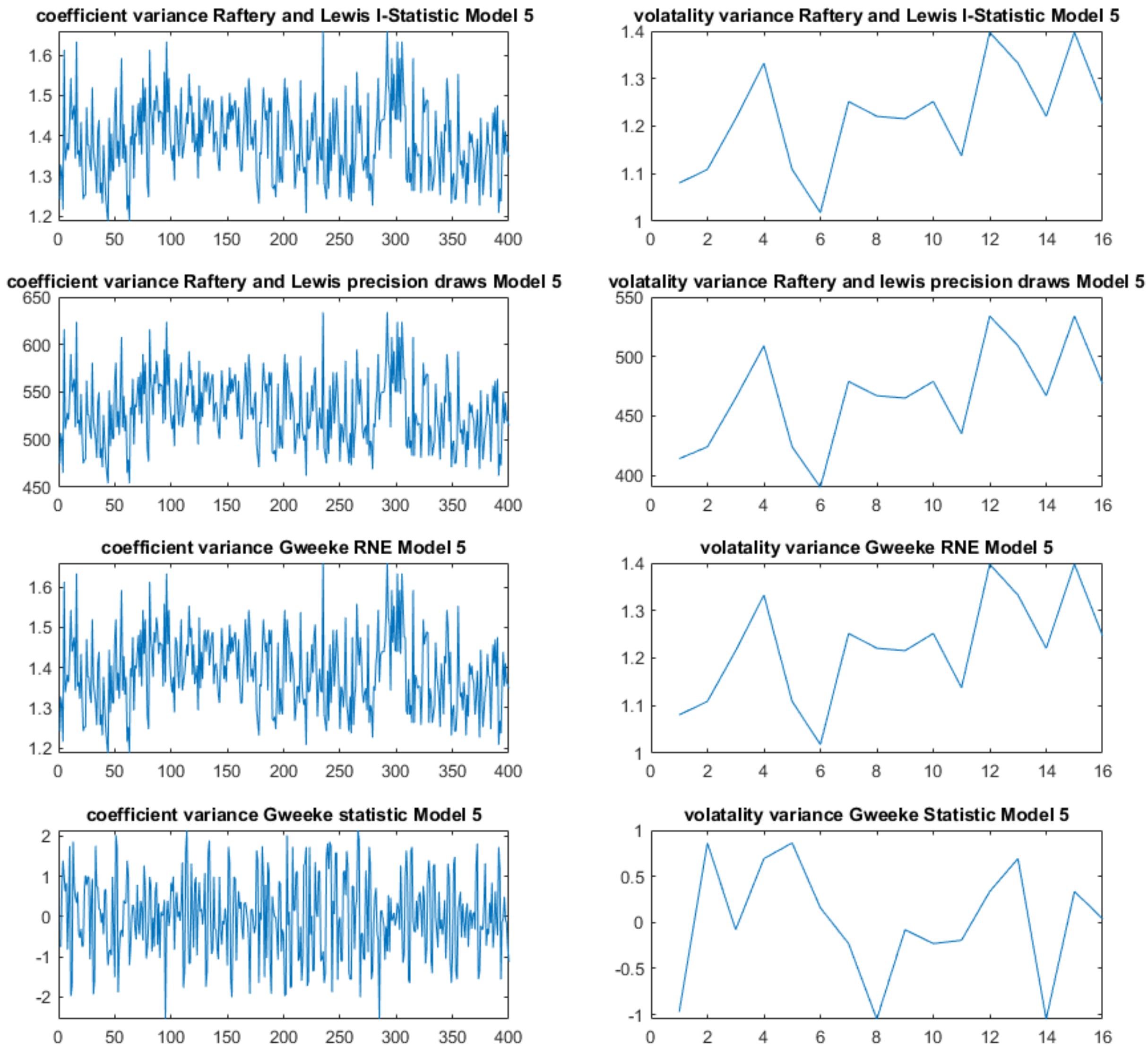

Figure A.9 Gweek's, Raftery and Lewis Convergence Diagnostic for Variance of Coefficient and Volatility Parameters in Model 5

Note: X-Axis reports the TVP-VAR coefficients, and Y axis reports their convergence diagnostic value

A.3 Robustness of Regression Results

Table A.2 Bayesian Linear Regression with Dependent Variables as PE Multipliers at 16 and 20 Quarters Computed with Prior hyperparameters B

	Revenue Expenditure Multipliers		Total Expenditure Multipliers		Capital Expenditure Multipliers	
	Multiplier at 16 Quarter	Multiplier at 20 Quarters	Multiplier at 16 Quarter	Multiplier at 20 Quarters	Multiplier at 16 Quarter	Multiplier at 20 Quarters
Structural Factors						
Intercept	2.9402***	3.6549***	2.7037***	3.8651***	3.5553***	4.4124***
	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
Debt-GDP Ratio	-0.6235***	-0.7192***	-0.4963**	-0.6176***	-0.6566**	-0.7481**
	(0.006)	(0.004)	(0.026)	(0.008)	(0.019)	(0.017)
Government Share	0.0019	0.0080	-0.0029	-0.0008	-0.0019	0.0062
	(0.573)	(0.752)	(0.400)	(0.474)	(0.441)	(0.652)
MPC^{DG}	0.1436***	0.1756***	0.1716***	0.01815***	0.4658***	0.5318***
	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
Credit-GDP Ratio	0.0072**	0.0067**	0.0106***	0.0114**	0.0204***	0.0277**
	(0.989)	(0.980)	(0.999)	(1.000)	(1.000)	(1.000)
Import Share	-0.0138**	-0.0174**	-0.0076	-0.0127*	-0.0253***	-0.0326***
	(0.049)	(0.025)	(0.178)	0.069	(0.008)	(0.003)
Trend	-0.0059**	-0.0149***	0.0026	-0.0064***	0.0335***	0.0088***
	(0.043)	(0.000)	(0.765)	(0.000)	(1.000)	(1.000)

Note: a. MPC^{DG} in regression is computed at the same quarter as PE multipliers.
b. The value in brackets shows the probability of regression coefficients being positive.
c. If the probability value is greater than 0.9, 0.95 and 0.99, then the regression coefficient is positive and significant at 10 percent, 5 percent and 1 percent levels.
d. If the probability value is less than 0.1, 0.05 and 0.01, then the regression coefficient is negative and significant at 10 percent, 5 percent and 1 percent levels.
e. *, **, *** indicates significance at 90, 95 and 99 percent levels

Table A.3 Bayesian Linear Regression with Dependent Variables as PE Multipliers at 4, 8, and 12 Quarters Computed with Prior hyperparameters B

	Revenue Expenditure Multipliers			Total Expenditure Multipliers			Capital Expenditure Multipliers		
	Short-Run		Medium-Run	Short-Run		Medium-Run	Short-Run		Medium-Run
	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters
Structural Factors									
Intercept	0.1534	1.0423*	1.8900***	0.0693	1.0688*	1.9741***	0.1667	1.2908**	2.2837***
	(0.614)	(0.945)	(0.997)	(0.556)	(0.944)	(0.996)	(0.618)	(0.966)	(0.998)
Debt-GDP Ratio	-0.0627	-0.2222	-0.4629**	-0.0274	-0.1927	-0.3880**	-0.0744	-0.1994	-0.4447**
	(0.385)	(0.162)	(0.026)	(0.453)	(0.202)	(0.05)	(0.364)	(0.208)	(0.047)
Government Share	-0.0012	-0.0014	0.0038	-0.0019	-0.0036	-0.0024	-0.0026	-0.0057	-0.0060
	(0.453)	(0.444)	(0.640)	(0.416)	(0.366)	(0.408)	(0.481)	(0.302)	(0.314)
MPC^{DG}	0.0357	0.0914*	0.1090***	0.0519	0.1448***	0.1728***	0.1459*	0.2854***	0.3703***
	(0.624)	(0.941)	(0.993)	(0.676)	(0.992)	(1.000)	(0.901)	(1.000)	(1.000)
Credit-GDP Ratio	0.0011	0.0027	0.0059**	0.0030	0.0058**	0.0091***	0.0031	0.0062**	0.0141***
	(0.645)	(0.823)	(0.973)	(0.843)	(0.975)	(0.998)	(0.857)	(0.974)	(1.000)
Import Share	-0.0008	-0.0025	-0.0083	-0.0006	-0.0004	-0.0040	-0.0016	-0.0068	-0.0165**
	(0.460)	(0.375)	(0.144)	(0.476)	0.478	(0.314)	(0.419)	0.207	(0.034)
Trend	-0.0001	-0.0031	-0.0066	-0.0004	-0.0006	0.0006	0.0015	0.0091***	0.0187***
	(0.480)	(0.108)	(0.014)	(0.415)	(0.408)	(0.588)	(0.794)	(0.999)	(1.000)

Note: a. MPC^{DG} in regression is computed at the same quarter as PE multipliers.
b. The value in brackets shows the probability of regression coefficients being positive.
c. If the probability value is greater than 0.9, 0.95 and 0.99, then the regression coefficient is positive and significant at 10 percent, 5 percent and 1 percent levels.
d. If the probability value is less than 0.1, 0.05 and 0.01, then the regression coefficient is negative and significant at 10 percent, 5 percent and 1 percent levels.
e. *, **, *** indicates significance at 90, 95 and 99 percent levels

Table A.4 Bayesian Linear Regression with Dependent Variables as PE Multipliers at 16 and 20 Quarters Computed with Prior hyperparameters C

	Revenue Expenditure Multipliers		Total Expenditure Multipliers		Capital Expenditure Multipliers	
	Multiplier at 16 Quarter	Multiplier at 20 Quarters	Multiplier at 16 Quarter	Multiplier at 20 Quarters	Multiplier at 16 Quarter	Multiplier at 20 Quarters
Structural Factors						
Intercept	2.2266***	3.0354***	3.3669***	3.6983***	4.1585***	3.8503***
	(0.999)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
Debt-GDP Ratio	-0.3849**	-0.4935**	-0.5855***	-0.6321***	-0.6174**	-0.5745**
	(0.050)	(0.032)	(0.009)	(0.006)	(0.016)	(0.033)
Government Share	0.0030	0.0053	0.0024	0.0048	0.0063	0.0037
	(0.609)	(0.681)	(0.588)	(0.671)	(0.691)	(0.608)
MPC^{DG}	0.1502***	0.1790***	0.2263***	0.2062***	0.4716***	0.5045***
	(0.999)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
Credit-GDP Ratio	0.0074***	0.0093**	0.0085***	0.0093***	0.0142***	0.0186**
	(0.991)	(0.999)	(0.997)	(0.998)	(1.000)	(1.000)
Import Share	-0.0053	-0.0112*	-0.0042	-0.0088	-0.0164***	-0.0194**
	(0.253)	(0.091)	(0.299)	0.145	(0.039)	(0.027)
Trend	-0.0086***	-0.0183***	0.0045*	-0.0075***	0.0293***	0.0048**
	(0.007)	(0.000)	(0.906)	(0.000)	(1.000)	(0.987)

Note: a. MPC^{DG} in regression is computed at the same quarter as PE multipliers.
b. The value in brackets shows the probability of regression coefficients being positive.
c. If the probability value is greater than 0.9, 0.95 and 0.99, then the regression coefficient is positive and significant at 10 percent, 5 percent and 1 percent levels.
d. If the probability value is less than 0.1, 0.05 and 0.01, then the regression coefficient is negative and significant at 10 percent, 5 percent and 1 percent levels.
e. *, **, *** indicates significance at 90, 95 and 99 percent levels

Table A.5 Bayesian Linear Regression with Dependent Variables as PE Multipliers at 4, 8, and 12 Quarters Computed with Prior hyperparameters C

	Revenue Expenditure Multipliers			Total Expenditure Multipliers			Capital Expenditure Multipliers		
	Short-Run		Medium-Run	Short-Run		Medium-Run	Short-Run		Medium-Run
	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters
Structural Factors									
Intercept	-0.0323	0.7641	1.4915**	0.3230	1.3173**	2.4941***	0.2587	1.2974**	3.1383***
	(0.479)	(0.875)	(0.983)	(0.714)	(0.977)	(0.999)	(0.674)	(0.969)	(0.998)
Debt-GDP Ratio	-0.0218	-0.1363	-0.2520	-0.0918	-0.2735	-0.5054**	-0.0512	-0.2107	-0.5476**
	(0.464)	(0.280)	(0.144)	(0.348)	(0.123)	(0.019)	(0.410)	(0.196)	(0.019)
Government Share	-0.0008	-0.0006	-0.0001	-0.0004	-0.0017	0.0007	-0.0004	-0.0026	0.0023
	(0.466)	(0.474)	(0.498)	(0.476)	(0.436)	(0.522)	(0.483)	(0.404)	(0.576)
MPC^{DG}	0.0561	0.1180*	0.1303**	0.1123	0.1962***	0.2095***	0.11314	0.3030***	0.4185***
	(0.655)	(0.933)	(0.987)	(0.785)	(0.993)	(1.000)	(0.822)	(1.000)	(1.000)
Credit-GDP Ratio	0.0019	0.0033	0.0051**	0.0030	0.0066**	0.0080***	0.0017	0.0066**	0.0103***
	(0.734)	(0.877)	(0.961)	(0.833)	(0.989)	(0.996)	(0.713)	(0.986)	(0.999)
Import Share	-0.0011	-0.0010	-0.0023	-0.0023	-0.0044	-0.0046	-0.0024	-0.0081	-0.0140**
	(0.442)	(0.452)	(0.385)	(0.381)	0.285	(0.280)	(0.377)	0.152	(0.055)
Trend	-0.0005	-0.0028	-0.0063	-0.0009	-0.0007	0.0007	0.0003	0.0058**	0.0168***
	(0.383)	(0.114)	(0.017)	(0.302)	(0.391)	(0.589)	(0.563)	(0.989)	(1.000)

Note: a. MPC^{DG} in regression is computed at the same quarter as PE multipliers.
b. The value in brackets shows the probability of regression coefficients being positive.
c. If the probability value is greater than 0.9, 0.95 and 0.99, then the regression coefficient is positive and significant at 10 percent, 5 percent and 1 percent levels.
d. If the probability value is less than 0.1, 0.05 and 0.01, then the regression coefficient is negative and significant at 10 percent, 5 percent and 1 percent levels.
e. *, **, *** indicates significance at 90, 95 and 99 percent levels

Table A.6 Bayesian Linear Regression with Dependent Variables as PE Multipliers at 16 and 20 Quarters Computed with Prior hyperparameters D

	Revenue Expenditure Multipliers		Total Expenditure Multipliers		Capital Expenditure Multipliers	
	Multiplier at 16 Quarter	Multiplier at 20 Quarters	Multiplier at 16 Quarter	Multiplier at 20 Quarters	Multiplier at 16 Quarter	Multiplier at 20 Quarters
Structural Factors						
Intercept	3.2234***	2.8201***	1.9290**	3.5589***	1.2270	1.0546
	(1.000)	(1.000)	(0.987)	(1.000)	(0.856)	(0.797)
Debt-GDP Ratio	-0.0380	-0.1215	-0.1844	-0.3540	0.6772*	0.4970
	(0.449)	(0.338)	(0.272)	(0.140)	(0.947)	(0.853)
Government Share	-0.0148	-0.0150	-0.0207*	-0.0237*	-0.0313*	-0.0362**
	(0.120)	(0.139)	(0.077)	(0.056)	(0.057)	(0.048)
MPC^{DG}	0.2381***	0.2376***	0.2316***	0.2012***	0.6059***	0.7276***
	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
Credit-GDP Ratio	0.0018	0.0010	0.0152***	0.0182***	0.0165***	0.0266**
	(0.680)	(0.596)	(0.999)	(1.000)	(0.998)	(1.000)
Import Share	-0.0052	-0.0141*	-0.0089	-0.0158*	0.0016	-0.0060
	(0.290)	(0.081)	(0.194)	(0.078)	(0.545)	(0.361)
Trend	0.0035	-0.0140***	0.0070*	-0.0043**	0.0541***	0.0129***
	(0.786)	(0.000)	(0.917)	(0.024)	(1.000)	(1.000)

Note: a. MPC^{DG} in regression is computed at the same quarter as PE multipliers.
b. The value in brackets shows the probability of regression coefficients being positive.
c. If the probability value is greater than 0.9, 0.95 and 0.99, then the regression coefficient is positive and significant at 10 percent, 5 percent and 1 percent levels.
d. If the probability value is less than 0.1, 0.05 and 0.01, then the regression coefficient is negative and significant at 10 percent, 5 percent and 1 percent levels.
e. *, **, *** indicates significance at 90, 95 and 99 percent levels

Table A.7 Bayesian Linear Regression with Dependent Variables as PE Multipliers at 4, 8, and 12 Quarters Computed with Prior hyperparameters D

	Revenue Expenditure Multipliers			Total Expenditure Multipliers			Capital Expenditure Multipliers		
	Short-Run		Medium-Run	Short-Run		Medium-Run	Short-Run		Medium-Run
	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters	Multiplier at 4 Quarter	Multiplier at 8 Quarters	Multiplier at 12 Quarters
Structural Factors									
Intercept	0.1081	1.3446**	2.4676***	-0.1953	0.3602	1.0006	-0.3643	-0.2332	0.5272
	(0.577)	(0.982)	(1.000)	(0.361)	(0.702)	(0.896)	(0.253)	(0.375)	(0.701)
Debt-GDP Ratio	-0.0561	-0.1442	-0.1053	-0.0065	-0.0965	-0.1014	0.0655	0.3480	0.5540*
	(0.394)	(0.274)	(0.340)	(0.493)	(0.352)	(0.358)	(0.612)	(0.891)	(0.938)
Government Share	-0.0023	-0.0077	-0.0126	-0.0052	-0.0131	-0.0162	-0.0046	-0.0157	-0.0212
	(0.413)	(0.246)	(0.144)	(0.307)	(0.139)	(0.112)	(0.331)	(0.113)	(0.106)
MPC^{DG}	0.0606	0.1792***	0.2324***	0.0582	0.1661***	0.2124***	0.0909	0.3138***	0.4917***
	(0.803)	(0.999)	(1.000)	(0.785)	(0.997)	(1.000)	(0.895)	(1.000)	(1.000)
Credit-GDP Ratio	0.0021	0.0030	0.0024	0.0049**	0.0112***	0.0141***	0.0028	0.0066**	0.0107**
	(0.766)	(0.821)	(0.747)	(0.956)	(0.999)	(1.000)	(0.836)	(0.957)	(0.980)
Import Share	-0.0022	-0.0046	-0.0040	-0.0010	-0.0038	-0.0054	0.0022	0.0022	0.0002
	(0.387)	(0.287)	(0.323)	(0.454)	(0.333)	(0.292)	(0.613)	(0.593)	(0.505)
Trend	-0.0010	-0.0018	0.0001	-0.0024	-0.0034	0.0012	0.0005	0.0125***	0.0334***
	(0.318)	(0.280)	(0.514)	(0.124)	(0.159)	(0.614)	(0.588)	(0.999)	(1.000)

Note: a. MPC^{DG} in regression is computed at the same quarter as PE multipliers.
b. The value in brackets shows the probability of regression coefficients being positive.
c. If the probability value is greater than 0.9, 0.95 and 0.99, then the regression coefficient is positive and significant at 10 percent, 5 percent and 1 percent levels.
d. If the probability value is less than 0.1, 0.05 and 0.01, then the regression coefficient is negative and significant at 10 percent, 5 percent and 1 percent levels.
e. *, **, *** indicates significance at 90, 95 and 99 percent levels