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Let's Get Fiscal: Extending the Small Macroeconometric Model of the Philippine Economy

Margarita Debuque-Gonzales and John Paul P. Corpus

CONTACT US:

RESEARCH INFORMATION DEPARTMENT
Philippine Institute for Development Studies

18th Floor, Three Cyberpod Centris - North Tower
EDSA corner Quezon Avenue, Quezon City, Philippines

publications@pids.gov.ph
(+632) 8877-4000

https://www.pids.gov.ph

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Margarita Debuque-Gonzales
John Paul P. Corpus

PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES

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Abstract

This study presents a small macroeconometric model with a fiscal sector, extending the model presented in Debuque and Corpus (2022). The model retains the original core blocks of domestic demand, international trade, employment, prices, and monetary sectors, and adds a fiscal sector consisting of equations for government revenues, expenditures, and debt. Behavioral equations are estimated in error-correction form (using ARDL methodology) on quarterly data from 2002 to 2019. In-sample simulations demonstrate acceptable levels of predictive accuracy for most macroeconomic variables, even when producing dynamic forecasts. The model also shows plausible outcomes on the fiscal side in response to shocks in world oil prices, the exchange rate, and primary expenditure, showing the expanded model's policy simulation capabilities. The next steps for developing the model include adding a detailed financial block, modeling the aggregate supply side, and incorporating expectations.

Keywords: macroeconometric model, Philippine economy, forecast, simulation, fiscal sector

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Let's Get Fiscal: Extending the Small Macroeconometric Model of the Philippine Economy

Margarita Debuque-Gonzales and John Paul P. Corpus*

1. Introduction

This paper extends the small macroeconometric model presented in Debuque and Corpus (2022) by adding a more detailed fiscal sector. As noted in the former study, there is a scarcity of working macroeconometric models that can be used for comprehensive policy analysis in the Philippines. This study contributes to filling the said gap.

A macroeconometric model that allows for fiscal policy analysis is particularly useful at a time when fiscal issues have become paramount. In 2021, the fiscal deficit reached 8.6 percent of GDP while the debt-to-GDP ratio rose to 60.4 percent, breaching the 60 percent indicative cap prescribed by economic authorities. In its Medium-Term Fiscal Framework, the current administration aims to reduce the fiscal deficit to 3 percent of GDP and bring the debt ratio below 60 percent by 2025.

Given the increased importance of the fiscal sector, we include an endogenous fiscal block that provides a better representation of the government sector. We specify its linkages with other sectors of the economy, particularly through ties with the monetary sector. Building a fiscal block allows us to conduct more realistic simulations that reveal responses of fiscal variables and outcomes for the public sector under different macroeconomic shocks, including fiscal policy shocks, as well as provides a better understanding of how the domestic economy functions.

The next section provides a brief review of macroeconometric models with fiscal blocks in the Philippine setting and in recent literature. Section 3 introduces the structure of the small model, the fiscal sector, and their interconnections. Section 4 presents the in-sample simulation results of the model, while Section 5 focuses on impact analysis, namely the effects of shocks to world oil prices, the nominal exchange rate, and primary expenditure.

2. Review of macroeconometric models and their fiscal block

There are two groups of macroeconometric models (MEMs) of the Philippine economy relevant to this paper. The first comprises the structural models built by the Philippine Institute for Development Studies (PIDS)—by itself or in collaboration with other parts of government—which were primarily meant to guide policymaking. The second consists of models constructed by non-government institutions, particularly in the early to mid-2000s, which were designed for both forecasting and policy analysis.

* Senior Research Fellow and Supervising Research Specialist, respectively, at the Philippine Institute for Development Studies. The authors acknowledge Ramona Maria Miral for her research assistance.

2.1. Philippine models

In the first group, one finds the PIDS Annual MEM of Yap (2000) which uses the same theoretical basis as the earlier PIDS-NEDA Annual MEM, originally created in the late 1980s to provide a broad framework for the country's medium-term development plan.[1] In the fiscal block of this model, tax revenues were disaggregated into direct taxes and trade taxes, which were modeled as functions of nominal GNP and nominal goods imports, respectively. Estimates of total taxes were then combined with endogenous government spending (consumption and construction) to compute for the government deficit. The fiscal sector was linked to the real sector primarily through the short-term interest rate. The 91-day Treasury bill (T-bill) rate was modeled as a function of the government deficit ratio and cast as correlates of (narrow and broad) money, which were in turn explanatory variables in production and demand equations.

The PIDS Annual MEM was ultimately followed by the PIDS-BSP Annual MEM (Reyes et al., 2020), which was likewise built as part of PIDS' objectives to assist macroeconomic stakeholders, especially in government, in their conduct of policy simulations, macroeconomic monitoring, and economic analysis. The PIDS-BSP model closely followed the PIDS-NEDA model (Reyes and Yap, 1993) while also drawing from Yap (2000). However, it featured greater disaggregation of household consumption spending and an updated breakdown of traded goods and services, to highlight subsectors that gained importance over the years (specifically, computer services exports, to capture the activity of BPOs, and tourism).

Similarly, fiscal sector accounts were also more finely disaggregated than in the earlier models, mirroring the general government income and outlay accounts of the Philippine System of National Accounts. Total revenues were divided into different streams and modelled separately, typically as a function of *both* the effective tax/contribution rate and revenue base. Government final consumption expenditures were taken as exogenous and linked to actual government spending through a bridge equation. The resulting model allowed for the calculation of the government deficit and debt stock.

In the second group, one finds the quarterly Ateneo Macroeconomic and Forecasting Model (AMFM), which was created based on the short-run version of the Murphy model of Australia (Rodriguez and Briones 2002). It was a smaller model designed to provide a transparent framework for comprehensive analysis of the impact of policy changes and exogenous shocks. The modeling strategy was similar to that used in many structural MEMs abroad, at least on the revenue side, with fiscal variables disaggregated and some revenue streams computed as the product of an exogenous tax rate and an endogenous macroeconomic base. This approach was adopted for various tax sources, including income and profit taxes, indirect taxes, and import taxes.[2] Expenditures were also disaggregated–into national government outlays for maintenance and operations, investment, interest payments, transfers, and net lending–but only interest payments were determined within the model, while the rest were considered exogenous. The AMFM's fiscal block consisted mostly of identity equations, with identities also used to compute for the budget deficit and public debt within the model.

[1] Versions included those by Constantino and Yap (1988), Constantino, et al. (1990), and Reyes and Yap (1993). The NEDA also built a quarterly macroeconometric model (NEDA-QMM) beginning the late 1990s, with the last update chronicled in the late 2000s (Bautista, Mariano, and Bawagan, 2009). However, details of the model, particularly of the fiscal block, are not available.

[2] Other revenue streams (i.e., other taxes and non-tax sources, comprising mostly transfers) were treated as exogenous variables.

The last non-government structural MEM of the Philippine economy created had been the small to medium-sized model put together by a team from the Asian Development Bank (Cagas et al. 2006).[3] Extra effort was taken to develop the model's fiscal block, by purposely linking it with other sectors (e.g., by including the debt-to-GDP ratio among the variables used to explain investment). As fiscal sustainability had been a salient concern during the period—with national government debt at above 70 percent of nominal GDP in the mid-2000s—fiscal simulation experiments were conducted by first setting upper bounds on deficits and the debt ratio, then additionally, by sustaining an increase in tax collections. This allowed the modelers to trace the impact of the fiscal adjustments on key macro variables, such as investment and GDP growth, and on the debt-to-GDP ratio.

The ADB model followed Hendry's dynamic specification approach and applied automatic econometric model selection to get the best model fit. In the resulting specification, government's total revenues were taken to be a simple function of government tax revenues, which in turn were modeled as a function of GNP. Total government expenditures, on the other hand, were divided into two components—interest payment on debt, modeled as a fraction of total debt that depends on the 91-day T-bill rate and the exchange rate; and non-interest spending, formulated as a function of total government revenues, the debt-to-GDP ratio, and the unemployment rate.

Government debt meanwhile was modeled as a behavioral equation, rather than computed as an identity using the government deficit, which was the usual approach. This specification was adopted due to the importance of non-deficit-financing factors during the period covered (i.e., debt that traced to losses of state-owned enterprises in the late 1980s and early 1990s). Public debt was divided into domestic debt, modeled as a function of the government deficit and the 91-day T-bill rate; and foreign debt, also formulated as a function of the government deficit, but which additionally depends on the interest differential between domestic and US lending rates and the exchange rate.

2.2. Recent structural models

Structural MEMs continue to emerge in the empirical literature despite the dominance of other methods, especially microfounded systems, with varied approaches taken in modeling the fiscal sector.[4] Bagnai et al. (2017), for instance, constructed a medium-sized MEM of the Italian economy based on a standard AS/AD framework, which was common for models of similar size in Europe. This research strategy was chosen, as it allowed the authors to conduct detailed policy experiments—mainly, the withdrawal of Italy from the euro area—through stochastic simulations of the model.[5]

The Italian model's fiscal block was typical of traditional structural MEMs, with revenue variables formulated as the nominal tax base multiplied by the relevant tax rate for direct and indirect taxes and nominal wages multiplied by the average social security contribution rate for social security contributions. Also following other MEMs, only social security benefits were modeled through a behavioral function, with the rest of the fiscal block formulated as identities, including government deficits and debt, with the latter making use of standard equations for

[3] See Ducanes et al. (2005) for the full model.

[4] See Debuque-Gonzales and Corpus (2022) for a review of developments in macroeconometric modeling.

[5] Authors of the paper note that such detailed policy scenarios would not have been possible using a vector autoregression (VAR), a popular alternative that addressed the Sim's Critique of 'incredible' identification restrictions imposed by MEMs, as VARs can be applied to a relatively limited number of variables.

debt dynamics. Government deficit and debt ratios (in percent of GDP) influence the long-term interest rate in this model, ultimately linking the fiscal sector to the real economy through capital accumulation.

More recently, Akbar and Ahmad (2021) built a large structural MEM to analyze the impacts of exchange rate depreciation in Pakistan. They also adopted an AS/AD framework but based on an IS-LM-BoP model for open economies. This allowed them to simulate the effects of an important policy event in the context of a developing economy. The model's fiscal block is close to that of the PIDS MEMs in the sense that revenues and expenditures were disaggregated, and various streams modeled, with different behavioral functions assigned to each stream. Identities were likewise used for government deficit and debt computations. The more unique feature was the use of balance-of-payments accounting to compute for foreign and domestic borrowing and to subsequently work out the time paths of foreign and domestic debt stocks.

3. The expanded macroeconometric model

The model we build in this paper extends the small macroeconometric model of the Philippine economy introduced in Debuque-Gonzales and Corpus (2022). We earlier argued for a pragmatic approach, where the goal was to build a policy model suitably guided by economic theory yet able to fit the data reasonably well. A premium was applied on usability, tractability, and ease of maintenance, apart from model validity and robustness. The same philosophy holds for the current model.

The original system comprised 5 blocks with 15 equations (10 behavioral and 5 identity equations), covering the basic parts of the economy, namely: (1) domestic demand, (2) international trade, (3) employment, (4) prices, and (5) rudimentarily, a financial/monetary sector. The current model adds a fiscal block and expands the financial/monetary sector, bringing the total number of equations to 38, of which 20 are behavioral equations and 18 are identities.

The grey-colored boxes in Figure 3.1 represent the original blocks of the macroeconometric model, while the red box represents the fiscal block. Table 3.1 summarizes the key equations and variables. We continue to adopt a stylized framework where output is determined from the demand side, as in earlier Keynes-based models and some small macroeconometric models of more recent vintage (e.g., Kasimati and Dawson, 2009; Hammersland and Træe, 2014).

3.1. Estimation method and data

We continue to follow an ARDL-ECM approach, which allows us to incorporate economic theory and intuition in the equations defining long-run equilibrium relationships as well as to capture observed data dynamics through the short-run equations. We estimated the behavioral equations through EViews, with the Akaike Information Criterion used to optimally select lag lengths up to a maximum of 2. Cointegration between variables meanwhile was tested using the Pesaran, Shin, and Smith (2001) bounds test.

Specifications were chosen such that coefficients of long-run variables display signs that conform with theory. Explanatory variables with coefficient signs that were inconsistent with theory or intuition were relegated to the short-run equation (if found to be significant) or dropped completely. In the absence of cointegration, behavioral equations were modeled as short-run ARDL models (i.e., in first differences). Residual diagnostic checks testing for homoskedasticity, serial correlation, and normality were performed. Cumulative sum (CUSUM) and CUSUM of squares tests were used to check parameter and variance stability, respectively. The system of behavioral equation and identities was solved in EViews using the Broyden solution algorithm. The model was then evaluated through forecast and impact simulations.

We used quarterly data spanning 2002 to 2019 to construct the model, two years longer than the data sample used in the original/small model (2002 to 2017). Data from the COVID-19 pandemic years of 2020 to 2022 were still excluded due to the unusual economic conditions during the period. All series were seasonally adjusted using the X-13 routine in EViews prior to estimation. Based on augmented Dickey Fuller tests, most series were revealed to be of order I(1) or I(0) (Appendix A). Table 3.2 summarizes the features of the data.

3.2. Model structure

The structure of the expanded model is discussed in greater detail below. The first part describes the blocks of the original/small macroeconometric model of the Philippine economy (loosely labelled as the basic blocks), while the second part details the newly added fiscal block.

3.2.1. The basic blocks

In the domestic demand block, private consumption is still formulated as a long-run function of disposable income (proxied by GDP net of internal revenue taxes), the employment rate, the real bank lending rate, and the CPI inflation rate.[6] However, short-run consumption growth is now specified as a function of disposable income and employment, rather than just its lag.[7] Investment also continues to be a function of GDP in the long run, in line with accelerator theory, but short-term investment growth is now modeled as dependent on price changes, to capture variations in cost, as well as on the real bank lending rate and GDP.

Notably, government consumption is no longer considered exogenous in the current model. Instead, it is cast as a function of primary spending (government spending net of interest payments) in the short and long horizons, with a trend variable added in the short-run specification.

As in the original small macro model, private investment and exports drive imports both in the long and short run, in the levels and first-differences equations.[8] Exports, in contrast, are now formulated as simply a function of the real peso-dollar exchange rate and world income in all horizons, with world income proxied by a trade-weighted aggregate of the GDP of the country's major export partners.[9] Although imports are no longer included as determinants of

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[6] As in Kasimati and Dawson (2009), we include inflation in the specification to capture wealth effects.

[7] The current model differs from the original small model mainly in the short-run specifications, with long-run equations remaining the same in most cases.

[8] In the earlier paper, the real effective exchange rate was omitted as an explanatory variable in the levels equation of imports because of the incorrect sign on the estimated coefficient (positive instead of negative). We similarly omit the real exchange rate (RER) in the current model. We substituted the REER in the original model with the RER in the current model, as it could be more conveniently computed within the model.

[9] These were: (1) Singapore, Malaysia, and Thailand from Southeast Asia; (2) Japan, Hong Kong, and South Korea from East Asia; (3) the United States and Mexico from North America; and (4) Netherlands, Germany, France,

exports in the expanded model, the overall structure of the trade block remains reflective of the country's role in the global supply chain.

The labor block consists solely of domestic employment. Employment is still cast as a variant of Okun's law, with the employment rate formulated as a function of GDP in the long run. In the short run, changes in the employment rate depend on its own lag.

Though we focus on developing the fiscal block, we also expand the financial/monetary block by adding equations for the 10-year Philippine treasury rate and effective interest rates on domestic as well as foreign debt.[10] The 10-year Philippine treasury rate is modeled as a function of the 91-day Philippine treasury bill (T-bill) rate in the long run, while corresponding changes in the yield of the domestic 10-year note are modeled as a function of inflation in the short run.

We formulate the effective interest rate on domestic debt as a function of the 10-year Philippine treasury rate in the long run but cast corresponding yield changes as simple autoregressions in the short run. Correspondingly, we formulate the effective interest rate on foreign debt as a function of the yield of the 10-year US treasury note and the Philippine debt-to-GDP ratio in both short and long horizons.

Unlike before, we were able to detect a cointegrating relationship for the policy rate and relevant variables.[11] We thus model the policy rate (the BSP's overnight reverse repurchase rate) as dependent on deviations of the inflation rate from the official target in the long run, with policy rate changes cast as an autoregressive function in the short run.[12]

We formulate the 91-day T-bill rate as a long-run function of the policy rate and the primary balance (as a percentage of GDP), and corresponding rate changes as a function of inflation in the short horizon. Previously modeled as solely a function of the 91-day T-bill rate in the absence of a long-maturity rate in the system, the real bank lending rate is now modeled as a long-term function of the policy rate and the 10-year Philippine treasury rate, while bank lending rate changes are formulated as a short-term function of its own lagged change and inflation. The policy rate this way transmits to the real economy—in summary, by driving the key short-term and long-term rates, the latter in turn influencing consumption and investment, and ultimately aggregate demand.

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and the United Kingdom from Europe. These economies comprised 75 percent of the market for Philippine exports from 2002 to 2019, on average. For each country, we used the real GDP series in 2014 prices converted into US dollars obtained from CEIC. Several export partners had to be omitted from the set: China (accounting for an average of 10.4 percent of exports during the period) and Taiwan (4.22 percent) due to the absence of comparable quarterly GDP data; and Vietnam (1.05 percent) and Indonesia (1.10 percent) due to their GDP series being short (starting only in 2010).

[10] Absent data on government debt interest rates, we construct the effective interest rates on domestic and foreign debt as follows. The domestic effective interest rate is defined as $100\left(\frac{XP_t^{INTD}}{D_{t-1}^{D}}\right)$, where XP_t^{INTD} is domestic interest payments in the current quarter, and D_{t-1}^{d} is domestic debt in the previous quarter. The foreign effective interest rate is defined as $100\left(\frac{XP_t^{INTF}}{D_{t-1}^{F}}\right)\left(\frac{xr_t}{xr_{t-1}}\right)^{-1}$, where XP_t^{INTF} is foreign interest payments in the current quarter, D_{t-1}^{F} is foreign debt in the previous quarter, and xr_t is the nominal peso-US dollar exchange rate.

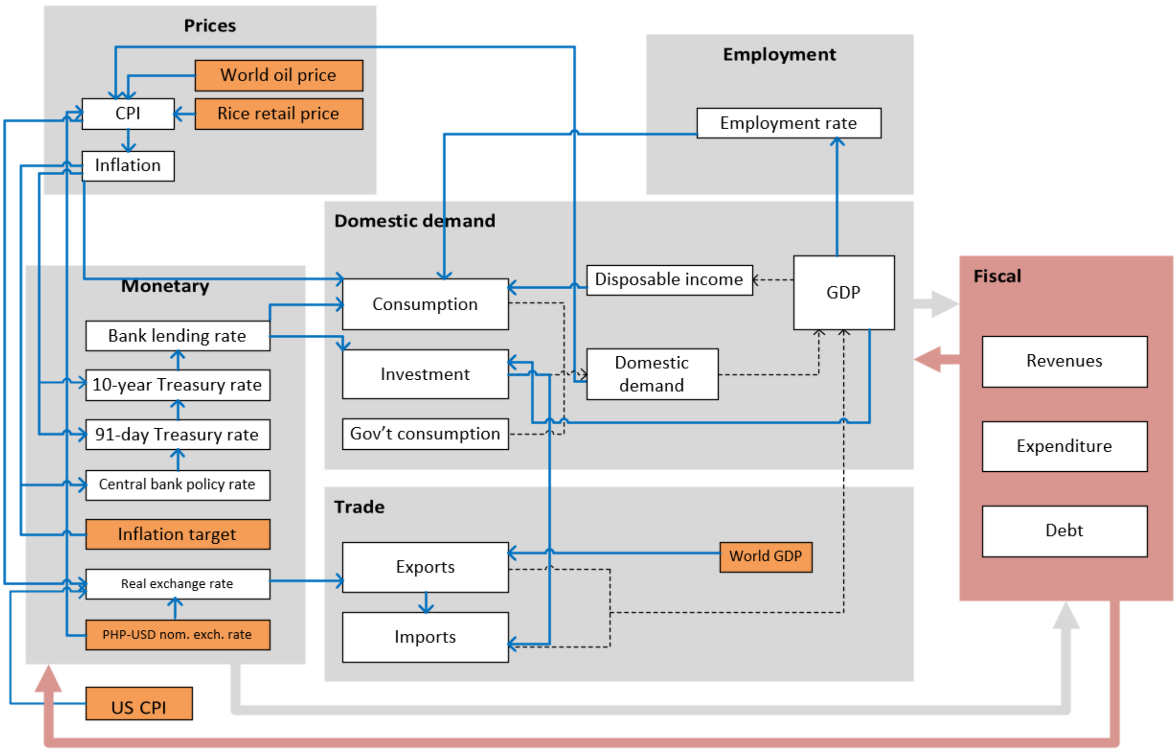
[11] Note though that the estimation sample was delimited to 2007Q1 to 2019Q4.

[12] As in the original model, a standard Taylor rule was not estimated, as incorporating an output variable (whether as output gap or growth) yielded incorrect coefficient signs.

In the price block, we still specify the evolution of the consumer price index (CPI) purely as a short run equation depending on changes in world oil and retail rice prices, domestic demand, and the nominal peso-dollar exchange rate.[13] This equation is similar to those of the central bank's workhorse models for inflation targeting—namely, the BSP's Single-Equation Model and Multi-Equation Model.

Lastly, we add the GDP deflator to the price block to be able to compute for nominal GDP within the system. The CPI and CPI inflation that drive this variable in the long and short-run specifications, respectively.

Figure 3.1. The Philippine macroeconometric model with a fiscal block



Note: Orange boxes denote the exogenous variables in the model. Solid blue lines represent behavioral relationships, while broken lines represent identities.
Source: Authors' illustration.

[13] Modeling the CPI equation as an ECM was initially attempted with money supply (M3-to-GDP ratio) as the long run determinant (following the quantity theory of money) and changes in the price of rice, world price of oil, nominal peso-dollar exchange rate, and domestic demand as short run determinants. Contrary to expectation, the money supply variable yielded the wrong sign (negative) in the long run equation. This led us to omit the money supply from the specification and model CPI as a purely short run equation.

3.2.2. The fiscal block

The fiscal block in our expanded macroeconometric model comprises equations for government revenues, expenditures, as well as debt. Figure 3.2 illustrates the newly added sector's interrelationships in greater detail.

Total revenues are defined as the sum of tax revenues and non-tax revenues. Non-tax revenues in turn are modeled as a function of GDP in the long run, while tax revenues are computed as the sum of internal tax revenues and customs revenues.

Internal tax revenues are modeled as a long-run function of GDP, while internal tax revenue growth is formulated as a function of its own lag in the short horizon. Customs revenues, meanwhile, are cast as a function of imports, the peso-dollar exchange rate, and the world price of oil in the long horizon, though only import growth drives customs revenue growth in the short run.

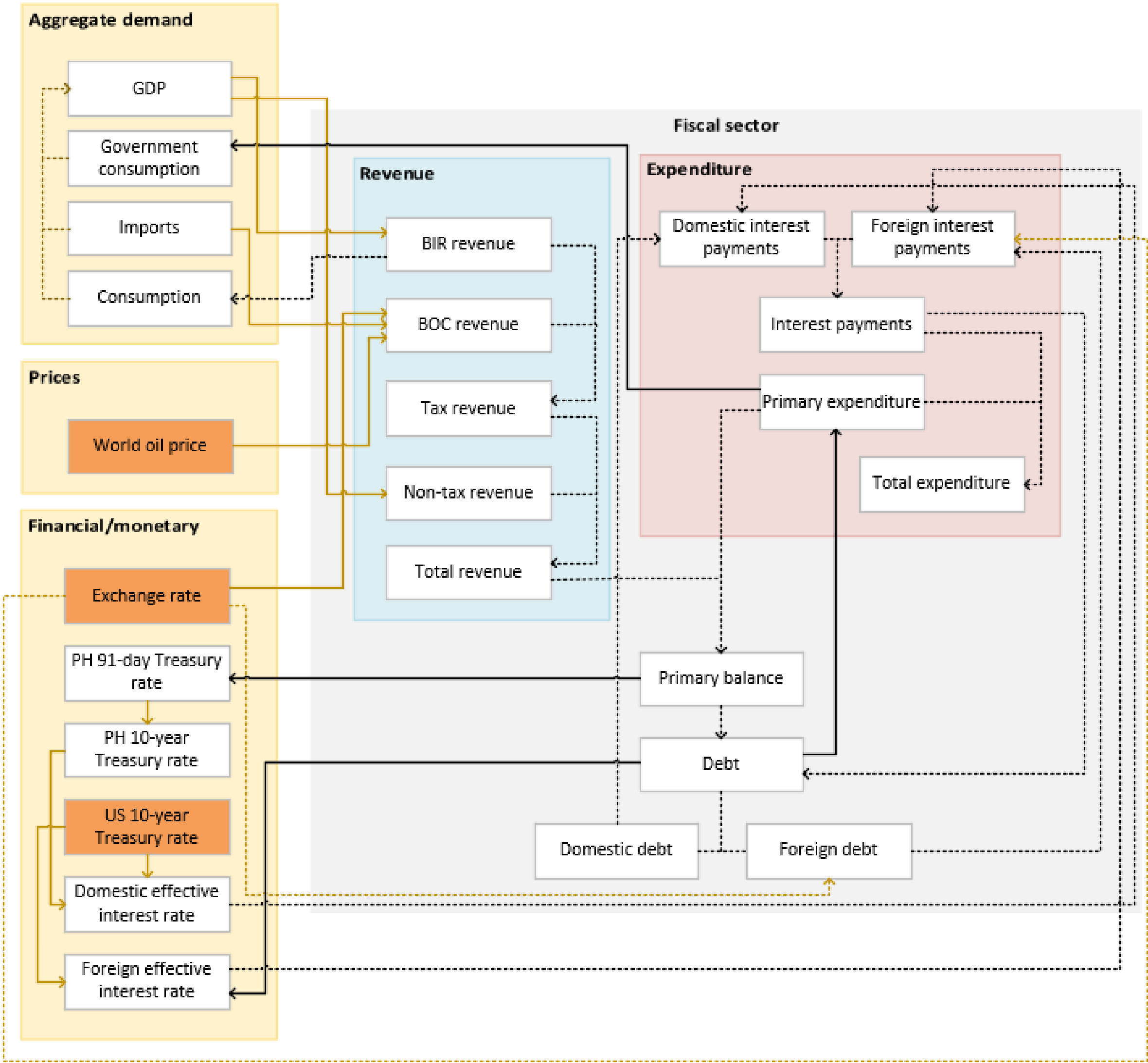
On the expenditure side, total expenditures are defined as the sum of primary expenditures and interest payments on debt. Primary expenditures respond negatively to the previous year's debt-to-GDP ratio in the long- and short-run specifications, ensuring that any escalation of debt does not continue indefinitely.

Interest payments are the sum of domestic and foreign interest payments. We compute domestic interest payments as the product of the effective interest rate on domestic debt and domestic debt from the previous period. Similarly, foreign interest payments are the product of the effective interest rate on foreign debt and foreign debt from the previous period, adjusted for exchange rate depreciation. Taking the difference between government revenues and primary expenditure yields the primary balance.

The level of government debt evolves in line with a simplified equation for debt dynamics. Specifically, current period debt derives from the sum of domestic and foreign debt from the previous period (the latter adjusted for exchange rate depreciation), interest on debt from the previous period, the current period primary deficit, and a residual term that accounts for all other unexplained sources of debt.

We define total government debt as the sum of domestic and foreign debt. Domestic and foreign debt levels are restricted to reflect the actual distribution of government debt by source.

Figure 3.2. The fiscal block in detail



Note: Orange boxes denote the exogenous variables in the model. Solid lines represent behavioral relationships, and broken lines represent identities.
Source: Authors' illustration.

Table 3.1. Key model equations and variables

Equations	Variables
Domestic demand	C = private consumption
$\log C_t = f(\log(YD_t), emp_t, rr_t^{bl}, \pi_t)$	CPI = consumer price index
$\log (I_t) = f\left(\log(Y_t)\, , \Delta rr_t^{bl}, \pi_t\right)$	CPI^{US} = US consumer price index
$\log G_t = f(XP_t^{PR})$	D = National government (NG) debt (nominal)
$\log M_t = f(I_t, X_t)$	D^D = Domestic NG debt (nominal)
$Y_t \equiv C_t + I_t + G_t + X_t - M_t$	D^F = Foreign NG debt (nominal)
$YD_t \equiv Y_t - RV_t^{TXBIR}$	emp = employment rate
$\log(P_t^Y) = f(\log(CPI_t))$	G = government consumption
$Y_t^N \equiv P_t^Y Y_t$	I = investment
	M = imports
Trade block	NX = net exports
$\log(X_t) = f(\log (Y_t^{WORLD})\, , \log(xrr_t))$	p^{oil} = world price of oil
$\log (M_t) = f(\log(I_t), \log(X_t))$	p^{rice} = retail price of rice
$NX_t \equiv X_t - M_t$	PB = Primary balance
	PY = GDP deflator
Employment block	r^{bl} = bank lending rate
$emp_t = f(Y_t)$	r^{cb} = Central bank policy rate
	r^{dd} = Effective interest rate on domestic debt
Price block	r^{df} = Effective interest rate on foreign debt
$\Delta \log(CPI_t) = f\left(\Delta\log(oil_t)\, , \Delta \log\left(p_t^{rice}\right), \Delta \log(DD_t)\, , \Delta \log(xr_t)\right)$	RES = Debt residual (nominal)
$\pi_t \equiv 100\left(\frac{CPI_t}{CPI_{t-4}} - 1\right)$	rr^{bl} = Real bank lending rate
	rr^{t10y} = Real 10-year Treasury rate
Monetary block	rr^{t91d} = Real 91-day Treasury rate
$r_t^{cb} = f(\pi_t - \pi_t^T)$	r^{t10y} = 10-year Treasury rate
$r_t^{t91d} = f(r_t^{cb}, PB_t/Y_t, \pi_t)$	r^{t10yUS} = US 10-year Treasury rate
$r_t^{t10y} = f(r_t^{t91d}, \pi_t)$	r^{t91d} = 91-day Treasury rate
$r_t^{bl} = f(r_t^{t10y}, \pi_t)$	RV = Total revenues (nominal)
$rr_t^{t91d} \equiv r_t^{t91d} - \pi_t$	RV^{NTX} = Non-tax revenues (nominal)
$rr_t^{t10y} \equiv r_t^{t10y} - \pi_t$	RV^{TX} = Tax revenues (nominal)
$rr_t^{bl} \equiv r_t^{bl} - \pi_t$	RV^{TXBIR} = Internal tax revenues (nominal)
$xrr_t = xr_t\left(\dfrac{CPI_t^{US}}{CPI_t}\right)$	RV^{TXBOC} = Customs revenues (nominal)
$r_t^{dd} = f\left(r_t^{t10y}\right)$	X = exports
$r_t^{df} = f\left(r_t^{t10yUS}, DY_t\right)$	XP = Total expenditure (nominal)
	XP^{IND} = Domestic interest payments (nominal)
Fiscal block	XP^{INF} = Foreign interest payments (nominal)
$\log(RV_t^{TXBIR}) = f(\log(Y_t^N))$	XP^{INT} = Interest payments (nominal)
$\log(RV_t^{TXBOC}) = f\ (\log(P_t^Y M_t), \log(p_t^{oil}), \log(xr_t))$	XP^{PR} = Primary expenditure (nominal)
$\log(RV_t^{NTX}) = f(\log(Y_t^N))$	xr = nominal peso-dollar exchange rate
$RV_t^{TX} \equiv RV_t^{TXBIR} + RV_t^{TXBOC}$	xrr = real peso-dollar exchange rate
$RV_t \equiv RV_t^{TX} + RV_t^{NTX}$	Y = GDP
$\log(XP_t^{PR}) = f(DY_t)$	YD = disposable income
$XP_t^{INT} \equiv XP_t^{IND} + XP_t^{INF}$	Y^N = nominal GDP
$XP_t \equiv XP_t^{PR} + XP_t^{INT}$	Y^{WORLD} = World GDP
$XP_t^{IND} \equiv r_t^{dd} \times D_{t-1}^D$	α= Share of domestic debt in total
$XP_t^{INF} \equiv \left(\frac{xr_t}{xr_{t-1}}\right) r_t^{df} D_{t-1}^F$	π = inflation rate
$PB_t \equiv RV_t - XP_t^{PR}$	π^T = inflation target (midpoint)
$D_t \equiv XP_t^{INT} + D_{t-1}^D + \left(\frac{xr_t}{xr_{t-1}}\right) D_{t-1}^F - PB_t + RES_t$	
$D_t^D \equiv \alpha_t D_t$	
$D_t^F \equiv (1 - \alpha_t) D_t$	

Table 3.2. Data summary

Variable	Obs.	Mean	Std. dev.	Min	Max
GDP	72	14.89	0.29	14.42	15.4
GDP growth	72	5.66	1.75	0.1	8.45
Household consumption	72	14.61	0.26	14.16	15.08
Investment	72	13.27	0.46	12.6	14.08
Government consumption	72	12.68	0.34	12.17	13.39
Imports	72	13.75	0.38	13.29	14.5
Exports	72	13.55	0.33	12.99	14.19
Disposable income	72	14.79	0.28	14.31	15.28
Domestic demand	72	14.95	0.31	14.5	15.51
Employment rate	59	93.23	0.89	91.88	95.35
Consumer price index	72	4.35	0.2	3.99	4.64
GDP deflator	72	4.4	0.17	4.05	4.62
US consumer price index	72	4.52	0.11	4.32	4.69
CPI inflation	72	3.75	2.02	-0.05	10.32
Deviation from inflation target	72	-0.25	1.92	-3.05	6.32
World oil price (USD per barrel)	72	4.09	0.47	3.02	4.77
Retail price of rice	61	6.48	0.25	5.88	6.81
PHP/USD exchange rate	72	3.88	0.09	3.71	4.03
Real PHP/USD exchange rate	72	4.05	0.16	3.83	4.36
Central bank policy rate	72	4.97	1.56	3	7.5
91-day Treasury rate	72	3.99	2.16	0.4	8.13
10-year Treasury rate	72	7.49	3.14	3.46	14.3
Bank lending rate	72	7.56	1.77	5.4	10.86
Real 91-day Treasury rate	72	0.24	2.13	-4.37	5.03
Real 10-year Treasury rate	72	3.74	2.99	-1.81	11.18
Real bank lending rate	72	3.81	1.94	-1.49	7.82
US 10-year Treasury rate	72	3.19	1.04	1.62	5.07
Nominal revenues	72	12.74	0.5	11.81	13.6
Nominal tax revenues	72	12.61	0.51	11.69	13.49
Nominal internal tax revenues	72	12.35	0.52	11.43	13.24
Nominal customs revenues	72	11.08	0.52	10	12.01
Nominal non-tax revenues	72	10.58	0.44	9.66	11.55
Nominal NG expenditure	72	12.89	0.47	12.16	13.88
Nominal primary expenditure	72	12.67	0.55	11.84	13.8
Nominal interest payments	72	11.19	0.16	10.59	11.53
Nominal domestic interest payments	72	10.75	0.2	10.21	11.2
Nominal foreign interest payments	72	10.13	0.15	9.43	10.36
Effective domestic interest rate	72	1.77	0.41	1.22	2.67
Effective foreign interest rate	72	1.35	0.19	1.01	1.77
NG debt	72	15.36	0.28	14.72	15.88
Domestic NG debt	72	14.84	0.37	14.06	15.47
Foreign NG debt	72	14.46	0.17	13.98	14.78
Debt/GDP	72	51.92	10.24	39.46	71.07
Domestic debt/GDP	72	30.29	3.46	25.59	37.75
Foreign debt/GDP	72	21.63	6.99	13.42	34.68

Note: Level variables are log-transformed. GDP omits statistical discrepancy.

4. Model evaluation

To evaluate the model's predictive performance, we generate in-sample static and dynamic forecasts in a deterministic setting for the period 2012Q1 to 2019Q4, or a forecast horizon of 32 quarters or eight years.[14] Static simulation generates a series of one-period ahead forecasts using actual (historical) values for lagged endogenous variables. Dynamic simulation, on the other hand, uses values for lagged endogenous variables that are predicted by the model based on previous periods. Although the model can generate out-of-sample forecasts, we do not perform out-of-sample evaluation since the validation sample would include the highly unusual and uncertain pandemic years of 2020 and 2021.

We use conventional forecast accuracy metrics to gauge forecast performance, namely, the mean absolute percentage error (MAPE) for level variables and mean absolute error (MAE) for rate or percentage variables.[15] In-sample forecasts are depicted alongside historical data in Figure 4.1, while forecast accuracy statistics are presented in Table 4.1. As static forecasts are expected to perform better than dynamic forecasts, the discussion pays greater attention to the latter as an indication of the models' predictive capabilities.

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[14] In a deterministic simulation, model inputs are held fixed at their known values and endogenous variables follow a single path over the forecast period.

[15] The formulas for the MAPE and MAE are, respectively, MAPE = $\frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t-F_t}{A_t}\right|$ and MAE = $\sum_{t=1}^{n}\frac{|A_t-F_t|}{n}$, where n is the number of observations, A_t are the actual values, F_t are the forecast values.

Figure 4.1. In-sample simulations

A. Core small model variables

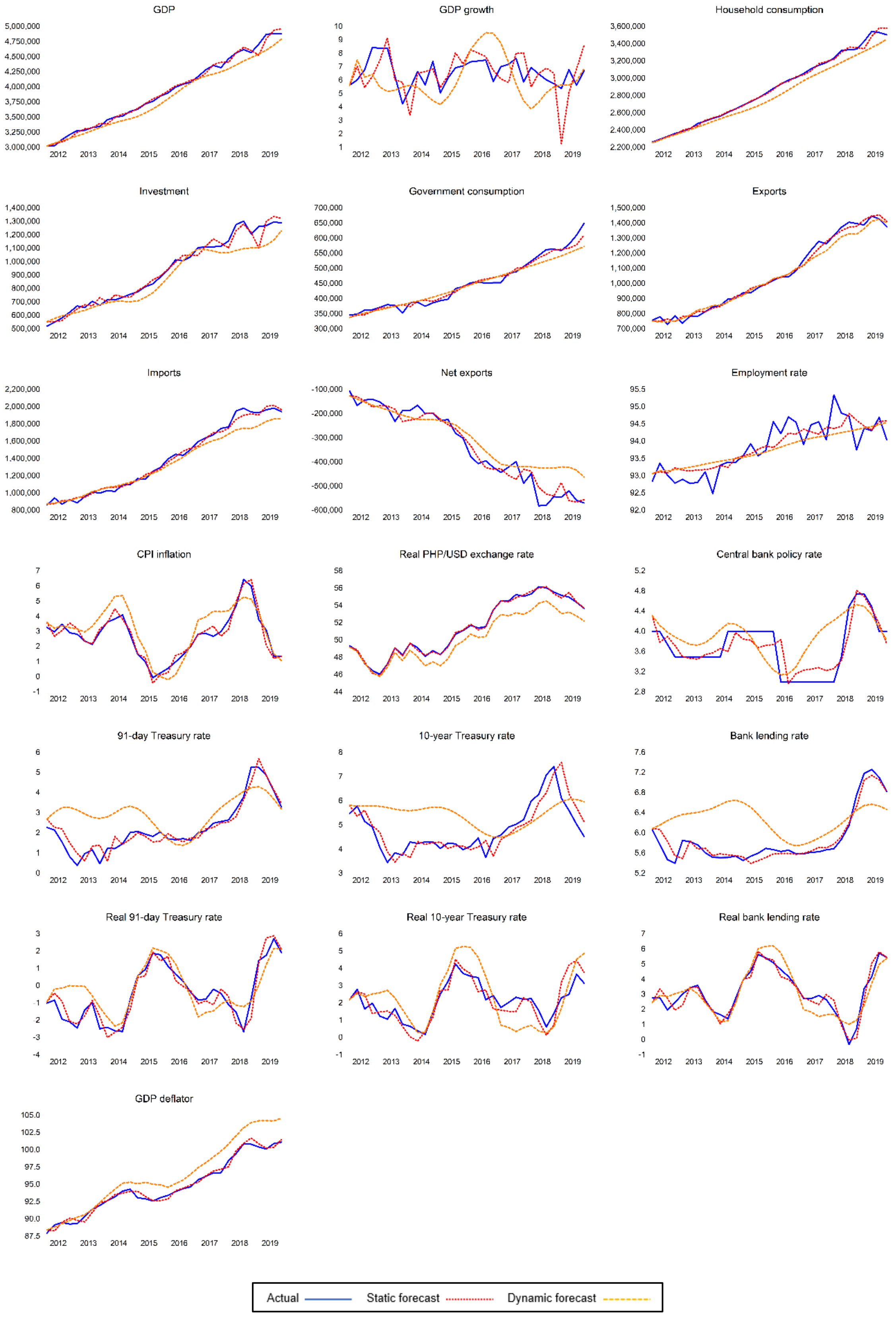
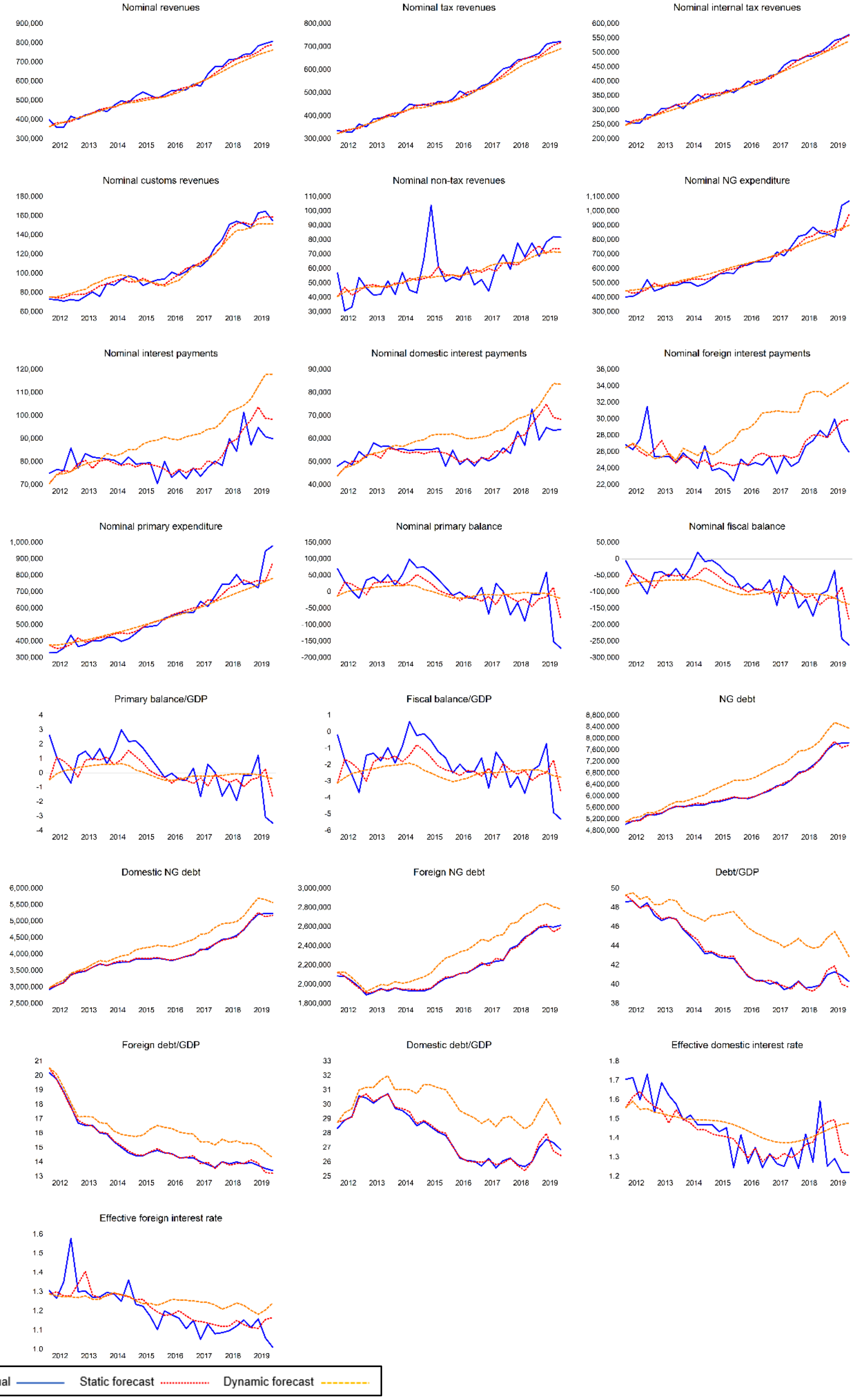


Figure 4.1. In-sample simulations (continued)

B. Fiscal block and related variables



Source: Authors' calculation.

Table 4.1. In-sample forecast accuracy, 2012Q1-2019Q4

	Static forecast	Dynamic forecast
I. Mean absolute percentage error (MAPE) of level variables, percent		
GDP	0.97	2.45
Household consumption	0.60	2.39
Investment	3.20	6.06
Government consumption	2.40	3.31
Exports	2.03	2.54
Imports	2.49	4.38
Net exports	9.94	14.65
Real PHP/USD exchange rate	0.29	2.25
Nominal revenues	3.04	3.73
Nominal tax revenues	2.34	3.01
Nominal internal tax revenues	2.56	2.87
Nominal customs revenues	4.10	6.13
Nominal non-tax revenues	15.07	15.10
Nominal NG expenditure	4.97	6.32
Nominal interest payments	4.19	13.46
Nominal domestic interest payments	5.35	13.63
Nominal foreign interest payments	4.13	14.02
Nominal primary expenditure	5.72	7.34
NG debt	0.58	7.23
Domestic NG debt	0.58	7.23
Foreign NG debt	0.63	7.23
GDP deflator	0.43	1.79
II. Mean absolute error (MAE) of rate and percentage variables, percentage points		
GDP growth	1.03	1.34
Employment rate	0.31	0.35
CPI inflation	0.30	0.72
Central bank policy rate	0.20	0.38
91-day Treasury rate	0.30	0.95
10-year Treasury rate	0.40	1.00
Bank lending rate	0.10	0.55
Real 91-day Treasury rate	0.38	0.71
Real 10-year Treasury rate	0.49	0.89
Real bank lending rate	0.34	0.52
Effective domestic interest rate	0.08	0.10
Effective foreign interest rate	0.05	0.08
Primary balance/GDP	0.97	1.08
Fiscal balance/GDP	0.96	1.14
Debt/GDP	0.25	3.32
Foreign debt/GDP	0.09	1.16
Domestic debt/GDP	0.16	2.17

Source: Authors' calculation. NG = national government.

Quarter-ahead predictions of GDP and its components have good accuracy, with MAPEs of under 5 percent for both static and dynamic forecasts. Net exports are the exception with relatively large MAPEs particularly from the dynamic simulation (14.65 percent), which stems from sizeable dynamic prediction errors for exports and imports in the last two forecast years.

The model's dynamic GDP growth predictions have a MAE of 1.34 percentage points. Predictions for inflation show better performance, with the dynamic forecast tracking the data rather well in addition to having relatively small errors (MAE of 0.72 percentage point). Forecasts for the employment rate also do well, with a MAE of 0.35 percentage point from the dynamic simulation.

The model's dynamic central bank policy rate forecast departs from the actual series' stepwise movement but captures the data's historical turning points (Figure 4.1A) and has relatively small absolute errors (0.38 percentage point on average). Dynamic predictions of market interest rates do somewhat worse, with MAEs of between 0.5 to 1 percentage point, as well as trajectories that are not quite successful at mimicking the data's actual movements. Their real counterparts perform better in this regard largely due to the more accurate dynamic inflation forecast.

Forecasts for revenue variables perform well with most having MAPEs of below 5 percent or slightly higher (in the case of the dynamic forecast for customs revenues). Non-tax revenues are the exception with forecast MAPEs of slightly over 15 percentage points.[16]

On the expenditure side, the dynamic prediction for primary expenditures (the largest expenditure component) outperforms those for the interest payment variables (MAPE of 7.34 percent versus 13 to 14 percent). Despite relatively good dynamic predictions for the effective debt interest rates (with MAEs of 0.8 to 1 percentage point), the model's dynamic forecast for interest payments drift away from the historical data at around 2014 to 2015, reflecting the divergence observed with dynamic debt forecasts (Figure 4.1B).

MAPEs of the model's debt level predictions notably rise from below 0.58 percent for the static simulation to 7.23 percent for the dynamic simulation. The gap between the actual and dynamic simulations of debt levels appears to have been due to the large downward errors in the dynamic primary balance forecast for 2014 and 2015. The consecutive larger-than-actual predicted primary deficits in this period were absorbed into the debt forecasts and in turn filtered through to the dynamic forecast paths of effective debt interest rates and interest payments.

[16] Non-tax revenues consist of income of the Bureau of Treasury (BTr) from various sources (such as interest income on government deposits with the BSP, income from BTr-managed funds, and dividends from government corporations), fees and charges, privatization proceeds, income from Malampaya, and other non-tax revenue streams. Non-tax revenues are relatively small, comprising an average of 11.86 percent of total revenues from 2002Q1 to 2019Q4.

5. Impact analysis (analytic shocks)

To further test the model's validity, we introduce shocks to the system and examine the response of the simulated dynamic paths of the model's endogenous variables. We consider the impact of three shocks: (1) a world oil price shock, (2) an exchange rate shock, and (3) a primary spending shock. The succeeding figures illustrate the simulation results, with the blue lines representing the deviation of the simulated dynamic paths from the (no-shock) baseline. The deviations are in percent terms for level variables[17] and in percentage points for rate and percentage variables. Appendixes C, D, and E show the simulated paths of the variables in their original units of measurement for each respective shock experiment.

5.1. World oil price shock

In this scenario, the world price of oil is raised by 20 percent relative to its baseline path in 2013. Figure 5.1 illustrates the simulation results.

The higher price of oil triggers faster inflation, which rises above the baseline during the first year, in 2013 (Figure 5.1A). This leads to a small upward adjustment in the central bank policy rate and consequently in nominal market interest rates. Although inflation causes real interest rates to fall below the baseline leading to a faint expansionary effect, price hikes eventually weigh down private investment and consumption, pulling GDP to below the baseline path. Exports meanwhile decline due to eventual real exchange rate appreciation, which adds to the downward pressure on total spending.

Inflation begins to decelerate by the second year, by 2014, causing real interest rates to rise. This leads to a deeper decline in investment, consumption, and GDP. GDP begins to climb back to the baseline path by mid-2014 to 2015, as both investment and consumption rebound owing to softer inflation and subsequently to a decline in real interest rates. Exports also recover as the real exchange rate weakens. Government consumption additionally rises in 2014 with an increase in primary spending.

The oil price shock meanwhile generates a windfall in customs revenues and causes total revenues to increase in 2013 (Figure 5.1B). Consequently, the primary balance improves during the period, leading to a decline in the debt ratio. Wider fiscal space allows primary expenditure to rise a year later, which worsens primary balance, causing the debt ratio to rise again by the end of 2014.

[17] Except for net exports, for which deviations are expressed in level terms.

Figure 5.1. World oil price shock

A. Core small model variables

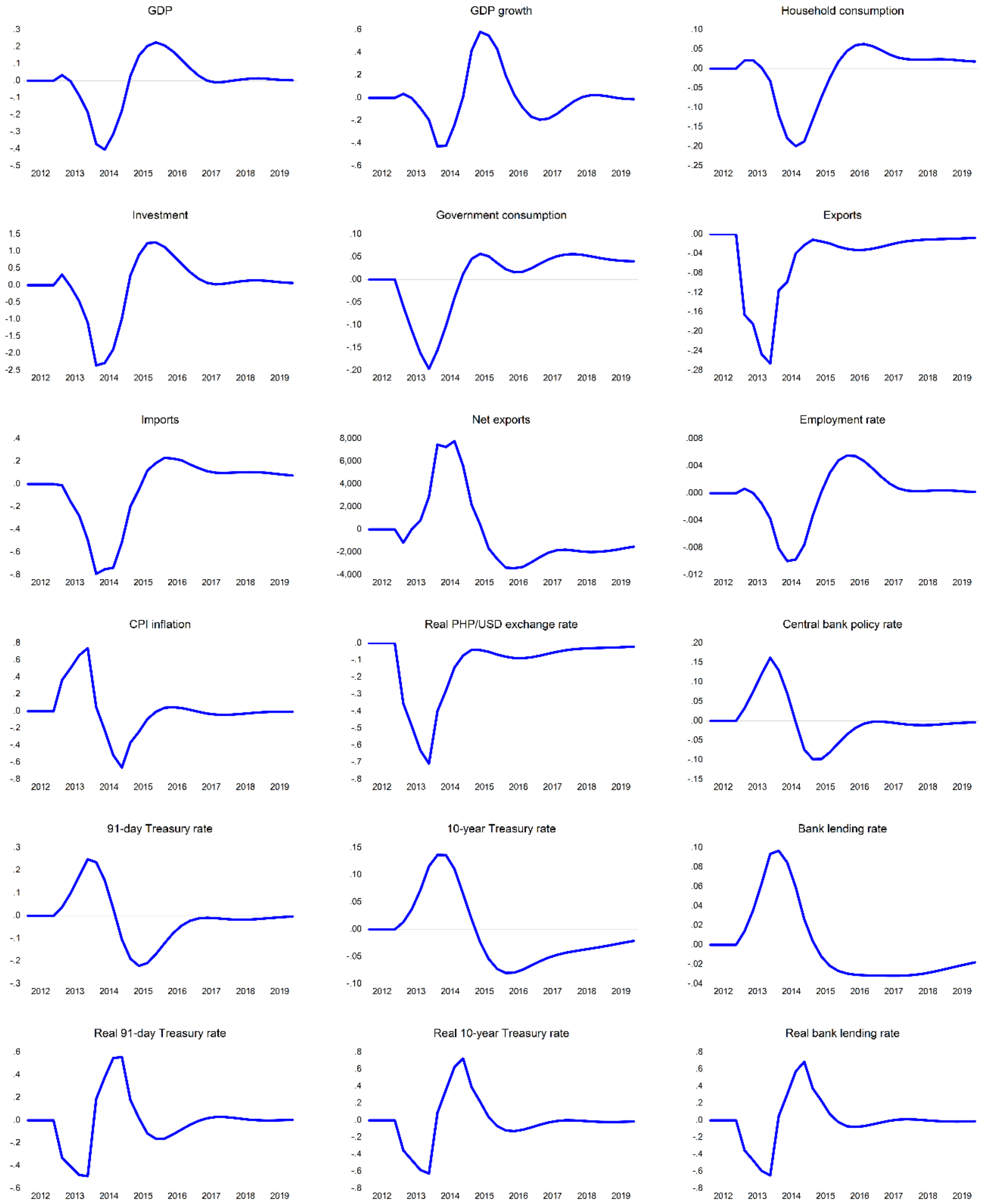
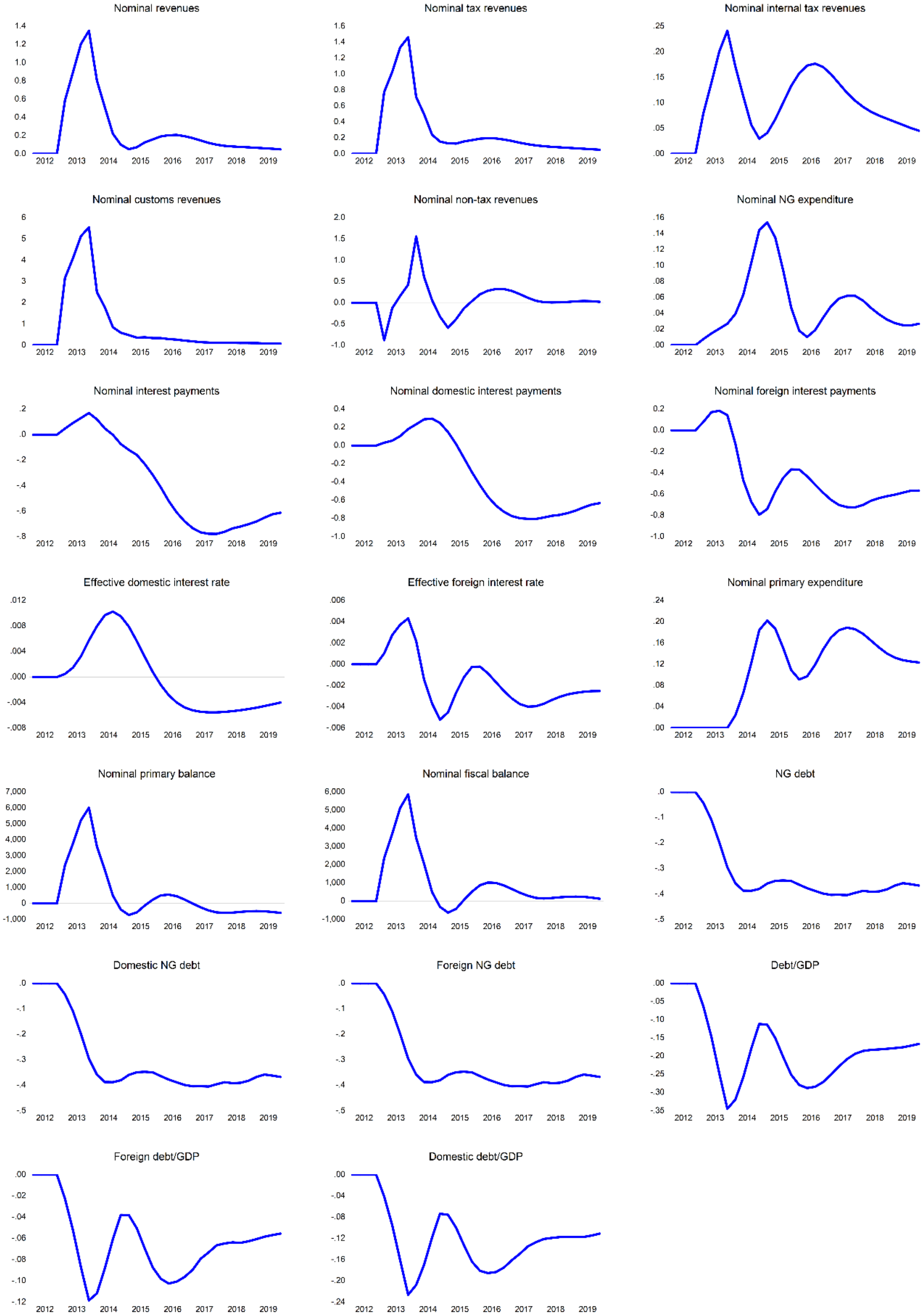


Figure 5.1. World oil price shock (continued)

B. Fiscal block and related variables



Source: Authors’ calculation.

5.2. Exchange rate shock

This experiment involves a weakening of the peso against the US dollar by 10 percent relative to the actual exchange rate in 2013. Simulation results are depicted in Figure 5.2.

The exchange rate shock leads to an increase in exports of about 3.4 percent in the first year, in 2013 (Figure 5.2A). Inflation also accelerates, causing the policy rate to tighten and nominal market interest rates to rise. However, real interest rates decline owing to the larger increase in inflation, thus promoting higher consumption and investment spending, and higher GDP growth overall.

By the second year, however, the inflation shock reverses, causing real interest rates to rise. Consequently, consumption and investment weaken. This, combined with the normalization of exports and a decline in government consumption due to developments in the fiscal sector, ultimately depress GDP growth. Eventually, real interest rates fall as inflation normalizes, leading to higher investment and consumption spending and ultimately faster GDP growth by the third year, in 2015.

On the fiscal side the exchange rate shock generates a windfall gain in customs revenues, causing overall revenues to improve in 2013 (Figure 5.2B). Despite the consequent improvement in the primary balance, total debt increases due to the upward revaluation of foreign debt. Higher debt causes a reduction in primary expenditure in the following year, pulling down government consumption. Subsequently, primary spending recovers as total debt falls back to baseline due to the normalization of the exchange rate.

Figure 5.2. Exchange rate shock

A. Core small model variables

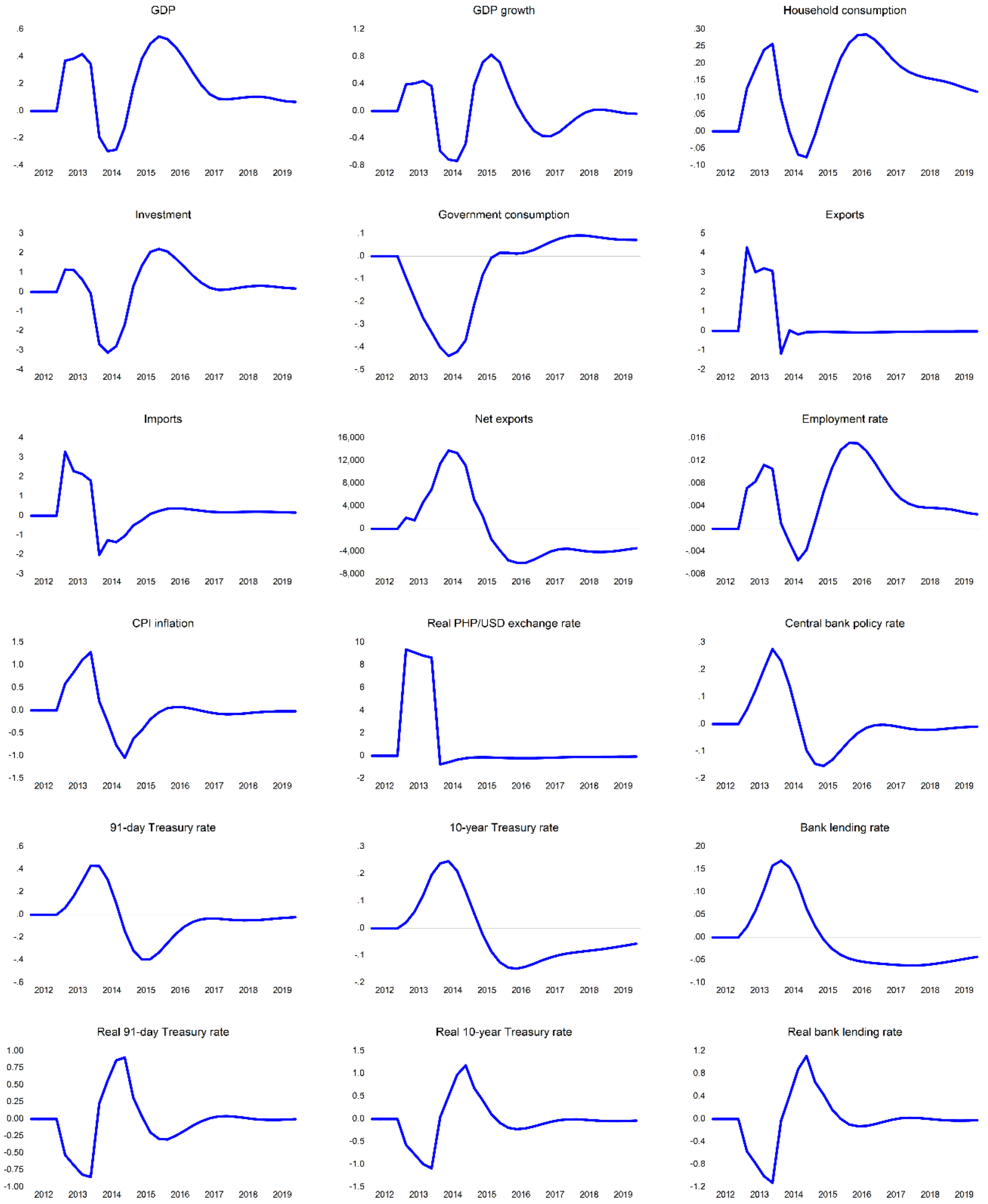
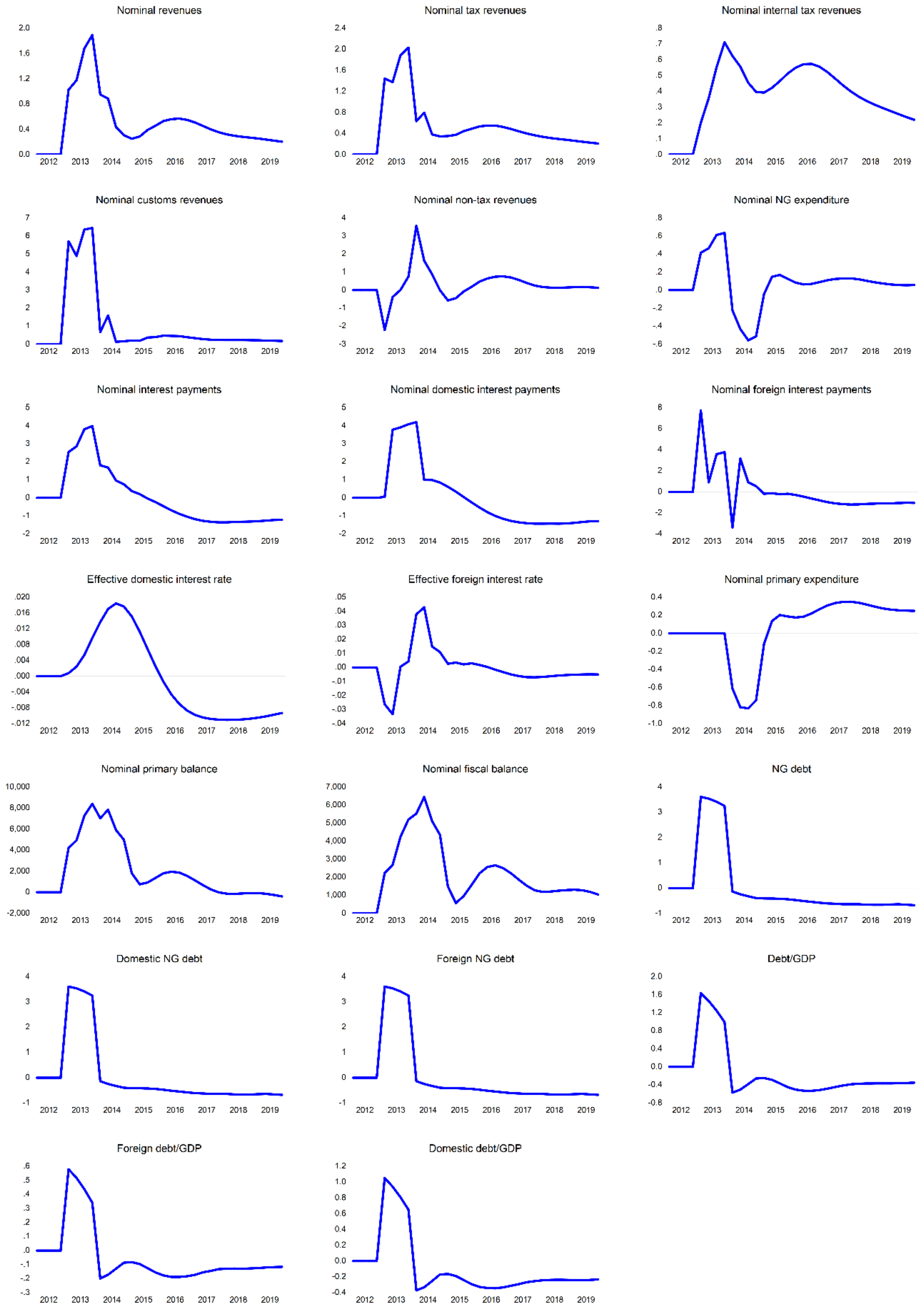


Figure 5.2. Exchange rate shock (continued)

B. Fiscal block and related variables



Source: Authors' calculation.

5.3. Primary spending shock

In this final exercise, primary spending is exogenously increased by 10 percent from its baseline path in 2013. As part of the experiment, we remove the mechanism for primary spending to react to worsening debt conditions. Thus, after the shock, primary spending follows its actual historical path. Figure 5.3 summarizes the simulation results.

The primary spending shock leads to an increase in government consumption, raising domestic demand (Figure 5.3A). Higher domestic demand causes inflation to pick up, triggering monetary tightening by the central bank which in turn leads to a rise in nominal market interest rates. A fall in real interest rates alongside a rise in total government spending, however, promote greater investment and consumption spending, although GDP growth is partly dampened by a decline in exports due to real peso appreciation tracing to higher domestic inflation. The increase in GDP begins to fade away in 2014 as government consumption normalizes, and both investment and consumption spending fall with the subsequent recovery of real interest rates.

The expansion of the real economy leads to an increase in both internal tax and customs revenues, the latter due to higher import demand (Figure 5.2B). However, the revenue improvements are outstripped by the primary spending shock, causing a sharp deterioration in the primary balance in 2013. While the primary balance eventually returns to baseline, the borrowing incurred during the shock period leads to a permanent increase in the debt stock.

Figure 5.3. Primary spending shock

A. Core small model variables

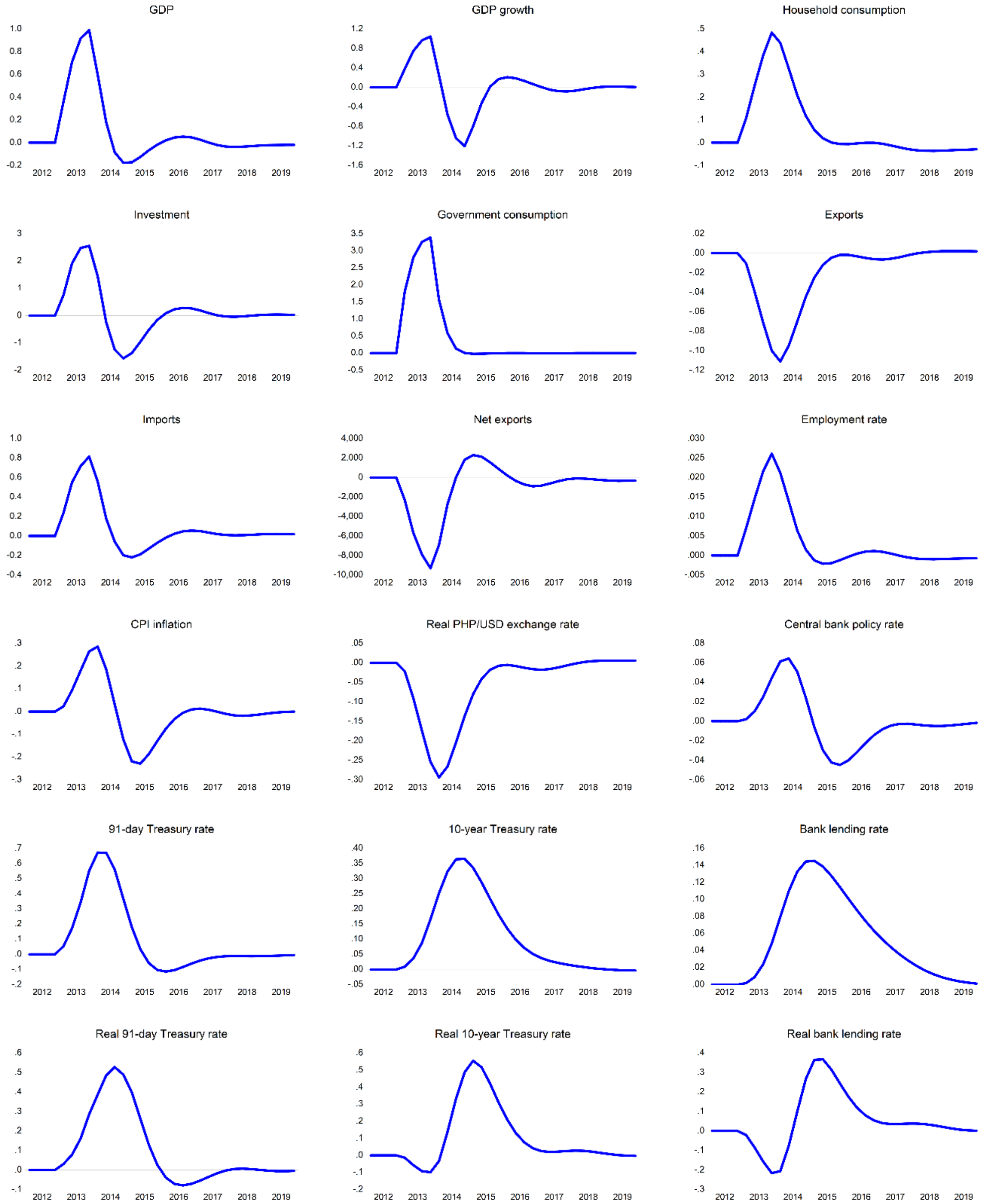
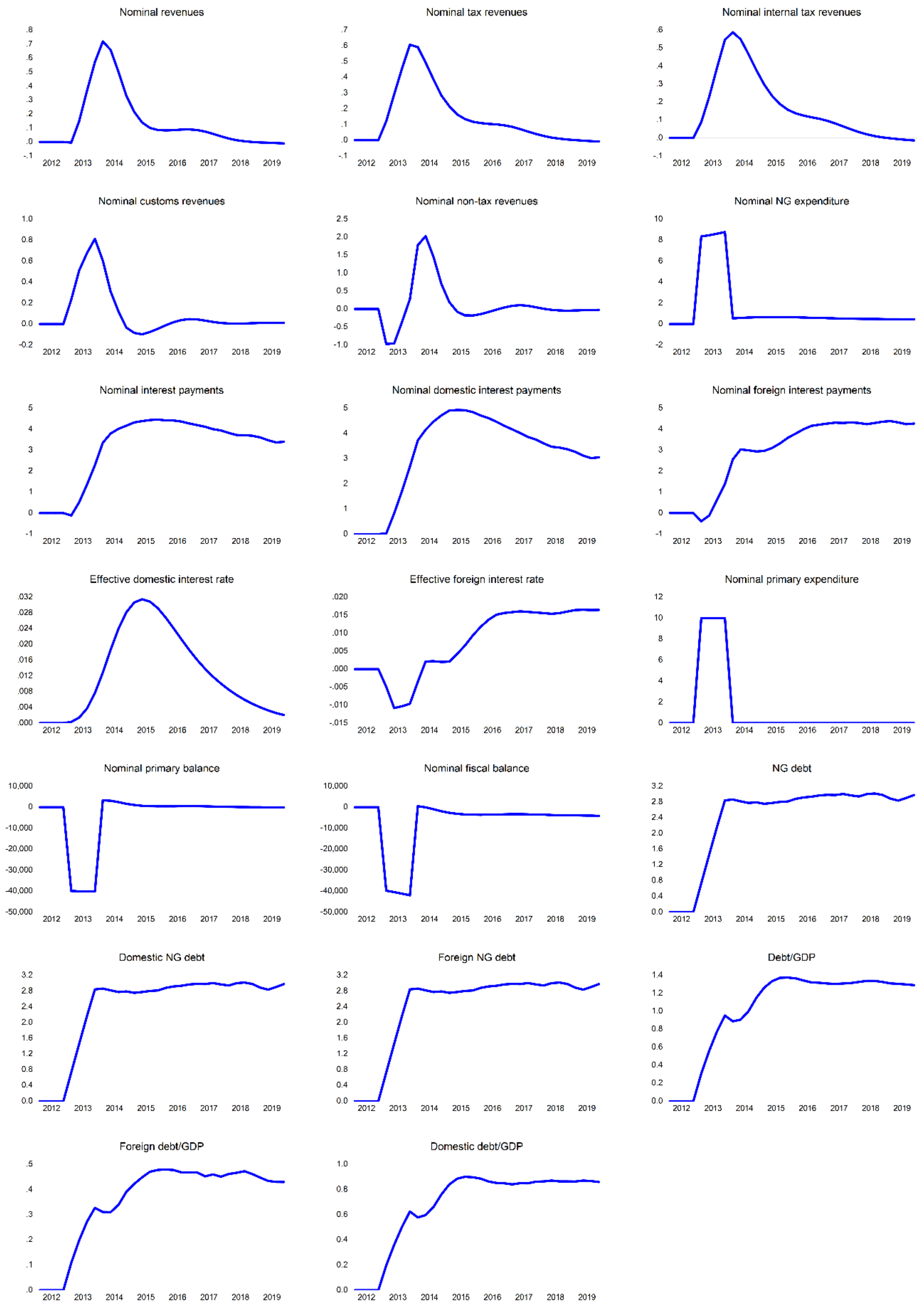


Figure 5.3. Primary spending shock (continued)

B. Fiscal block and related variables



Source: Authors' calculation.

6. Conclusion

In this paper, we aimed to expand our small macroeconometric model of the Philippine economy to include a relatively detailed fiscal block that seeks to capture the government sector and related mechanisms. Developing the model in this direction has become essential with fiscal issues rising in importance and policy tradeoffs becoming even sharper under the current, less benign macroeconomic environment (Debuque-Gonzales et al., 2022).

The addition of a more detailed fiscal block brings us a step closer to building a reliable macroeconometric model that can be used for policy simulation and analysis, as well as quick forecasting. Model simulations, particularly in-sample simulations, continue to demonstrate acceptable levels of predictive accuracy for most macroeconomic variables, even when producing dynamic forecasts. The expanded model has been able to predict key macroeconomic variables reasonably well, though much can still be improved on the fiscal side.

Simulation exercises also demonstrate the expanded model's usefulness for macroeconomic analysis relevant to policymaking. Apart from the expected negative impact of an oil price shock on macroeconomic conditions (higher inflation and slower growth), the simulations reveal more details on the likely outcomes on the fiscal side. These include a tax windfall from customs revenues that improves the primary balance and lowers debt indicators, though the trend eventually reverses as primary spending rises.

Similarly, exchange rate simulations show that a positive exchange rate shock (peso depreciation) generates an increase in customs revenues and the primary balance, but the gains are offset by a rise in foreign debt in domestic-currency terms. This again is in addition to other important findings, such as the positive response of exports to surprise depreciation and the positive net effect on growth, at least initially.

Policy simulation capacity, meanwhile, is also displayed through the primary balance simulations, where a primary spending shock and removal of a significant fiscal response triggers an increase in inflation relative to the baseline, higher growth, and eventual monetary tightening. While there are revenue improvements because of greater economic activity, these are offset by a sharp decline in the primary balance, bringing about an increase in the public debt stock.

As a continuous work in progress, further improvements in the model should be in terms of adding a more detailed financial block, modeling the aggregate supply side (specially to capture productivity effects), strengthening the linkages across blocks, and incorporating the role of expectations. The model may also be adjusted in response to important economic developments or structural changes, such as what could have possibly occurred because of the COVID-19 pandemic, and to include key features of the Philippine economy (e.g., key sectors such as those related to the business-process-related industry and key inflows such as overseas Filipinos' remittances).

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Appendix A. Results of Augmented Dickey-Fuller tests on model variables

	diff=0	diff=1	diff=2
GDP	0.98	0	0
GDP growth	0.01	0	0
Consumption	1	0.04	0
Investment	0.97	0	0
Gov't consumption	1	0	0
Imports	1	0	0
Exports	0.94	0	0
Disposable income	1	0	0
Domestic demand	1	0	0
Employment rate	0.71	0	0
CPI	0.47	0	0
GDP deflator	0.03	0	0
US CPI	0.36	0	0
Inflation rate	0	0	0
Inflation - inflation target	0.01	0	0
World oil price	0.15	0	0
Retail price of rice	0.08	0	0
Nominal exchange rate	0.49	0	0
Real exchange rate	0.63	0	0
Central bank policy rate	0.47	0	0
91-day Treasury rate	0.07	0	0
10-year Treasury rate	0.07	0	0
Bank lending rate	0.04	0	0
Real 91-day Treasury rate	0.08	0	0
Real 10-year Treasury rate	0.02	0	0
Real bank lending rate	0	0	0
US 10-year Treasury rate	0.59	0	0
Nominal revenues	0.89	0	0
Nominal tax revenues	0.92	0	0
Nominal internal tax revenues	0.91	0	0
Nominal customs revenues	0.79	0	0
Nominal non-tax revenues	0.54	0	0
Nominal expenditure	1	0	0
Nominal primary expenditure	1	0	0
Nominal interest payments	0.01	0	0
Nominal domestic interest payments	0.13	0	0
Nominal foreign interest payments	0	0	0
Effective interest rate on domestic debt	0.67	0	0
Effective interest rate on foreign debt	0.94	0	0
Primary balance/GDP	0.02	0	0
NG debt	0.72	0	0
Domestic NG debt	0.73	0	0
Foreign NG debt	0.44	0	0
Debt/GDP	0.86	0	0
Domestic debt/GDP	0.91	0	0
Foreign debt/GDP	0.95	0	0

Note: Figures are *p*-values from the Augmented Dickey-Fuller tests, with the null hypothesis being the presence of a unit root. The first, second, and third column shows result of the test in levels, first difference, and second difference, respectively. Level variables are log-transformed.

Appendix B. Behavioral equations

Refer to Table 3.1 for variable names. In estimated equations, subscripted figures enclosed in square brackets are t-statistics. Figures enclosed in parentheses in residual diagnostic tests are p-values. Asterisks after F-Bounds test statistic are significance levels (*** 1 percent, ** 5 percent, * 10 percent).

1. Consumption

a. Long-run equation

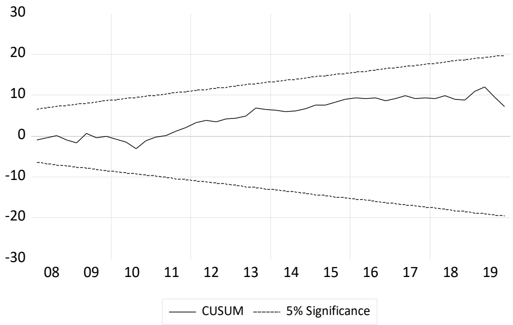
$$\log C_t = 0.96 \log YD_{t[6.90]} + 0.00emp_{t[0.05]} - 0.01rr^{bl}_{t[-0.43]} - 0.00\pi_{t[-0.41]} + 0.42_{[0.60]} + ec_t$$

b. ECM form

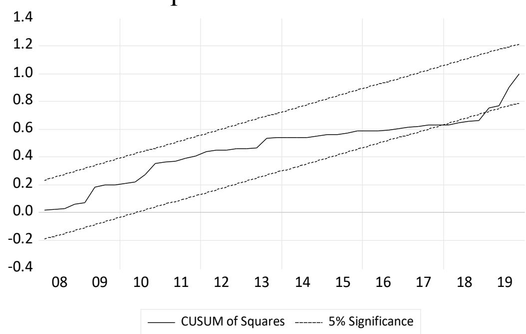
$$\Delta \log C_t = 0.26\Delta \log YD_{t[4.22]} + 0.00\Delta emp_{t[1.93]} + 0.01\Delta emp_{t-1[2.84]} - 0.13ec_{t-1[-7.37]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.998
Adjusted R-squared (ECM)	0.31
Residual diagnostics	
Residual normality (Jarque-Bera)	0.15 (0.93)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (8)	21.36 (0.01)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	6.44 (0.17)
F-Bounds test	8.19***

CUSUM test



CUSUM of squares test



2. Investment

a. Long-run equation

$$\log I_t = 1.57 \log Y_{t[11.59]} - 10.17_{[-4.93]} + ec_t$$

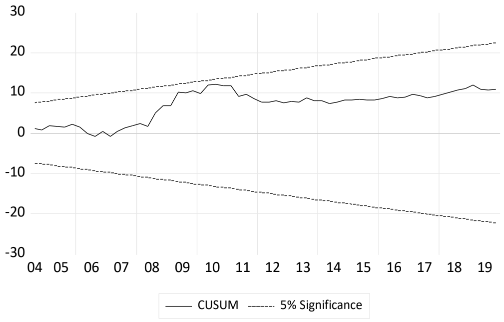
b. ECM form

$$\Delta \log I_t = -0.28\Delta \log I_{t-1\,[-2.58]} + 2.04\Delta \log Y_{t[3.53]} + 1.82\Delta \log Y_{t-1[2.90]} - 0.01\Delta rr^{BL}{}_{t[-1.81]} - 0.01\pi_{t[-2.70]} - 0.19ec_{t-1[-2.76]} + \epsilon_t$$

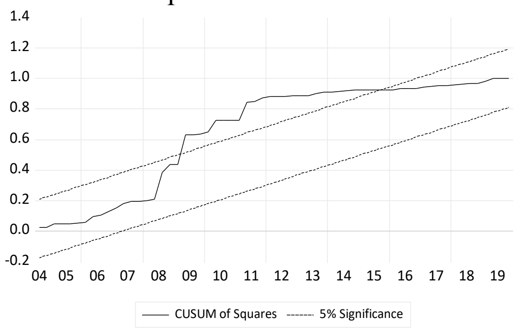
Adjusted R-squared (ARDL)	0.98
Adjusted R-squared (ECM)	0.31
Residual diagnostics	

Residual normality (Jarque-Bera)	0.56 (0.75)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi2$ (7)	22.81 (0.00)
No serial correlation (Breusch-Godfrey) $\chi2$ (4)	4.34 (0.36)
F-Bounds test	2.46

CUSUM test



CUSUM of squares test



3. Government consumption

a. Long-run equation

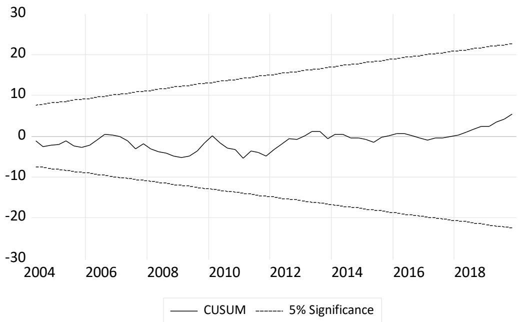
$$\log G_t = 0.36 \log XP^{PR}_{t[5.43]} + ec_t$$

b. ECM form

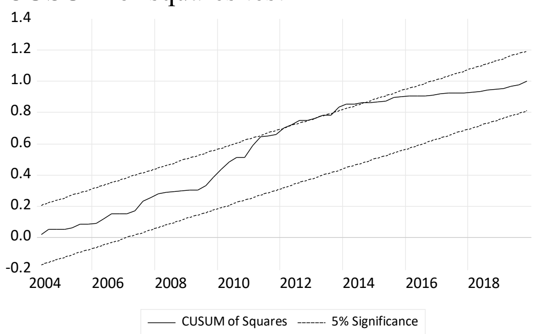
$$\begin{aligned}\Delta \log G_t = {} & 0.01 Trend_{t[4.43]} \\ & + 0.03 \Delta \log G_{t-1[0.25]} \\ & + 0.19 \Delta \log XP^{PR}_{t[3.31]} \\ & - 0.02 \Delta \log XP^{PR}_{t-1[-0.26]} - 0.65 ec_{t-1[-4.33]} + 4.97_{[4.34]} + \epsilon_t\end{aligned}$$

Adjusted R-squared (ARDL)	0.99
Adjusted R-squared (ECM)	0.29
Residual diagnostics	
Residual normality (Jarque-Bera)	1.77 (0.41)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi2$ (6)	11.52 (0.07)
No serial correlation (Breusch-Godfrey) $\chi2$ (4)	4.11 (0.39)
F-Bounds test	9.24***

CUSUM test



CUSUM of squares test



4. Imports

a. Long-run equation

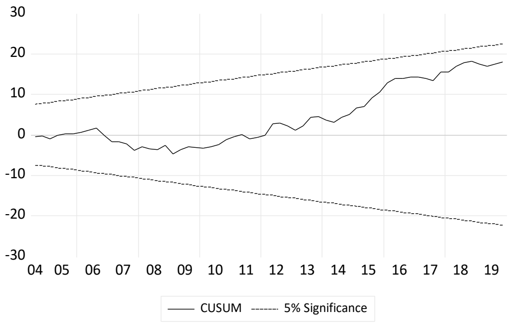
$$\log M_t = 0.67 \log I_{t[7.11]} + 0.31 \log X_{t[2.53]} + 0.58_{[0.91]} + ec_t$$

b. ECM form

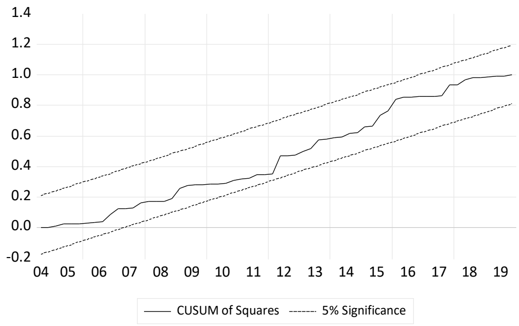
$$\begin{aligned} \Delta \log M_t = & -0.37\Delta \log M_{t-1[-5.24]} \\ & + 0.33\Delta \log I_{t[9.23]} \\ & + 0.68\Delta \log X_{t[11.03]} + 0.30\Delta \log X_{t-1[3.97]} - 0.18ec_{t-1[-4.29]} + \epsilon_t \end{aligned}$$

Adjusted R-squared (ARDL)	0.997
Adjusted R-squared (ECM)	0.75
Residual diagnostics	
Residual normality (Jarque-Bera)	1.35 (0.51)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi2$ (7)	8.44 (0.30)
No serial correlation (Breusch-Godfrey) $\chi2$ (4)	6.99 (0.14)
F-Bounds test	4.39***

CUSUM test



CUSUM of squares test



5. Exports

a. Long-run equation

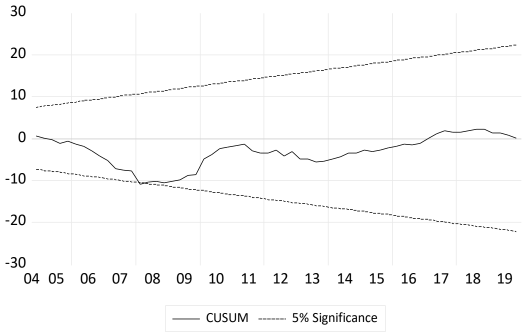
$$\log X_t = 4.16 \log Y^{WORLD}_{t[18.65]} + 0.37 \log xrr_{t[2.85]} - 46.75_{[-13.05]} + ec_t$$

b. ECM form

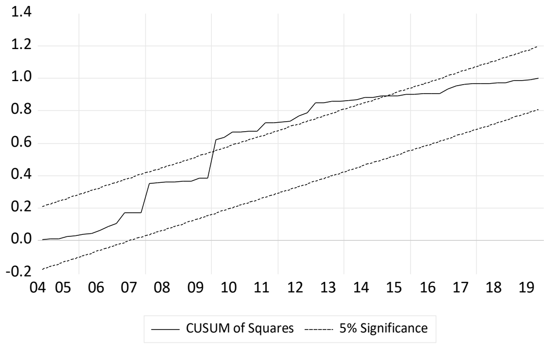
$$\begin{aligned} \Delta \log X_t = & -0.20\Delta \log X_{t-1[-1.86]} \\ & + 2.53\Delta \log Y^{WORLD}_{t[4.11]} + 0.47\Delta \log xrr_{t[2.31]} - 0.32ec_{t-1[-3.98]} + \epsilon_t \end{aligned}$$

Adjusted R-squared (ARDL)	0.99
Adjusted R-squared (ECM)	0.29
Residual diagnostics	
Residual normality (Jarque-Bera)	43.16 (0.00)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi2$ (6)	6.25 (0.40)
No serial correlation (Breusch-Godfrey) $\chi2$ (4)	3.10 (0.54)
F-Bounds test	3.77**$^{2.5\%}$

CUSUM test



CUSUM of squares test



6. **Employment rate**
   a. Long-run equation

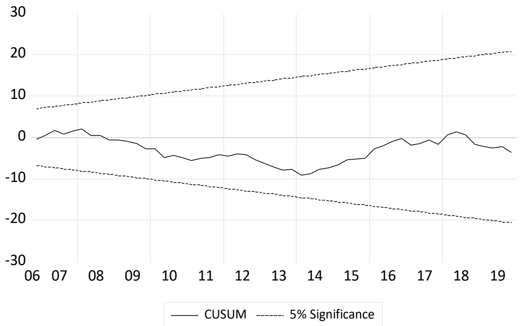
$$emp_t = 3.35 \log Y_{t[9.29]} + 43.07_{[8.02]} + ec_t$$

   b. ECM form

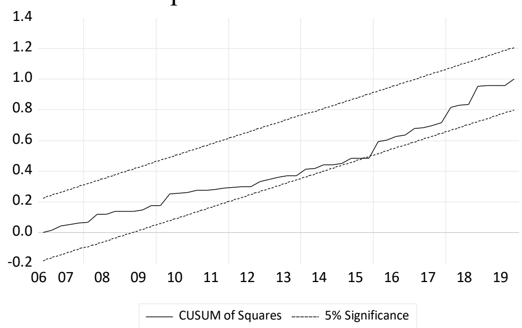
$$\Delta emp_t = -0.30 \Delta emp_{t-1[-2.42]} - 0.58 ec_{t-1[-3.77]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.82
Adjusted R-squared (ECM)	0.45
Residual diagnostics	
Residual normality (Jarque-Bera)	0.04 (0.98)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (3)	3.61 (0.31)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	2.88 (0.58)
F-Bounds test	$4.57^{**2.5\%}$

CUSUM test



CUSUM of squares test



7. **Internal tax revenues**
   a. Long-run equation

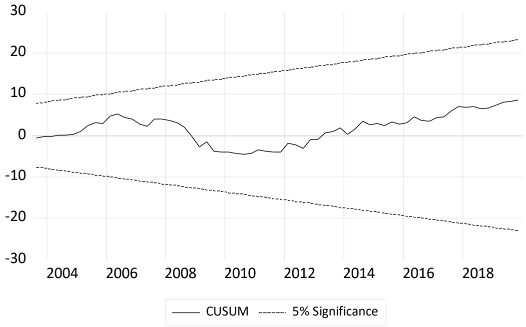
$$\log RV_t^{TXBIR} = 1.12 \log Y^N_{t[30.68]} - 3.96_{[-6.99]} + ec_t$$

   b. ECM form

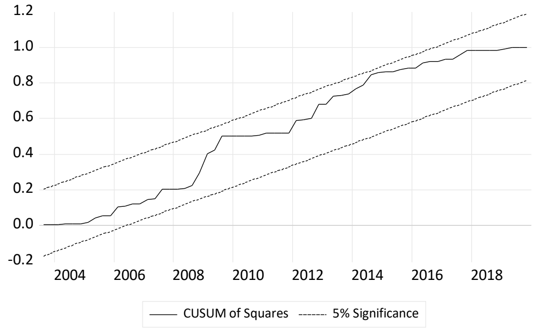
$$\Delta \log RV_t^{TXBIR} = -0.27 \Delta \log RV^{TXBIR}{}_{t-1[-3.03]} - 0.21 ec_{t-1[-7.60]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.995
Adjusted R-squared (ECM)	0.21
Residual diagnostics	
Residual normality (Jarque-Bera)	2.18 (0.34)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (3)	0.36 (0.95)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	2.41 (0.66)
F-Bounds test	18.67***

CUSUM test



CUSUM of squares test



8. Customs revenues

a. Long-run equation

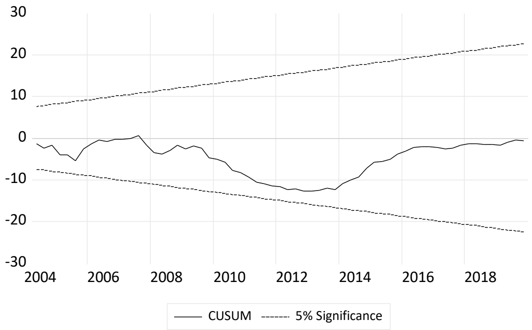
$$\log RV_t^{TXBOC} = 0.83\log(M_t * PY_t)_{[20.23]} + 0.35\log oil_{t[4.18]} + 0.52\log xr_{t[1.41]} - 7.44_{[-5.16]} + ec_t$$

b. ECM form

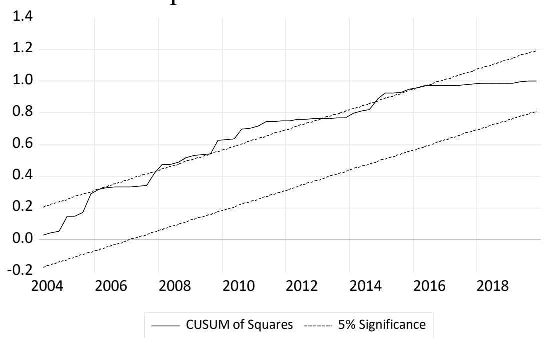
$$\Delta\log RV_t^{TXBOC} = -0.21\Delta\log RV^{TXBOC}{}_{t-1[-2.45]} + 0.91\Delta\log(PY_t * M_t)_{[4.82]} - 0.44ec_{t-1[-5.46]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.97
Adjusted R-squared (ECM)	0.49
Residual diagnostics	
Residual normality (Jarque-Bera)	26.11 (0.00)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (6)	13.42 (0.04)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	4.90 (0.30)
F-Bounds test	5.60***

CUSUM test



CUSUM of squares test



9. **Non-tax revenues**

a. Long-run equation

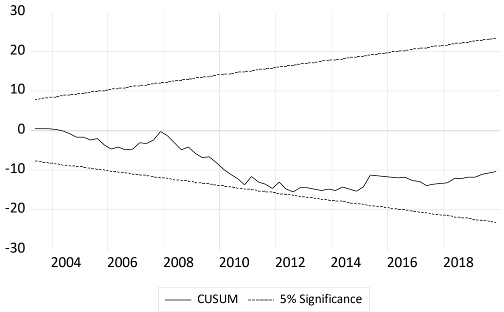
$$\log RV_t^{NTX} = 0.80 \log Y_{t[13.01]}^N - 1.07_{[-1.17]} + ec_t$$

b. ECM form

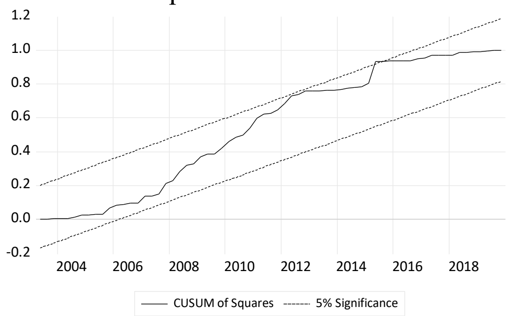
$$\Delta \log RV_t^{NTX} = -2.57 \Delta \log Y_{t[-2.38]}^N - 0.83 ec_{t-1[-7.19]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.74
Adjusted R-squared (ECM)	0.42
Residual diagnostics	
Residual normality (Jarque-Bera)	13.16 (0.00)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (2)	1.43 (0.70)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	4.43 (0.35)
F-Bounds test	16.72***

CUSUM test



CUSUM of squares test



10. **Primary expenditure**

a. Long-run equation

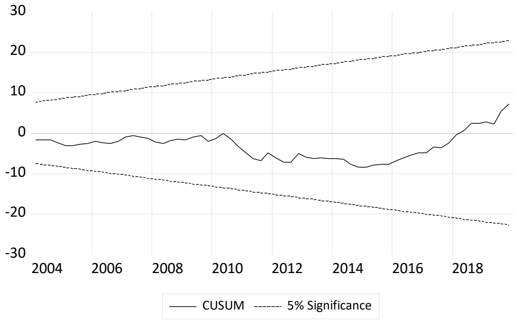
$$\log XP_t^{PR} = -0.01 \Delta DY_{t-4[-1.50]} + ec_t$$

b. ECM form

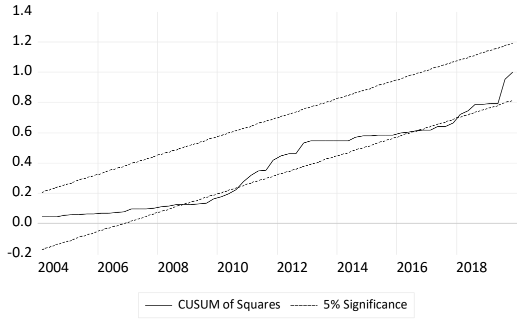
$$\Delta \log XP_t^{PR} = 0.13 Trend_{t[4.85]} + 6.76_{[4.78]} - 0.55 ec_{t-1[-4.77]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.97
Adjusted R-squared (ECM)	0.28
Residual diagnostics	
Residual normality (Jarque-Bera)	3.04 (0.22)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (6)	3.79 (0.28)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	4.74 (0.32)
F-Bounds test	11.20***

CUSUM test



CUSUM of squares test



11. Effective interest rate on domestic debt

a. Long-run equation

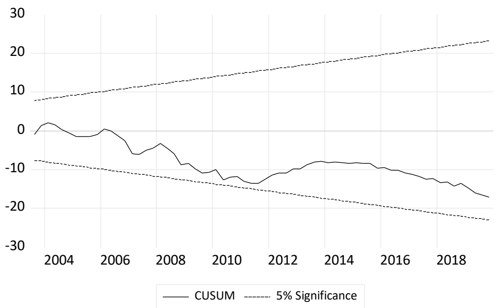
$$r_t^{dd} = 0.73_{[5.10]} + 0.13\, r_t^{t10y}{}_{[7.21]} + ec_t$$

b. ECM form

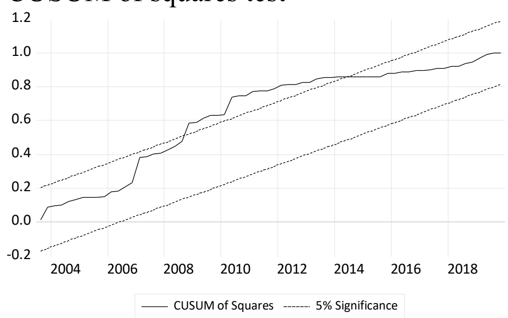
$$\Delta r_t^{dd} = -0.46 \Delta r_{t-1}^{dd}{}_{[-4.78]} - 0.28\, ec_{t-1[-3.49]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.87
Adjusted R-squared (ECM)	0.42
Residual diagnostics	
Residual normality (Jarque-Bera)	9.75 (0.01)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (4)	9.06 (0.03)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	3.99 (0.41)
F-Bounds test	3.94*

CUSUM test



CUSUM of squares test



12. Effective interest rate in foreign debt

a. Long-run equation

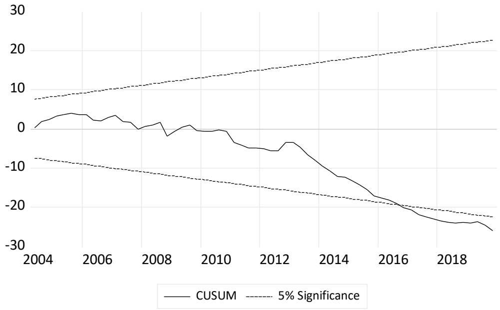
$$r_t^{df} = 0.03 r_{t[0.59]}^{t10yUS} + 0.01 DY_{t[2.76]} + 0.60_{[4.98]} + ec_t$$

b. ECM form

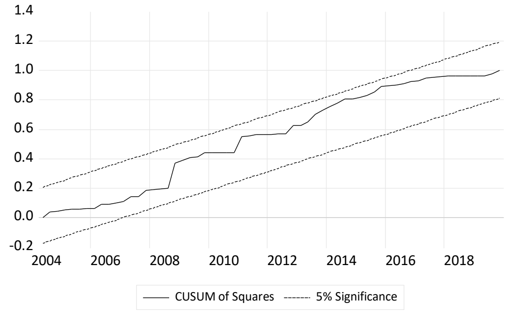
$$\Delta r_t^{df} = -0.36 r_{t-1[-3.74]}^{df} - 0.02 \Delta DY_{t[-0.97]} - 0.02 \Delta DY_{t-1[-1.43]} - 0.46 ec_{t-1[-4.07]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.64
Adjusted R-squared (ECM)	0.46
Residual diagnostics	
Residual normality (Jarque-Bera)	8.32 (0.02)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (7)	7.49 (0.28)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	15.71 (0.00)
F-Bounds test	3.95**$^{2.5\%}$

CUSUM test



CUSUM of squares test



13. Central bank policy rate

a. Long-run equation

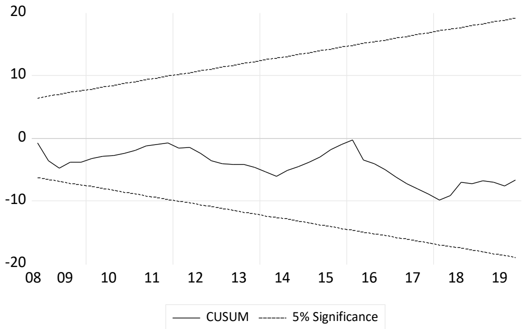
$$r_t^{cb} = 0.34(\pi_t - \pi_t^T)_{[2.76]} + 3.95_{[24.32]} + ec_t$$

b. ECM form

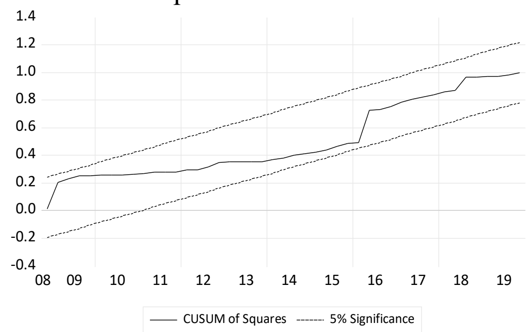
$$\Delta r_t^{cb} = 0.15\Delta r^{cb}{}_{t-1[1.55]} - 0.26ec_{t-1[-5.01]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.86
Adjusted R-squared (ECM)	0.45
Residual diagnostics	
Residual normality (Jarque-Bera)	7.81 (0.02)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (3)	4.57 (0.21)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	6.37 (0.17)
F-Bounds test	8.01***

CUSUM test



CUSUM of squares test



14. 91-day Treasury bill rate

a. Long-run equation

$$r_t^{t91d} = 1.29\, r_t^{cb}{}_{[3.08]} - 0.59\, movav\left(\frac{pb_t}{y_t}, 4\right)_{[-2.27]} - 3.08_{[-3.69]} + ec_t$$

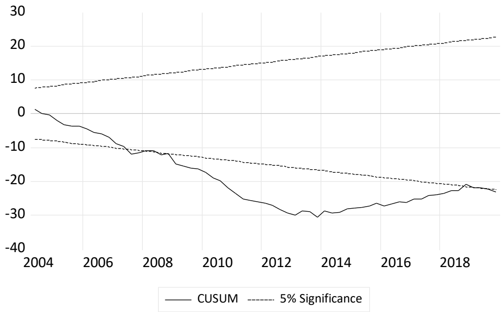
where the $movav(pb_t/y_t, 4)$ is the simple moving average of the primary balance-to-GDP ratio for four quarters.

b. ECM form

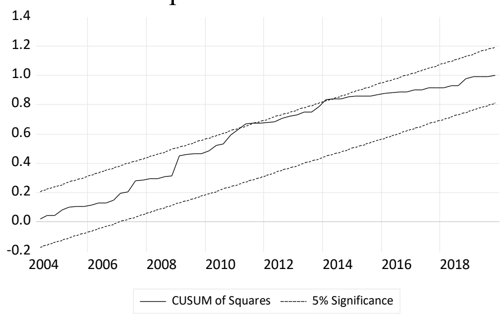
$$\Delta r_t^{t91d} = 0.35\, \Delta r_t^{t91d}{}_{[3.33]} + 0.08\pi_{t[3.52]} - 0.25ec_{t[-4.36]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.95
Adjusted R-squared (ECM)	0.31
Residual diagnostics	
Residual normality (Jarque-Bera)	0.95 (0.62)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi2$ (5)	5.03 (0.41)
No serial correlation (Breusch-Godfrey) $\chi2$ (4)	5.23 (0.26)
F-Bounds test	4.54**

CUSUM test



CUSUM of squares test



15. 10-year Treasury bond rate

a. Long-run equation

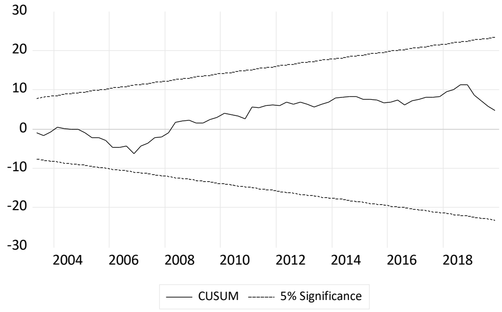
$$r_t^{t10y} = 1.07 r^{t91d}{}_{t[2.84]} + 1.85_{[1.85]} + ec_t$$

b. ECM form

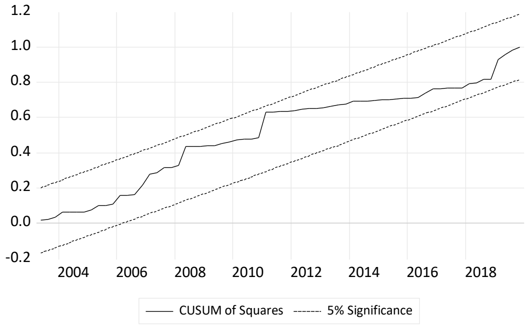
$$r_t^{t10y} = 0.02\pi_{t[1.00]} - 0.15ec_{t-1[-3.52]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.96
Adjusted R-squared (ECM)	0.12
Residual diagnostics	
Residual normality (Jarque-Bera)	4.48 (0.09)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi2$ (3)	4.46 (0.22)
No serial correlation (Breusch-Godfrey) $\chi2$ (4)	2.98 (0.56)
F-Bounds test	4.00**

CUSUM test



CUSUM of squares test



16. Bank lending rate

a. Long-run equation

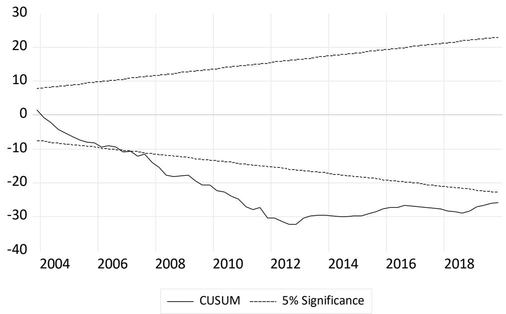
$$r_t^{bl} = 0.53r_{t[8.80]}^{t10y} + 2.91_{[7.35]} + ec_t$$

b. ECM form

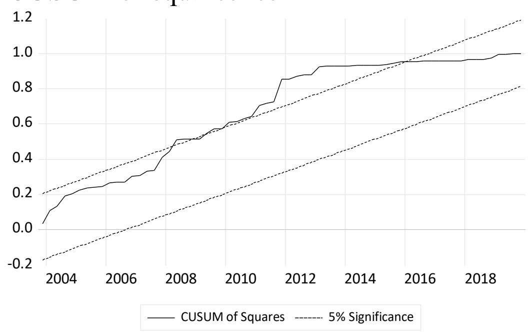
$$\Delta r_t^{bl} = 0.19\Delta {r^{bl}}_{\mathrm{t-1}[2.17]} + 0.03\pi_{t[3.11]} - 0.20ec_{t-1[-4.91]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.97
Adjusted R-squared (ECM)	0.27
Residual diagnostics	
Residual normality (Jarque-Bera)	21.20 (0.00)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (4)	9.27 (0.05)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	8.52 (0.07)
F-Bounds test	7.80***

CUSUM test



CUSUM of squares test

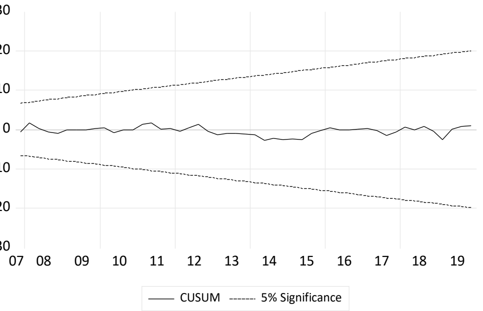


17. Consumer price index

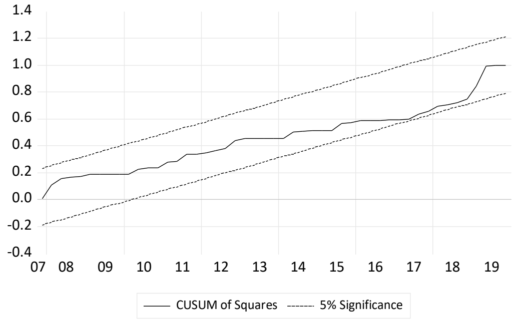
$$\Delta \log CPI_t = 0.06\Delta \log {p^{oil}}_{t[2.94]} + 0.15\Delta \log {p^{rice}}_{t[3.27]} + 0.44\Delta \log DD_{t[4.61]} + 0.18\Delta \log xr_{t[2.05]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.68
Residual diagnostics	
Residual normality (Jarque-Bera)	1.45 (0.48)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (9)	14.33 (0.11)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	5.25 (0.26)

CUSUM test



CUSUM of squares test



18. GDP deflator

a. Long-run equation

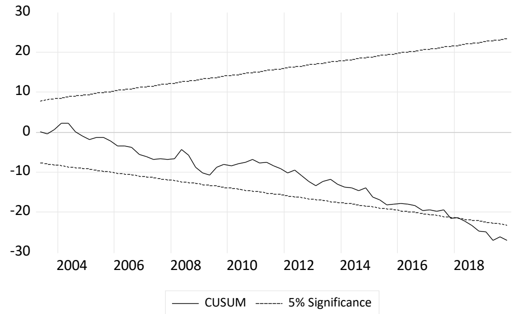
$$\log P_t^Y = 0.78 \log CPI_{t[12.67]} + 1.00_{t[3.61]} + ec_t$$

b. ECM form

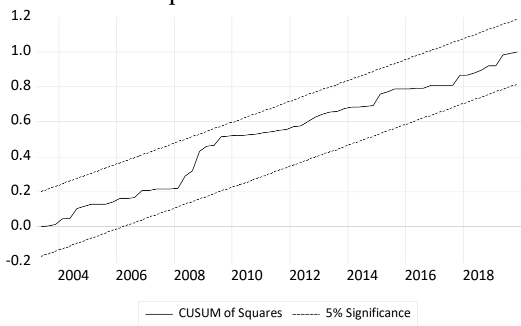
$$\Delta \log P_t^Y = 0.88 \Delta \log CPI_{t[16.37]} - 0.10 ec_{t-1[-3.54]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.999
Adjusted R-squared (ECM)	0.60
Residual diagnostics	
Residual normality (Jarque-Bera)	0.11 (0.95)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (3)	2.47 (0.48)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	7.50 (0.11)
F-Bounds test	4.05**

CUSUM test



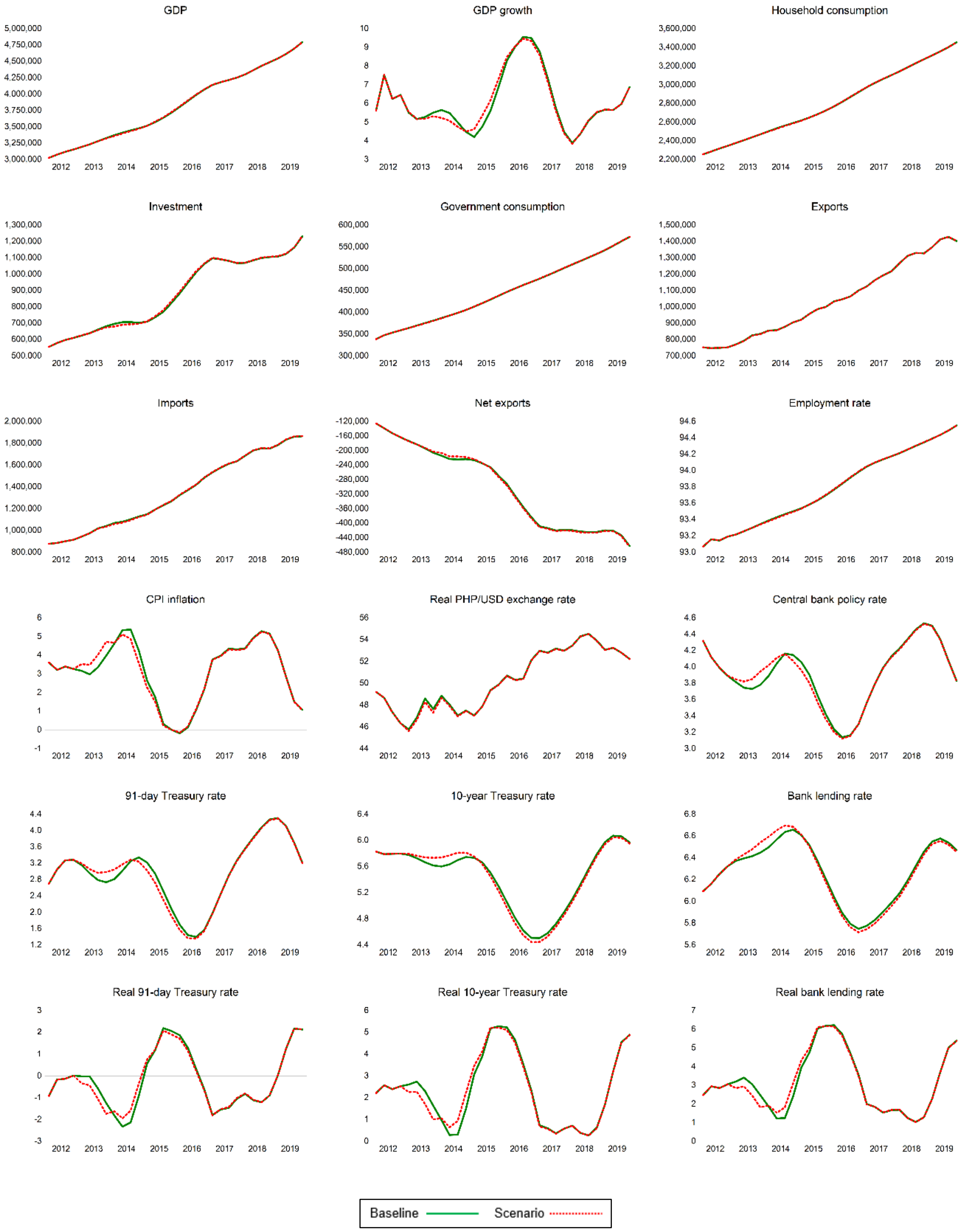
CUSUM of squares test



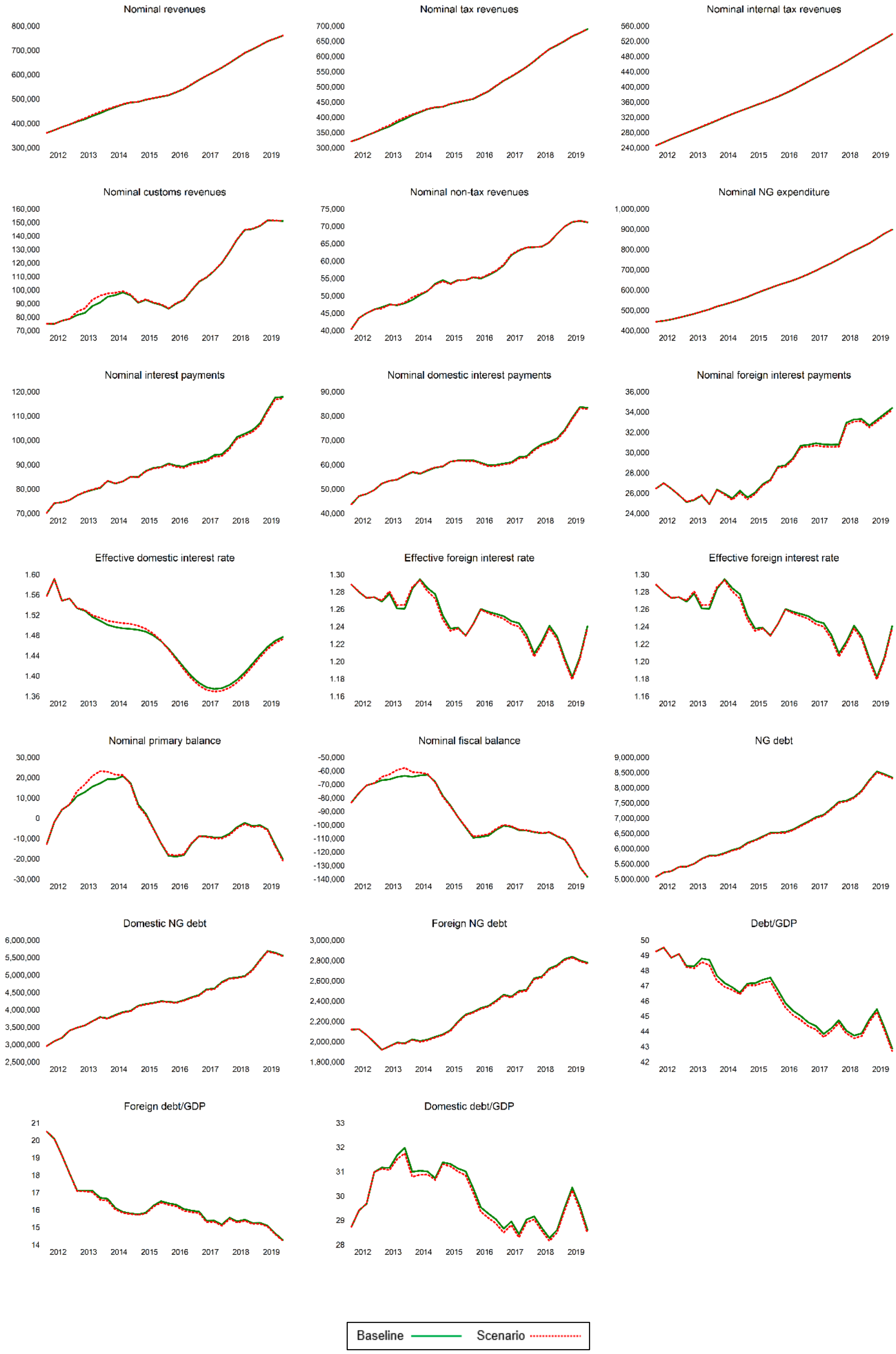
Appendix C. Oil price shock simulation results

Note: Green lines represent baseline paths, while red broken lines represent scenario paths.

A. Core model variables



B. Fiscal block and related variables

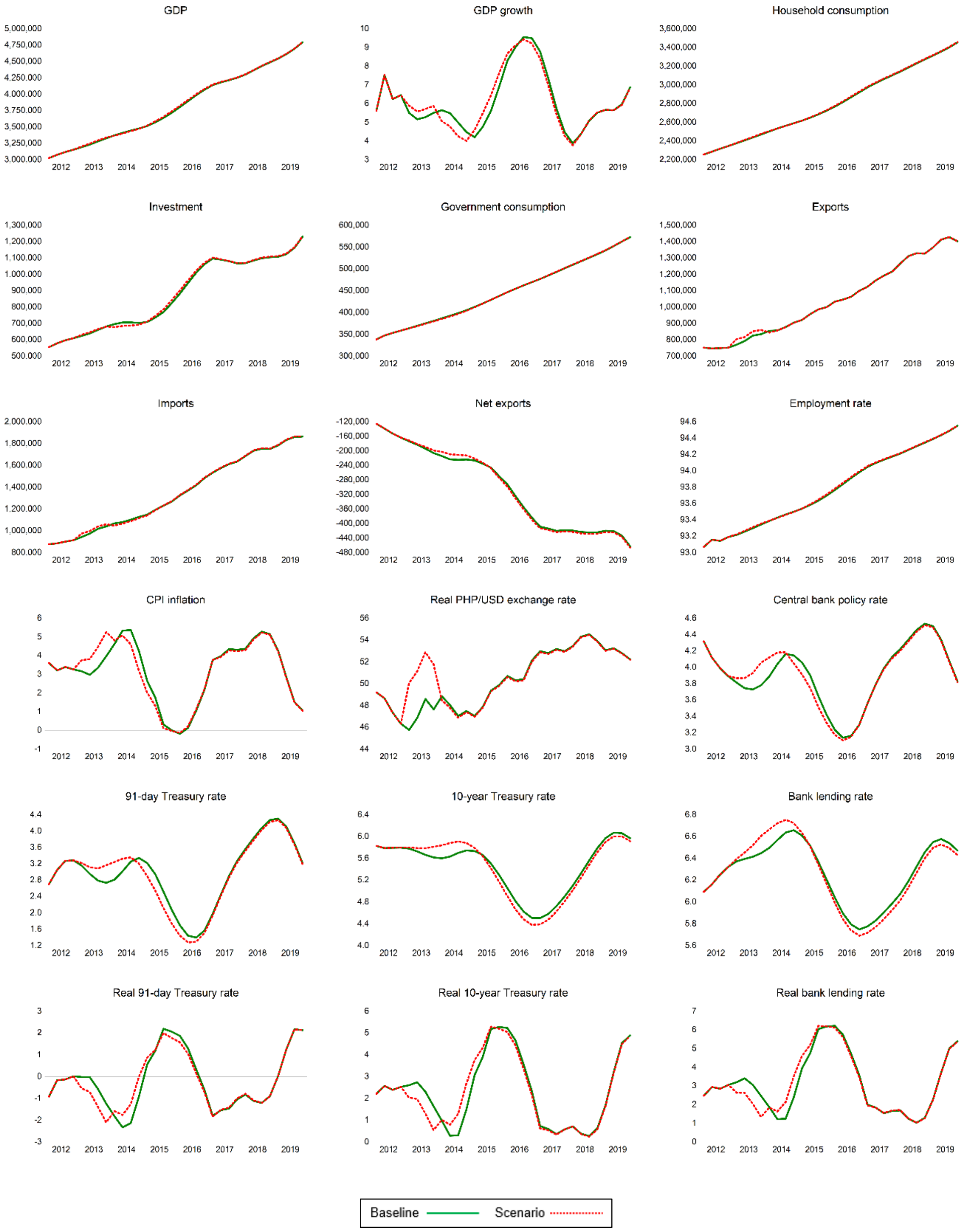


Source: Authors' calculation.

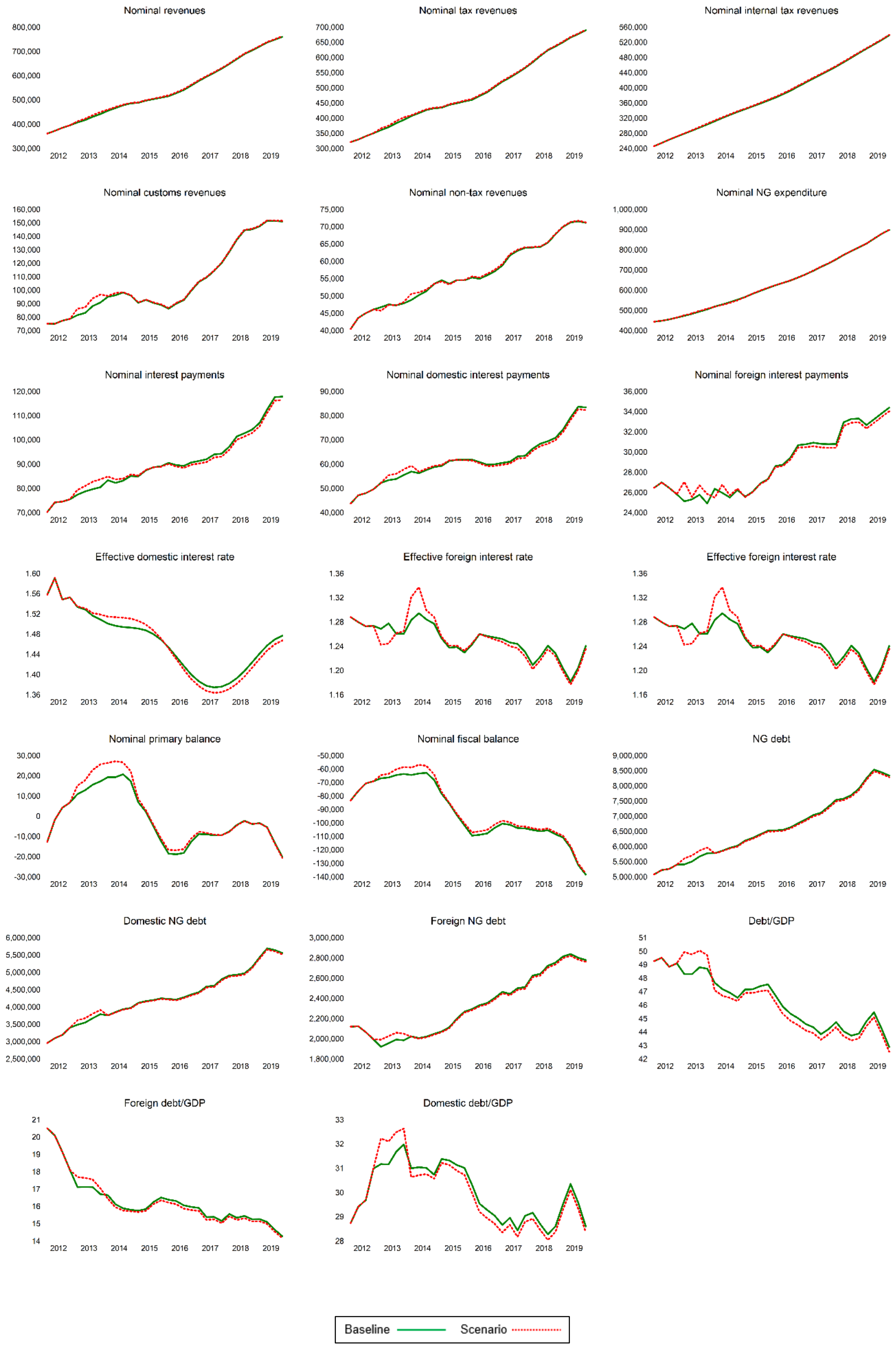
Appendix D. Exchange rate shock simulation results

Note: Green lines represent baseline paths, while red broken lines represent scenario paths.

A. Core model variables



B. Fiscal block and related variables



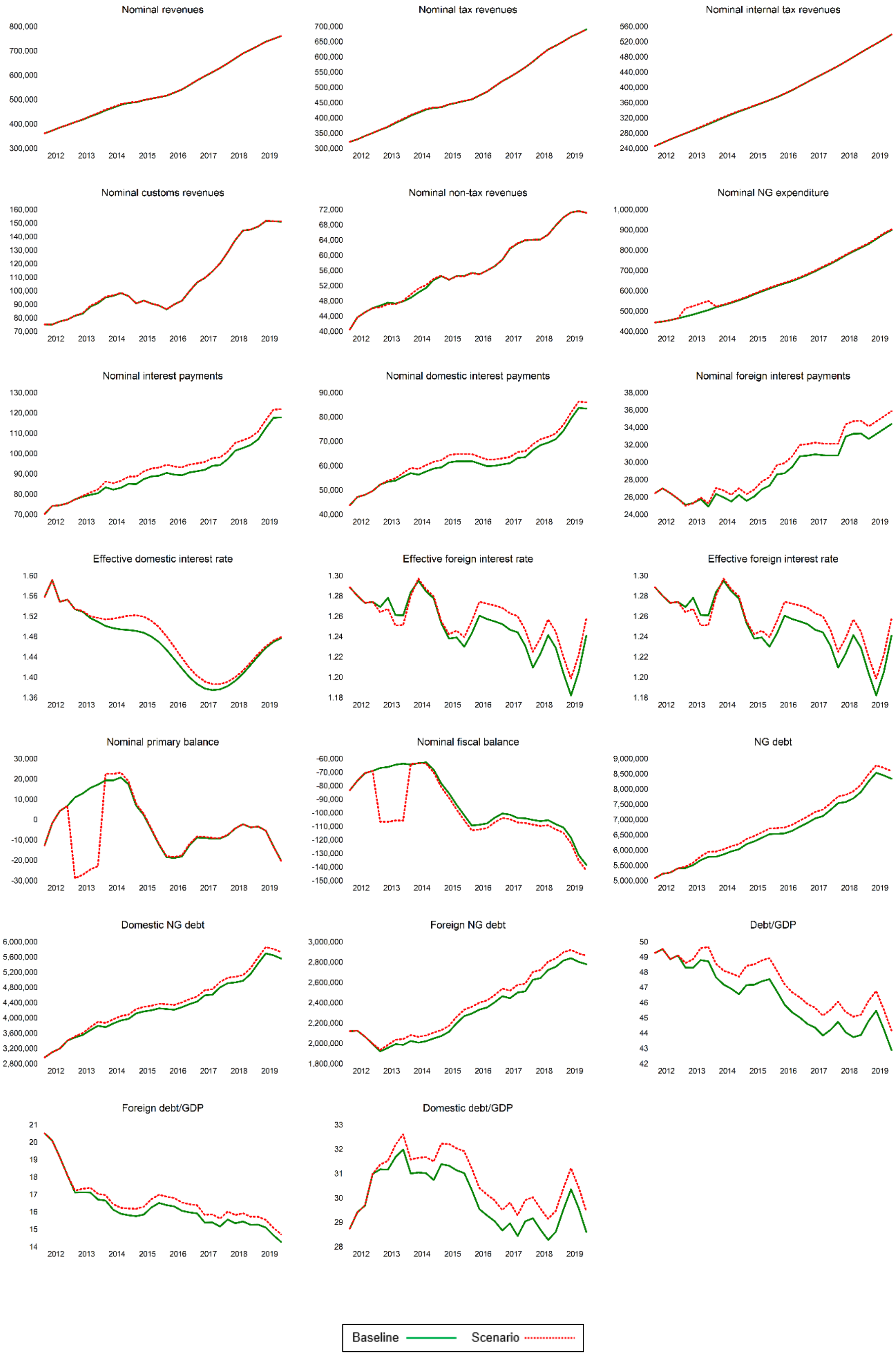
Source: Authors' calculation.

Appendix E. Primary spending shock

Note: Green lines represent baseline paths, while red broken lines represent scenario paths.

A. Core model variables

B. Fiscal block and related variables



Source: Authors' calculation.