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Quantifying the Short-Run Macroeconomic Impacts of the COVID-19 Pandemic: A Macroeconometric Approach

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Abstract

While the COVID-19 pandemic's effects on the Philippine economy have been widely chronicled, there has not been an effort at an ex-post quantification of the pandemic's impacts using counterfactual analysis. This paper aims to fill this gap. Using a modified version of the PIDS small macroeconometric model, forecasts for 2020 and 2021 are generated to serve as counterfactual paths of key economic indicators in the pandemic's absence. The gap between the actual and counterfactual trajectories is interpreted as comprising the pandemic's impact. The impact estimates lend further evidence to the pandemic's severe and lasting effects on the real economy, with real output, private domestic spending (particularly investment), and the employment rate suffering significant negative deviations from their counterfactual levels. Model simulations also clarify the extent of the deterioration of public finances triggered by the pandemic, particularly on tax revenues, the fiscal balance, and government debt. On the other hand, the pandemic's estimated impacts on inflation and key domestic interest rates are less evident.

Keywords: macroeconometric model, COVID-19 pandemic, Philippine economy

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Quantifying the Short-Run Macroeconomic Impacts of the COVID-19 Pandemic: A Macroeconometric Approach

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1. Introduction

The COVID-19 pandemic and the ensuing public health response inflicted a heavy and lasting toll on the Philippine economy. In the real economy, the immediate impacts included the deepest contraction of output in the post-war era; the widespread falloff in economic activity, most pronounced in contact-dependent services sectors; and a collapse of both household consumption and private investment. In the labor front, the pandemic triggered a sharp increase in both unemployment and underemployment, while in the fiscal sector, the effects consisted of a steep decline in revenue collections, the widening of the government deficit, and the consequent escalation of public debt.

There exists a considerable body of literature chronicling the effects of the pandemic on the Philippine economy as it unfolded, many of which are from institutions that regularly monitor the country's economic performance (e.g., Debuque-Gonzales et al 2021; Debuque-Gonzales 2022; World Bank 2020a, 2020b, 2021a, 2021b; International Monetary Fund 2021). However, there has not been an effort at an ex-post quantification of the pandemic's macroeconomic impacts. This analysis would involve comparing the path of macroeconomic variables in response to the pandemic shock with their trajectories in the absence of the same shock.

Macroeconometric models are among the tools available for performing quantitative analyses of the economy-wide effects of economic shocks. The Philippine Institute for Development Studies (PIDS) has recently revived institutional efforts to develop and maintain such a model. Debuque-Gonzales and Corpus (2022a) initially constructed a small-scale quarterly macroeconometric model featuring a demand-driven core. Behavioral equations were estimated through Autoregressive Distributed Lag-Error Correction Method (ARDL-ECM) using data from 2002 through 2017. The same authors later extended the model to include a fiscal block consisting of revenues, spending, and government debt (Debuque-Gonzales and Corpus 2022b).

The PIDS small model can be used to carry out a quantitative assessment of the pandemic's impacts on key macroeconomic indicators. Such an approach would provide a clearer picture (and understanding) of the pandemic's impacts on the Philippine macroeconomy. This would allow for better policy guidance in the post-COVID period when policymakers must make more complex decisions, given the emerging domestic and external macroeconomic environment, as they lead the country towards recovery. This application also presents an opportunity to further improve and develop the macroeconometric model.

The next section provides a brief review of efforts to use macroeconomic models to quantify the COVID-19 pandemic's economic impacts in the literature. Section 3 reviews the structure of the PIDS small model. Section 4 discusses the methodology for quantitative assessment. Section 5 discusses the results, and Section 6 ends with some concluding remarks.

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2. Literature review

The body of research that aims to quantify the economic impact of the COVID-19 pandemic using macroeconomic models is quite lean and consists mostly of papers that use computable general equilibrium (CGE) models. These studies use static or dynamic CGE models to generate shocks that simulate disturbances triggered by the pandemic on different dimensions of the economy such as labor supply, consumer demand, production, government spending, and others. The pandemic's effects are then measured by comparing the resulting path of model variables relative to their equilibrium position under a baseline scenario. Several studies use CGE methodology to project the impact of the pandemic on global GDP (e.g., Malizsewa, Mattoo, and van den Mensbrugghe [2020]; McKibbin and Fernando [2020]; Cho, Kim, and Kim [2021]; and Beckman, Baquedano, and Countryman [2021]). Others focus on the impact of the pandemic in specific countries, e.g., Walmsley et al (2023) for the United States, and Posse et al (2020) for Brazil.

In our review of the literature, it appears that the only application of a macroeconometric model to estimate the COVID-19 pandemic's impacts is a working paper by the United Nations Economic Commission for Africa (UNECA 2021). The paper features an annual Africa-wide model consisting of 41 equations (25 behavioral and 16 identities or bridge equations) organized into five sectors (aggregate demand, aggregate supply, prices, fiscal, and monetary). Behavioral equations are estimated using ECM. The model is determined in the short run by a Keynesian demand side and in the long run by a neoclassical supply side. The pandemic is simulated through eight shocks, namely, shocks in labor supply, external demand, oil and non-oil prices, global non-oil prices, prices of non-oil imports and exports, investment, and government revenue. Altogether, the shocks lead to a reduction in GDP by 4.8-8.4 percentage points in 2020 compared to the model's baseline projections.

To our knowledge, similar analyses of the pandemic's economic impacts (i.e., using macroeconomic models) have not been done for the Philippines. An adjacent effort was that of Abrigo et al (2020) written very early in the pandemic, which used input-output analysis to estimate the impact of the COVID-19 shock on the domestic economy. They projected output losses in the range of PHP 276.3 billion to PHP 2.5 trillion in 2020—about 1.4 percent to 12.8 percent of 2019 GDP, respectively—with manufacturing, wholesale and retail trade, and other services accounting for most of the decline.

3. The PIDS small macroeconometric model

This section discusses the data, estimation strategy, and structure of the macroeconometric model used in the paper. It is a slightly modified version of the system presented in Debuque-Gonzales and Corpus (2022b). The model, visualized in Figure 1, consists of six blocks covering basic sectors of the economy, namely, (1) domestic demand, (2) international trade, (3) employment, (4) prices, (5) financial/monetary sector, and (6) fiscal sector. The elements and structure of the previous model are largely retained, and output remains determined from the demand-side. The main modification consists of the introduction of inflation expectations (in place of actual inflation) into some behavioral equations in the domestic demand and monetary blocks (see Sub-section 3.2 below). The addition of inflation expectations brings the total number of equations to 39 (21 behavioral equations and 18 identities). Table 1 summarizes the model's key equations and variables.

Table 1. Key model equations and variables

Equations	Variables
Domestic demand	C = Household consumption
$\log C_t = f(\log(YD_t), emp_t, r_t^{bl} - \pi_t^e, \pi_t^e)$	CPI = Consumer Price Index
$\log(I_t) = f(\log(Y_t), \Delta(r_t^{bl} - \pi_t^e), \pi_t^e)$	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
	P^Y = GDP deflator
Employment block	r^{bl} = Bank lending rate
$emp_t = f(Y_t)$	r^{cb} = BSP policy rate
	r^{dd} = Effective interest rate on domestic debt
Price block	r^{df} = Effective interest rate on foreign debt
$\Delta\log(CPI_t) =$	RES = Debt residual (nominal)
$f\left(\Delta\log\left(p_t^{oil}\right), \Delta\log\left(p_t^{rice}\right), \Delta\log(DD_t), \Delta\log(xr_t)\right)$	rr^{bl} = Real bank lending rate
	rr^{t10y} = Real 10-year Treasury rate
$\pi_t \equiv 100\left(\frac{CPI_t}{CPI_{t-4}} - 1\right)$	rr^{t91d} = Real 91-day Treasury rate
	r^{t10y} = 10-year Treasury rate
Monetary block	r^{t10yUS} = US 10-year Treasury rate
$r_t^{cb} = f(\pi_t^e - \pi_t^T)$	r^{t91d} = 91-day Treasury rate
$r_t^{t91d} = f(r_t^{cb}, PB_t/Y_t, \pi_t^e)$	RV = Total revenues (nominal)
$r_t^{t10y} = f(r_t^{t91d}, \pi_t^e)$	RV^{NTX} = Non-tax revenues (nominal)
$r_t^{bl} = f(r_t^{t10y}, \pi_t^e)$	RV^{TX} = Tax revenues (nominal)
$rr_t^{t91d} \equiv r_t^{t91d} - \pi_t$	RV^{TXBIR} = Internal tax revenues (nominal)
$rr_t^{t10y} \equiv r_t^{t10y} - \pi_t$	RV^{TXBOC} = Customs revenues (nominal)
$rr_t^{bl} \equiv r_t^{bl} - \pi_t$	X = exports
	XP = Total expenditure (nominal)
$xrr_t = xr_t\left(\frac{CPI_t^{US}}{CPI_t}\right)$	XP^{IND} = Domestic interest payments (nominal)
	XP^{INF} = Foreign interest payments (nominal)
	XP^{INT} = Interest payments (nominal)
$r_t^{dd} = f\left(r_t^{t10y}\right)$	XP^{PR} = Primary expenditure (nominal)
$r_t^{df} = f\left(r_t^{t10yUS}, DY_t\right)$	xr = nominal peso-dollar exchange rate
	xrr = real peso-dollar exchange rate
Fiscal block	Y = GDP
$\log(RV_t^{TXBIR}) = f(\log(Y_t^N))$	YD = disposable income
$\log(RV_t^{TXBOC}) = f(\log(P_t^Y M_t), \log(p_t^{oil}), \log(xr_t))$	Y^N = nominal GDP
$\log(RV_t^{NTX}) = f(\log(Y_t^N))$	Y^{WORLD} = World GDP
$RV_t^{TX} \equiv RV_t^{TXBIR} + RV_t^{TXBOC}$	α= Share of domestic debt in total
$RV_t \equiv RV_t^{TX} + RV_t^{NTX}$	π = inflation rate
$\log(XP_t^{PR}) = f(DY_t)$	π^T = inflation target (midpoint)
$XP_t^{INT} \equiv XP_t^{IND} + XP_t^{INF}$	π_t^e = expected inflation rate
$XP_t \equiv XP_t^{PR} + XP_t^{INT}$	
$XP_t^{IND} \equiv r_t^{dd} \times D_{t-1}^D$	
$XP_t^{INF} \equiv \left(\frac{xr_t}{xr_{t-1}}\right) r_t^{df} D_{t-1}^F$	
$PB_t \equiv RV_t - XP_t^{PR}$	
$D_t \equiv XP_t^{INT} + D_{t-1}^D + \left(\frac{xr_t}{xr_{t-1}}\right) D_{t-1}^F - PB_t + RES_t$	
$D_t^D \equiv \alpha_t D_t$	
$D_t^F \equiv (1 - \alpha_t) D_t$	

3.1. Data and estimation method

The model's behavioral equations were estimated using the ARDL-ECM method in EViews. The optimal leg length was selected (up to a maximum of two) using the Akaike Information Criterion, while cointegration between variables was tested using the Pesaran, Shin, and Smith (2001) bounds test. Specifications were selected so that the coefficients of long-run variables have signs that are consistent with theory. Explanatory variables with coefficient signs that contradicted theory or intuition were either relegated to the short-run equation or deleted entirely. Behavioral equations were modeled as short-run ARDL models (i.e., in first differences) in the absence of cointegration.

Residual diagnostic checks testing for homoskedasticity, serial correlation, and normality were performed. Parameter and variance stability were checked using the cumulative sum (CUSUM) and CUSUM of squares tests, respectively. The system of behavioral equation and identities was solved in EViews using the Broyden solution algorithm.

Quarterly data spanning 2002 to 2019 were used to construct the model. All series were seasonally adjusted using the X-13 routine in EViews prior to estimation. Appendix A presents a summary of the data, while Appendix B shows the results of the unit root (augmented Dickey Fuller) tests.

3.2. Model structure

Domestic demand block

In the domestic demand block, household consumption in the long run is specified as a function of disposable income (defined as GDP net of internal tax revenues), the employment rate, the expected inflation rate, and the bank lending rate adjusted for expected inflation. In the short-run, consumption is a function of disposable income and employment. Short-run investment is determined by expected inflation, the bank lending rate net of expected inflation, and output growth, while long-run investment is a function of GDP. Meanwhile, government consumption is a function of primary spending (government spending less interest payments) in both the short run and long run, with a linear time trend included in the short-run dynamics.

Trade block

Imports are driven by private investment and exports both in the long run and short run. Meanwhile, exports are a function of the real peso-dollar exchange rate and world income in both long and short horizons.[1]

Employment block

The employment block consists solely of the employment rate. The employment rate is modelled as dependent on GDP in the long run, adopting a variant of Okun's law. In the short run, the change in employment rate depends on its own lag.

Price block

Movements in the Consumer Price Index (CPI) is formulated as a purely short run equation determined by changes in domestic demand, the nominal peso-dollar exchange rate, the world

[1] World income is represented by a trade-weighted aggregate of the GDPs of the country's major export partners. See Debuque-Gonzales and Corpus (2022a, 2022b) for details.

oil price, and the domestic retail price of rice.[2] The GDP deflator, used for computing nominal GDP within the system, is driven by the CPI and CPI inflation in the long-run and short-run equations, respectively. Lastly, inflation expectations—formulated as an autoregressive process—is incorporated into the model, using the fitted series from the regression of next-quarter inflation on current and lagged inflation.[3]

Monetary/financial block

The monetary/financial block consists primarily of the central bank policy rate, interest rates on short-term and long-term government securities, and the bank lending rate.

The central bank policy rate (or the BSP's overnight reverse repurchase rate) is modeled as a function of deviations of the expected inflation rate from the official inflation target in the long run, and of its own lag in the short run. The 91-day Treasury (T-bill) rate depends on the central bank policy rate and the primary balance (as a percentage of GDP) in the long run, while its short-run movements are determined by its own lag and expected inflation. Meanwhile, the 10-year Treasury bond rate is cast as a function of the 91-day Philippine T-bill rate in the long run, with its short-run changes specified as a function of expected inflation. The bank lending rate, in turn, is modeled as a long-term function of the policy rate and the 10-year Treasury rate, while bank lending rate changes are formulated as a short-term function of its own lagged change and inflation.

This block also includes the interest rates on domestic and foreign debt. The effective interest rate on domestic debt is determined by the 10-year Philippine Treasury rate in the long run and by its own lag in the short run. Meanwhile, the effective interest rate on foreign debt is a function of the yield on the 10-year US Treasury note in the long run, its own lag in the short run, and the Philippine debt-to-GDP ratio in both long and short horizons.

Fiscal block

Equations for government revenues, expenditures, and debt comprise the model's fiscal block, illustrated in Figure 1 Panel B.

On the revenue side, total revenues are the sum of tax revenues and non-tax revenues. Non-tax revenues are cast as a long-run function of GDP. Tax revenues, meanwhile, are composed of internal tax and customs revenues. Internal tax revenues are specified as a function of GDP in the long run, while the corresponding short-run movements depend on their own lag. Customs revenues are modeled as a function of imports, the nominal peso-dollar exchange rate, and the world price of oil in the long run, with import growth driving customs revenue growth in the short run.

On the expenditure side, total expenditures consist of primary expenditures and interest payments on government debt. Primary expenditures (or total spending net of interest payments) react negatively to the previous year's debt-to-GDP ratio in the long and short run. Meanwhile, interest payments are the sum of domestic and foreign interest payments. Interest payments (domestic and foreign) are the product of the corresponding effective interest rate on debt and the debt stock from the previous period (with foreign interest payments adjusted for

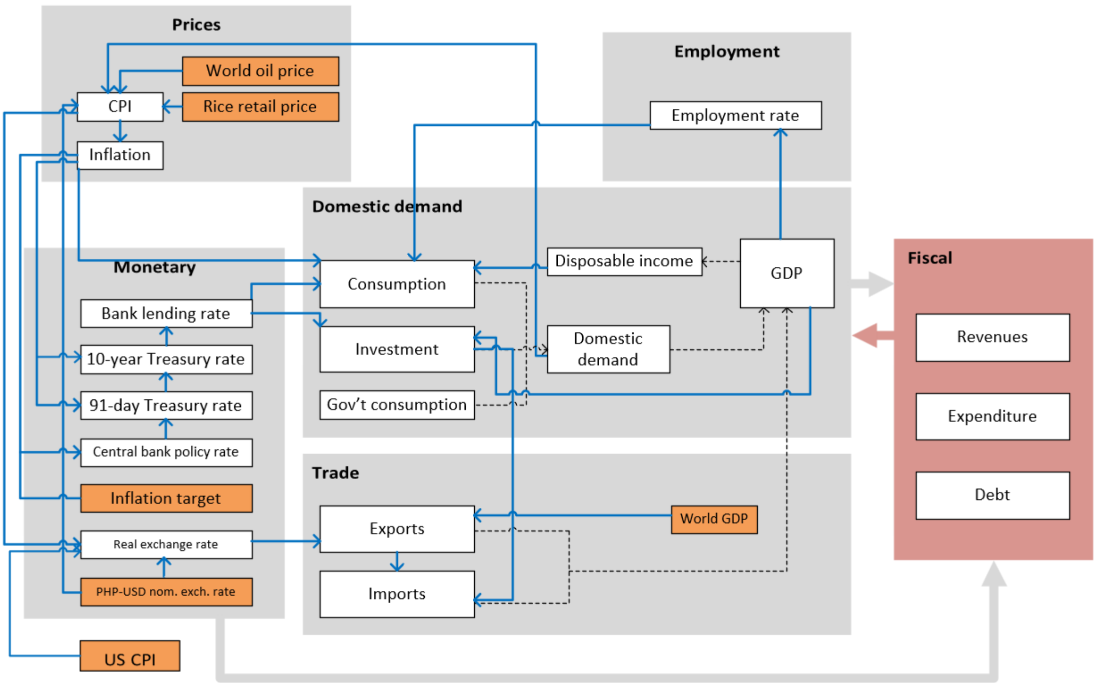
[2] This specification is similar to the those of the BSP's Single-Equation Model and Multi-Equation Model, which are the central bank's workhorse models for inflation targeting.
[3] The equation is estimated using ordinary least squares regression.

exchange rate depreciation). The primary balance is derived from the difference of government revenues and primary expenditures.

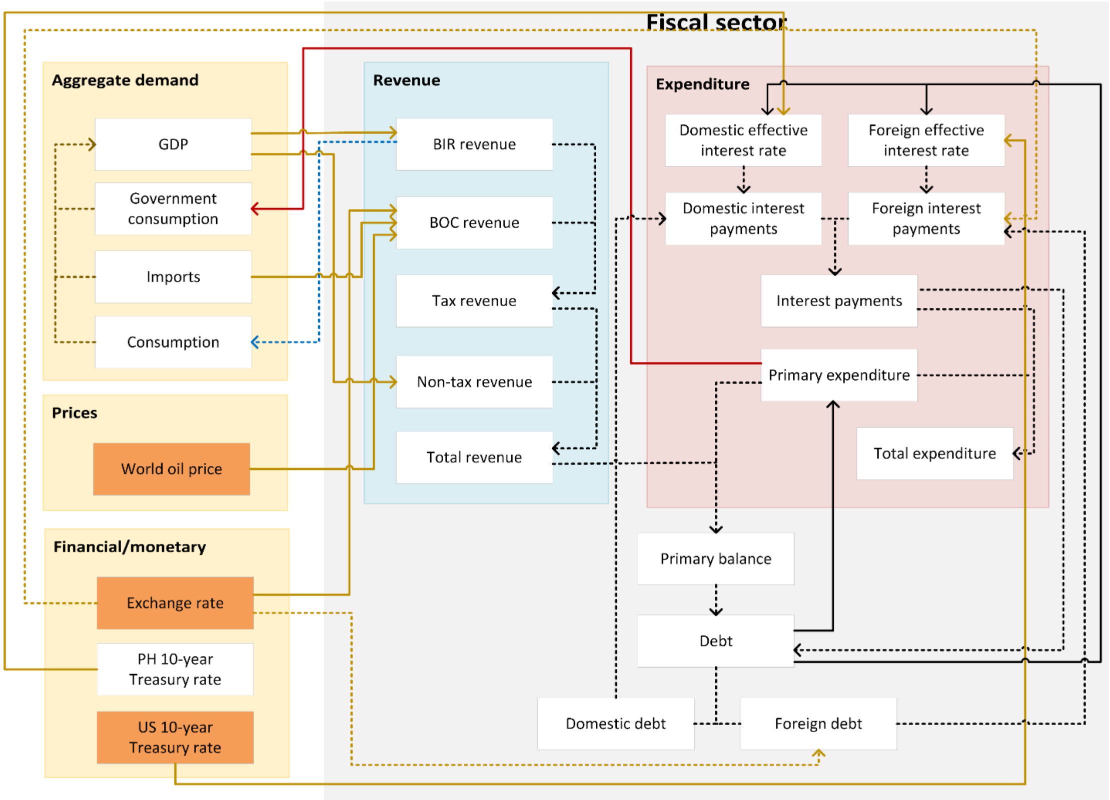
Finally, government debt is derived from the sum of domestic and foreign debt from the previous period, the corresponding interest payments on existing debt, the current period's primary deficit, and a residual term capturing other sources of debt. Total government debt is also the sum of domestic and foreign debt, whose shares are restricted to reflect their actual contributions to the total debt stock.

Figure 1. The PIDS small macroeconometric model

A. Overview



B. The fiscal sector in detail



Note: Orange boxes denote exogenous variables. Solid lines represent behavioral relationships, while broken lines represent identities.

Source: Authors' illustration.

4. Methodology

The PIDS small model is used to generate out-of-sample forecasts for the period 2020Q1 through to 2021Q. These forecasts serve as the counterfactual paths of the model's macroeconomic variables in the absence of the COVID-19 pandemic. The projections were generated through dynamic stochastic simulations. Five thousand simulations using bootstrapped estimation residuals were performed, generating a distribution of forecast paths for the model's endogenous variables.[4] Forecasts for exogenous variables, meanwhile, were generated using the autoregressive integrated moving average (ARIMA) method. The difference between the actual and counterfactual trajectories of key macroeconomic variables is interpreted as largely comprising the pandemic's impact, given that the public health crisis was unarguably the biggest shock during the period.

Forecasts were not generated beyond 2021 as the effects of geopolitical events and global economic conditions began to overshadow those of the pandemic in 2022. These include the Russian invasion of Ukraine, the subsequent surge in world oil and commodity prices, the resulting bout of high inflation, and aggressive policy rate hikes by central banks across the world.

Pandemic impacts are calculated for the model's key variables, namely: GDP, its demand-side components, and the employment rate; the inflation rate; the central bank policy rate, interest rates on short-term and long-term government securities, and the bank lending rate; and measures of revenue, expenditure, fiscal balance, and government debt.

Two measures are presented for each variable. First is the impact of the pandemic, represented by the (percentage or percentage-point) deviation of a variable's actual values in 2020 and 2021 from their mean forecast values for the same years under a No-COVID scenario. Second is the counterfactual change in the variable between 2019 and 2021, derived by taking the (percentage or percentage-point) difference of its mean forecasted value for 2021 under a no-COVID scenario with its actual value in 2019.[5]

Uncertainty from the forecasts is incorporated in these measures by calculating high- and low-end estimates using the model's upper-bound (95th percentile) and lower bound (5th percentile) projections.

[4] The innovations were randomly drawn from the residuals of each estimated behavioral equation and incorporated into the simulations.

[5] Mathematically, these measures can respectively be written out as

$$Deviation_t = \begin{cases} 100\left(\frac{x_t^a}{\bar{x}_t^f} - 1\right), & \text{for level variables} \\ 100\left(x_t^a - \bar{x}_t^f\right), & \text{for rate variables} \end{cases}, \ t = 2020, 2021 \qquad (1)$$

$$Change = \begin{cases} 100\left(\frac{\bar{x}_t^f}{x_{2019}^a} - 1\right), & \text{for level variables} \\ 100\left(\bar{x}_t^f - x_{2019}^a\right), & \text{for rate variables} \end{cases}, \ t = 2021 \qquad (2)$$

where x_t^a is the variable's actual value in 2020 or 2021, x_{2019}^a its actual value in 2019, and $\bar{x}_t^f$ its mean forecast value in the 2020 or 2021.

5. Results

This section discusses the model-based estimates of the pandemic's impacts on key macroeconomic variables as captured by metrics discussed in Section 4. Results are presented first for real economy variables, namely, GDP, its components, and employment; second, for financial/monetary sector variables; and finally, for fiscal sector variables.

The actual and forecast paths of the key endogenous variables during the pandemic are also depicted in graphs. In these graphs, blue lines represent the actual (historical) series, the red broken lines represent the mean of the out-of-sample forecasts, while the lower and upper orange broken lines represent the 5th and 95th percentiles, respectively, of the forecast distribution. Graphs of exogenous variables' historical and forecast series are shown in Appendix D.

5.1. GDP, aggregate demand components, and employment

The model predicts that GDP would have continued its upward trajectory in 2020 and 2021 had the pandemic not occurred (see Figure 2). The pandemic, however, induced a downward deviation in output that is well outside the range of predicted paths for the variable. Based on the mean forecast for a No-COVID scenario, the estimated loss in output is 12 percent in 2020 and 13 percent in 2021 (see Figure 3 Panel A). If the pandemic had not occurred, the model projects that GDP in 2021 would have been roughly 10 percent higher than its pre-pandemic peak in 2019, rather than 4.3 percent lower (see Figure 3 Panel B).

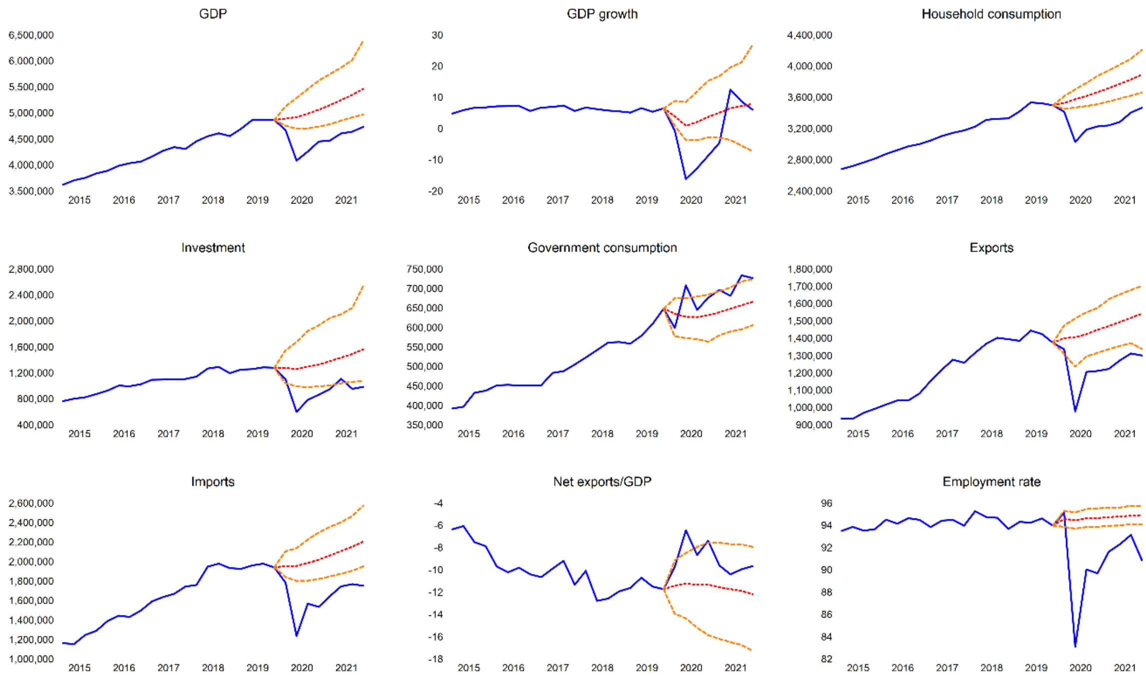
These losses in total output can be traced to large losses in private domestic spending. The model simulations suggest that the observed decline in household consumption, which accounts for 70 percent of aggregate demand, is equivalent to a loss of over 10 percent of its mean counterfactual level (10.6% in 2020 and 11.9% in 2021). Private investment, meanwhile, lost about a third (34.7% in 2020 and 31.6% in 2021) of its mean projected level without the pandemic shock.

Exports and imports were likewise lower (by 16.6% and 22.5% in 2020, respectively) compared to their predicted values without the pandemic. The larger contraction in imports compared to exports translated to a 3.3-percentage point improvement in net exports (as a percentage of GDP) compared to its mean counterfactual position in 2020.

In contrast, actual government consumption exceeded its mean projected path in 2020 (by 4.3%) and 2021 (by 8.7%), although it was within the upper end of the forecast range. This result is due to elevated government spending for various pandemic-related emergency relief and public health measures during those years.

Meanwhile, the mean model prediction suggests that the pandemic cut the rate of employment by 5.1 percentage points in 2020 and by 2.9 percentage points in 2021. Without the pandemic, the employment rate would have risen by 0.5 percentage points compared to its 2019 level.

Figure 2. GDP, aggregate demand components, and employment rate: actual vs. model forecast



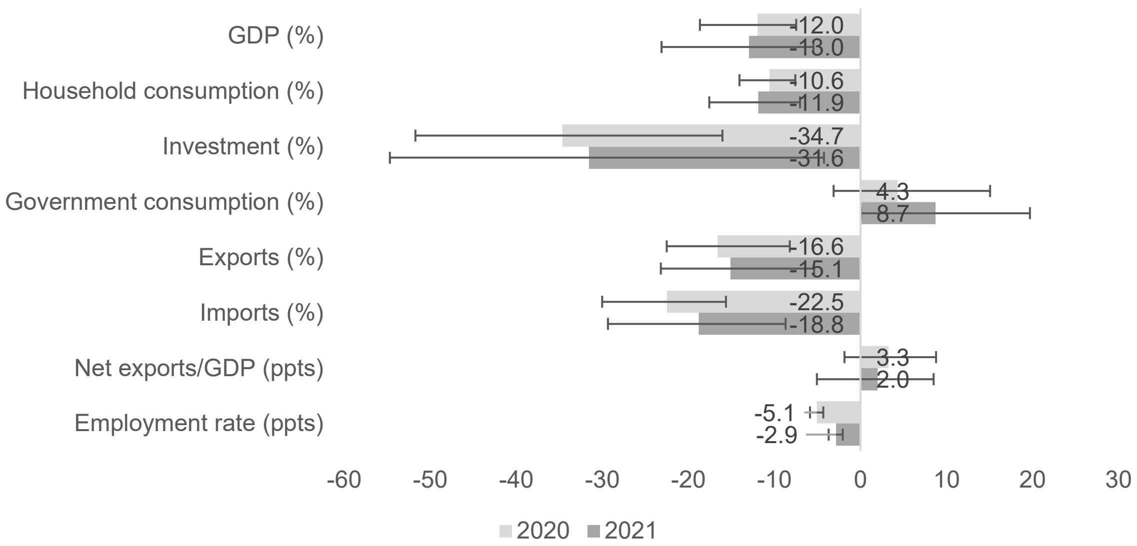
Note: Blue lines depict actual data. Red broken lines depict the mean model forecast path. The upper and lower orange broken lines respectively depict the 95th and 5th percentiles of the forecast distribution.

Source: Authors' calculations.

Figure 3. Impacts of the COVID-19 pandemic on GDP, aggregate demand components, and employment rate

A. Deviation of actual series from model forecast, 2020 and 2021

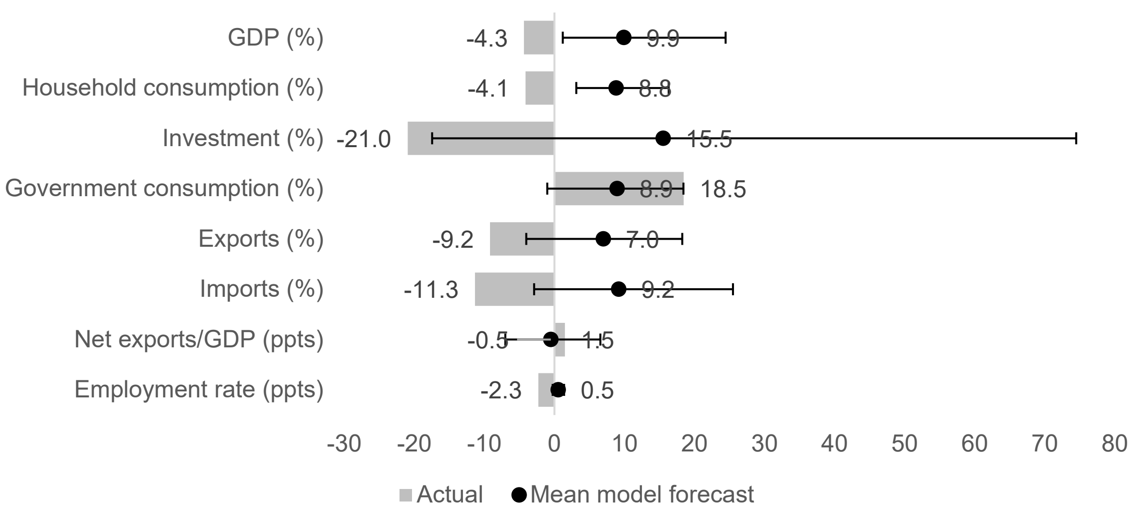
Percent or percentage points



Note: The shaded bars represent the percentage or percentage-point difference of the actual data from the mean of the model forecast for 2020 and 2021 in a No-COVID scenario. The error bars represent the range of deviations corresponding to 95 percent of the forecasts. The deviations were derived from the annualized series and forecasts. ppts = percentage points.

B. Change between 2019 and 2021: actual series vs. model forecast

Percent or percentage points



Note: The shaded bars represent the actual percentage or percentage-point change in each variable between 2019 and 2021. The markers represent the percentage or percentage-point change difference of the mean of the model forecast for 2021 in a No-COVID scenario from their baseline value in 2019. The error bars represent the range of differences corresponding to 95 percent of the forecasts. ppts = percentage points.

Source: Authors' calculation.

5.2. *Inflation and key domestic interest rates*

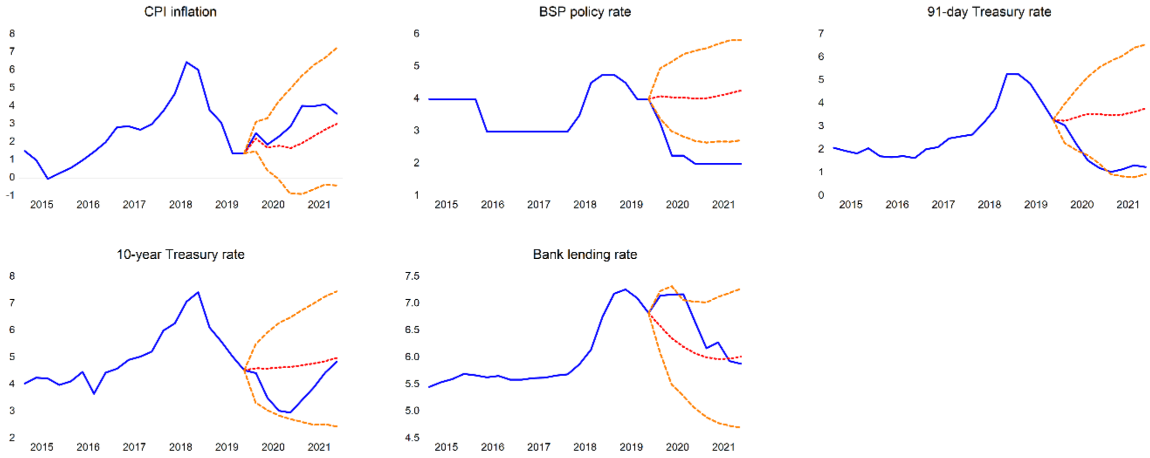
As shown in Figures 4 and 5 (Panel A), actual inflation was slightly higher than the model's mean forecast in a No-COVID scenario, exceeding the latter by 0.6 percentage point in 2020 and by 1.4 percentage points in 2021. The observed inflation between 2019 and 2021 is 6.4 percent, higher than the model's mean forecast of 4.4 percent (see Figure 5 Panel B). However, the actual path of inflation during the pandemic is well within the model's forecast range.

Meanwhile, the central bank policy rate (or overnight reverse repurchase rate) fell well below the model's forecast during the period in question. Successive rate cuts by the central bank between February and November 2020 aimed at easing financial conditions brought the policy rate from 4 percent to a historic low of 2 percent, where it remained until the first quarter of 2022. On the other hand, the mean projected trajectory of the policy rate sans the pandemic is essentially flat, rising only by 0.2 percentage points between 2019 and 2021. Thus, the policy rate deviated from the mean model forecast by -1.6 percentage points in 2020 and by -2.1 percentage points in 2021.

A similar divergence between the actual and forecast trajectories is seen in the interest rates on short-term and long-term government borrowing in 2020 and 2021. The actual paths of the 91-day T-bill rate and 10-year T-bond rate (especially the former) largely track the downward path of the policy rate during the pandemic, while the model's average projection for these variables resemble the slightly upward mean forecast path of the policy rate. In particular, the 91-day T-bill rate diverged from the model's mean forecast by -1.4 percentage points in 2020 and by -2.4 percentage points in 2021. The observed 10-year T-bond rate is similarly lower than the mean's forecast but by a smaller amount (-1.1 percentage points and -0.7 percentage points, respectively, in 2020 and 2021). These divergences, however, fall within the range of deviations implied by the model's forecasts.

Unlike government Treasury rates, the average lending rate of universal and commercial banks temporarily rose in 2020 before falling in 2021. The upswing is in line with the observed tightening of credit standards for enterprises and households during the period (e.g., Debuque-Gonzales 2022), reflecting banks' heightened risk aversion amid the extreme uncertainty in the early stages of the pandemic. In contrast, the model's average forecast path for the variable followed a downward course in 2020 before levelling off in 2021. Thus, the observed bank lending rate departed from the model's mean forecast by 0.7 percentage point in 2020 and 0.1 percentage point in 2021—although the latter is within the range of divergences predicted by the model.

Figure 4. Inflation rate and key domestic interest rates: actual vs. model forecast



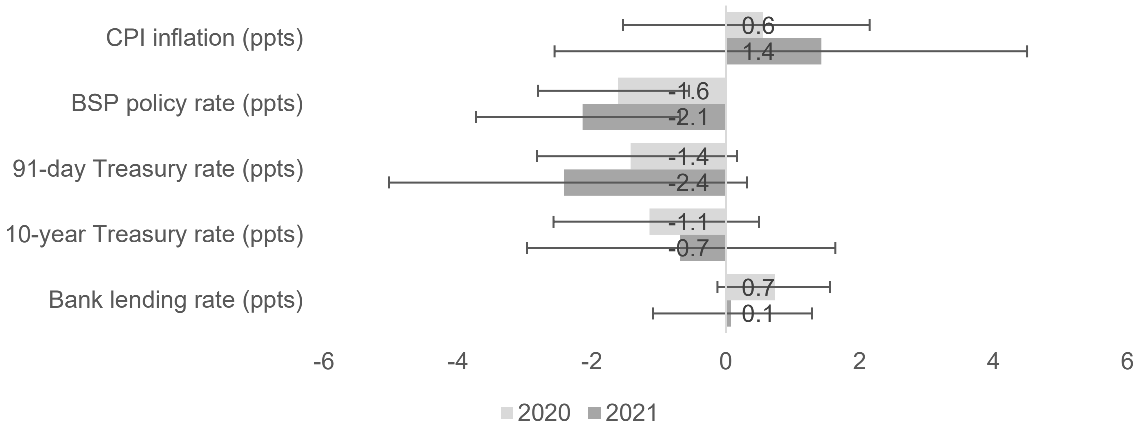
Note: Blue lines depict actual data. Red broken lines depict the mean model forecast path. The upper and lower orange broken lines respectively depict the 95th and 5th percentiles of the forecast distribution.

Source: Authors' calculations.

Figure 5. Impacts of the COVID-19 pandemic on inflation and key domestic interest rates

A. Deviation of actual series from model forecast, 2020 and 2021

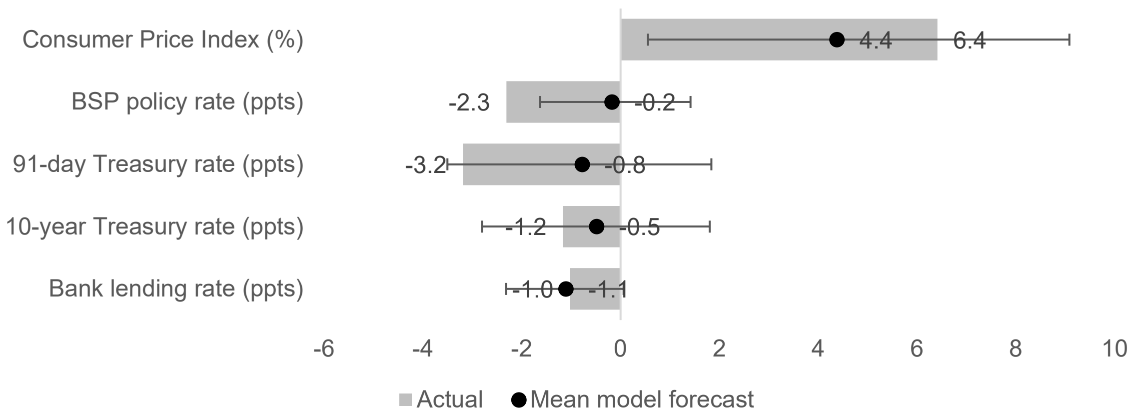
Percent or percentage points



Note: The shaded bars represent the percentage or percentage-point difference of the actual data from the mean of the model forecast for 2020 and 2021 in a No-COVID scenario. The error bars represent the range of deviations corresponding to 95 percent of the forecasts. The deviations were derived from the annualized series and forecasts. ppts = percentage points.

B. Change between 2019 and 2021: actual series vs. model forecast

Percent or percentage points



Note: The shaded bars represent the actual percentage or percentage-point change in each variable between 2019 and 2021. The markers represent the percentage or percentage-point change difference of the mean of the model forecast for 2021 in a No-COVID scenario from their baseline value in 2019. The error bars represent the range of differences corresponding to 95 percent of the forecasts. ppts = percentage points.

Source: Authors' calculation.

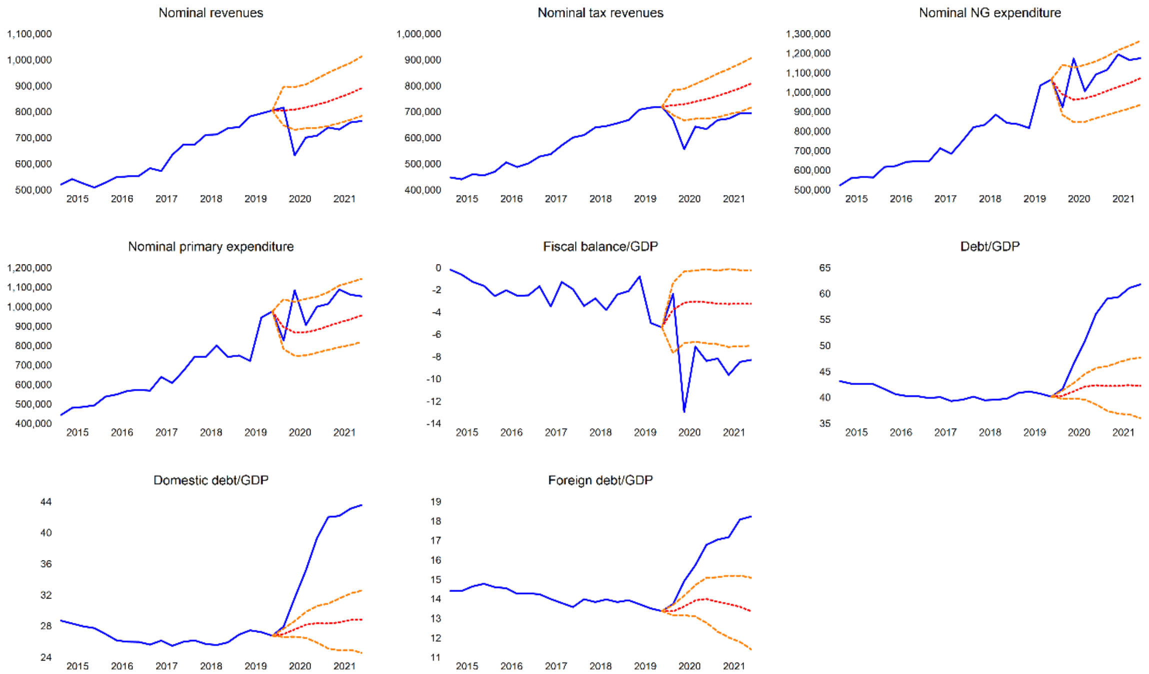
5.3. Revenues, expenditure, and government debt

In a no-COVID scenario, the model predicts total government revenues and tax revenues (which comprise 90% of the former) to remain on an upward course (see Figure 6). The observed decline in total revenues amounted to a departure from the mean forecast of -12.2 percent in 2020 and -13.3 percent in 2021 (see Figure 7 Panel A). Sans the pandemic, total revenues would have exceeded its level in 2019 by 10.6 percent based on the model's mean forecast (see Figure 7 Panel B). The corresponding deviations and counterfactual growth in tax revenues are of similar magnitude.

In contrast, the mean counterfactual trajectories of the national government's total and primary expenditure are lower than their actual paths during the pandemic. As previously mentioned, various public health and social welfare measures bolstered public spending in the first two years of the pandemic. Compared to the model's average forecast, total government spending is higher by 7.4 percent in 2020 and 11.9 percent in 2021. The mean forecast implies a growth in total expenditure of 10.6 percent between 2019 and 2021, slower than the 23.8 percent change recorded. The corresponding estimates for primary expenditure are comparable in size. The upper range of the model's forecast paths, however, encompass the actual course taken by total and primary spending during the period.

Consequently, the model projects that the fiscal deficit, and in turn, government debt, would have been smaller in 2020 and 2021 had the pandemic not occurred. The observed fiscal deficit (as a share of GDP) is larger than the model's average forecast by 4.3 percentage points in 2020 and 5.4 percentage points in 2021. The mean forecast suggests that the fiscal balance (as a percentage of GDP) would have remained largely unchanged between 2019 and 2021, instead of deteriorating by 5.3 percentage points. Similarly, the debt-to-GDP ratio during the pandemic is higher than the average model projection by 13.8 percentage points in 2020 and 19.7 percentage points in 2021. The debt ratio is predicted to rise by merely 1.9 percentage points between 2019 and 2021 in the absence of the pandemic—far smaller than the 21.6-percentage-point expansion that occurred during the period.

Figure 6. Revenues, expenditure, and government debt: actual vs. model forecast



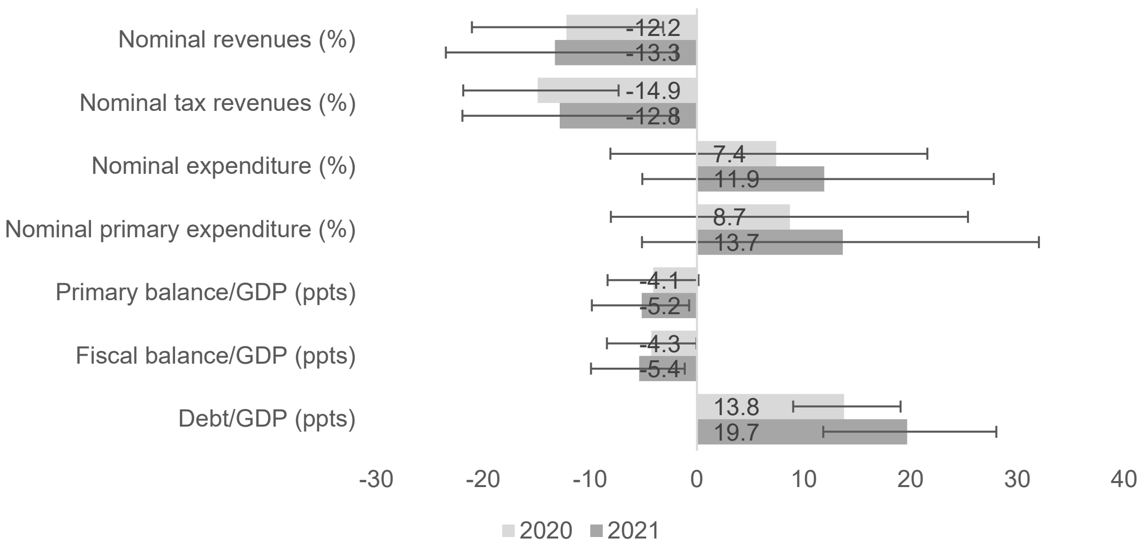
Note: Blue lines depict actual data. Red broken lines depict the mean model forecast path. The upper and lower orange broken lines respectively depict the 95th and 5th percentiles of the forecast distribution.

Source: Authors' calculations.

Figure 7. Impacts of the COVID-19 pandemic on revenues, expenditure, and government debt

A. Deviation of actual series from model forecast, 2020 and 2021

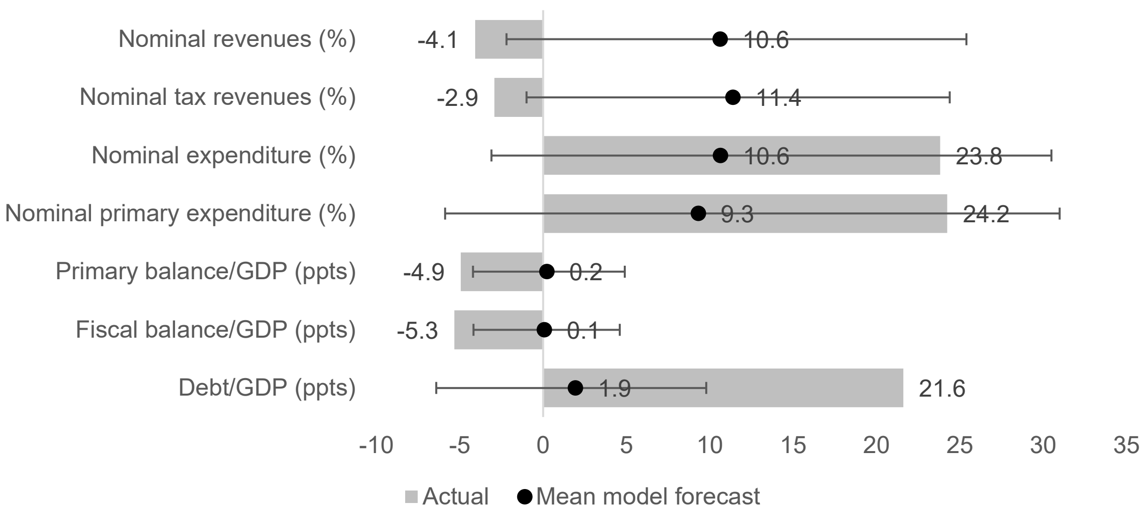
Percent or percentage points



Note: The shaded bars represent the percentage or percentage-point difference of the actual data from the mean of the model forecast for 2020 and 2021 in a No-COVID scenario. The error bars represent the range of deviations corresponding to 95 percent of the forecasts. The deviations were derived from the annualized series and forecasts. ppts = percentage points.

B. Change between 2019 and 2021: actual series vs. model forecast

Percent or percentage points



Note: The shaded bars represent the actual percentage or percentage-point change in each variable between 2019 and 2021. The markers represent the percentage or percentage-point change difference of the mean of the model forecast for 2021 in a No-COVID scenario from their baseline value in 2019. The error bars represent the range of differences corresponding to 95 percent of the forecasts. ppts = percentage points.

Source: Authors' calculation.

6. Conclusions

This paper applies the PIDS small macroeconometric model with a fiscal sector and inflation expectations to provide a quantitative account of the short-run impact of the COVID-19 pandemic crisis on the Philippine economy. The model is used to generate dynamic out-of-sample forecasts for key macroeconomic variables for 2020 and 2021. These forecasts are treated as the variables' counterfactual paths in the absence of the pandemic. The deviation of the variables from their respective forecast paths quantifies the pandemic's impact during the same years. Forecasts of the variables for 2021 are also compared with their pre-pandemic levels in 2019 to obtain their counterfactual change between the said years.

The paper's findings lend further evidence to the pandemic's severe and lasting effects on the real economy. Real output fell beneath its average counterfactual level by 12 percent in 2020 and 13 percent in 2021. Private investment bore the steepest decline, departing from its counterfactual position by over -30 percent in both years. Meanwhile, the rate of employment deviated from its forecasted level by about -5 percentage points in 2020 and nearly -3 percentage points in 2021.

Moreover, model simulations clarify the extent of the deterioration of public finances triggered by the pandemic. The impact is most evident on the revenue side, with tax collection falling short of its mean model forecast by 13-15 percent in the pandemic's first two years. Primary spending, meanwhile, rose by about a tenth higher than its average counterfactual path, albeit being within the range of the model's projections. Consequently, the fiscal deficit and government debt (both as a share of GDP) swelled to considerably worse levels than their respective mean forecasts (by 5 percentage points for the former, and by 20 percentage points for the latter, in 2021).

The pandemic also had an unambiguous effect on the central bank policy rate, deviating by an average of 2 percentage points lower than its counterfactual path. On the other hand, less clearcut are the pandemic's estimated impacts on inflation and key domestic interest rates. On average, the model predicts lower inflation and higher interest rates on short-term and long-term government borrowing in 2020 and 2021 had the pandemic not occurred. The bank lending rate, meanwhile, would have been lower in 2020 given the tightening of bank credit seen in the pandemic's early phase. However, these variables' actual trajectories fall within the range of counterfactual paths predicted by the model.

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Appendix A. Summary statistics

	Obs.	Mean	Std. dev.	Min	Max
Log(GDP)	72	14.89	0.29	14.42	15.40
GDP growth	72	5.66	1.75	0.10	8.45
Log(Household consumption)	72	14.61	0.26	14.16	15.08
Log(Investment)	72	13.27	0.46	12.60	14.08
Log(Government consumption)	72	12.68	0.34	12.17	13.39
Log(Imports)	72	13.75	0.38	13.29	14.50
Log(Exports)	72	13.55	0.33	12.99	14.19
Log(Disposable income)	72	14.79	0.28	14.31	15.28
Log(Domestic demand)	72	14.95	0.31	14.50	15.51
Employment rate	59	93.23	0.89	91.88	95.35
Log(Consumer Price Index)	72	4.35	0.20	3.99	4.64
Log(GDP deflator)	72	4.40	0.17	4.05	4.62
Log(US CPI)	72	4.52	0.11	4.32	4.69
CPI inflation rate	72	3.75	2.02	-0.05	10.32
Deviation of inflation from target inflation	72	-0.25	1.92	-3.05	6.32
Expected inflation	71	3.75	1.88	0.12	10.21
Deviation of expected inflation from target inflation	71	-0.23	1.80	-2.88	6.21
Log(World price of oil [USD/barrel])	72	4.09	0.47	3.02	4.77
Log(Retail price of ordinary rice [USD/ton])	61	6.48	0.25	5.88	6.81
Log(Nominal PHP-USD exchange rate)	72	3.88	0.09	3.71	4.03
Log(Real PHP-USD exchange rate)	72	4.05	0.16	3.83	4.36
BSP policy rate	72	4.97	1.56	3.00	7.50
91-day Treasury rate	72	3.99	2.16	0.40	8.13
10-year Treasury rate	72	7.49	3.14	3.46	14.30
Bank lending rate	72	7.56	1.77	5.40	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
10-year US Treasury rate	72	3.19	1.04	1.62	5.07
Log(Nominal revenues)	72	12.74	0.50	11.81	13.60
Log(Nominal tax revenues)	72	12.61	0.51	11.69	13.49
Log(Nominal internal tax revenues)	72	12.35	0.52	11.43	13.24
Log(Nominal customs revenues)	72	11.08	0.52	10.00	12.01
Log(Nominal non-tax revenues)	72	10.58	0.44	9.66	11.55
Log(Nominal expenditure)	72	12.89	0.47	12.16	13.88
Log(Nominal primary expenditure)	72	12.67	0.55	11.84	13.80
Log(Nominal interest payments)	72	11.19	0.16	10.59	11.53
Log(Nominal domestic interest payments)	72	10.75	0.20	10.21	11.20
Log(Nominal foreign interest payments)	72	10.13	0.15	9.43	10.36
Effective interest rate on domestic debt	72	1.77	0.41	1.22	2.67
Effective interest rate on foreign debt	72	1.35	0.19	1.01	1.77
Fiscal balance/GDP	72	-2.30	1.62	-6.77	1.17
Primary balance/GDP	72	0.92	1.76	-3.47	4.64
Log(National government debt)	72	15.36	0.28	14.72	15.88
Log(Domestic debt)	72	14.84	0.37	14.06	15.47
Log(Foreign 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

Source: Authors' calculation.

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

	diff=0	diff=1	diff=2
Log(GDP)	0.98	0.00	0.00
GDP growth	0.01	0.00	0.00
Log(Household consumption)	1.00	0.04	0.00
Log(Investment)	0.97	0.00	0.00
Log(Government consumption)	1.00	0.00	0.00
Log(Imports)	1.00	0.00	0.00
Log(Exports)	0.94	0.00	0.00
Log(Disposable income)	1.00	0.00	0.00
Log(Domestic demand)	1.00	0.00	0.00
Employment rate	0.71	0.00	0.00
Log(Consumer Price Index)	0.47	0.00	0.00
Log(GDP deflator)	0.03	0.00	0.00
Log(US CPI)	0.36	0.00	0.00
CPI inflation rate	0.00	0.00	0.00
Deviation of inflation from target inflation	0.01	0.00	0.00
Expected inflation	0.05	0.00	0.00
Deviation of expected inflation from target inflation	0.01	0.00	0.00
Log(World price of oil)	0.15	0.00	0.00
Log(Retail price of rice)	0.08	0.00	0.00
Log(Nominal PHP-USD exchange rate)	0.49	0.00	0.00
Log(Real PHP-USD exchange rate)	0.63	0.00	0.00
BSP policy rate	0.47	0.00	0.00
91-day Treasury rate	0.07	0.00	0.00
10-year Treasury rate	0.07	0.00	0.00
Bank lending rate	0.04	0.00	0.00
Real 91-day Treasury rate	0.08	0.00	0.00
Real 10-year Treasury rate	0.02	0.00	0.00
Real bank lending rate	0.00	0.00	0.00
10-year US Treasury rate	0.59	0.00	0.00
Log(Nominal revenues)	0.89	0.00	0.00
Log(Nominal tax revenues)	0.92	0.00	0.00
Log(Nominal internal tax revenues)	0.91	0.00	0.00
Log(Nominal customs revenues)	0.79	0.00	0.00
Log(Nominal non-tax revenues)	0.54	0.00	0.00
Log(Nominal expenditure)	1.00	0.00	0.00
Log(Nominal primary expenditure)	1.00	0.00	0.00
Log(Nominal interest payments)	0.01	0.00	0.00
Log(Nominal domestic interest payments)	0.13	0.00	0.00
Log(Nominal foreign interest payments)	0.00	0.00	0.00
Effective interest rate on domestic debt	0.67	0.00	0.00
Effective interest rate on foreign debt	0.94	0.00	0.00
Fiscal balance/GDP	0.00	0.00	0.00
Primary balance/GDP	0.02	0.00	0.00
Log(National government debt)	0.72	0.00	0.00
Log(Domestic debt)	0.73	0.00	0.00
Log(Foreign debt)	0.44	0.00	0.00
Debt/GDP	0.86	0.00	0.00
Domestic debt/GDP	0.91	0.00	0.00
Foreign debt/GDP	0.95	0.00	0.00

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 C. Behavioral equations

Refer to Table 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**

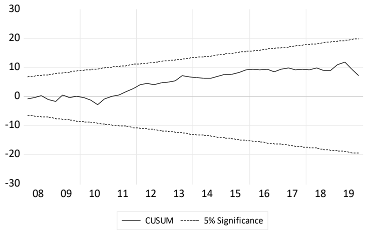
$$\log C_t = 0.34_{[0.56]} + 0.95 \log YD_{t[7.34]} + 0.003 emp_{t[0.14]} - 0.004(r_t^{bl} - \pi_t^e)_{[-0.38]} - 0.005\pi^e_{t[-0.45]} + ec_t$$

   b. **ECM form**

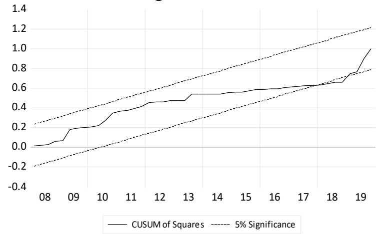
$$\Delta \log C_t = 0.27\Delta \log YD_{t[4.26]} + 0.004\Delta emp_{t[1.88]} + 0.01\Delta emp_{t-1[2.71]} - 0.14 ec_{t-1[-7.36]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.999
Adjusted R-squared (ECM)	0.34
Residual diagnostics	
Residual normality (Jarque-Bera)	0.18 (0.92)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi2$ (8)	23.40 (0.003)***
No serial correlation (Breusch-Godfrey) $\chi2$ (4)	6.30 (0.18)
F-Bounds test	8.18***

CUSUM test



CUSUM of squares test



2. **Investment**

   a. **Long-run equation**

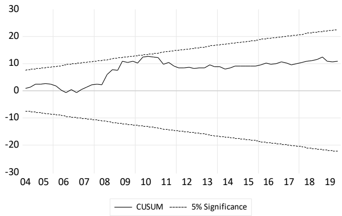
$$\log I_t = -10.74_{[-4.60]} + 1.61 \log Y_{t[12.17]} + ec_t$$

   b. **ECM form**

$$\Delta \log I_t = -0.28\Delta \log I_{t-1\,[-2.62]} + 2.18\Delta \log Y_{t[3.64]} + 2.01\Delta \log Y_{t-1[3.13]} - 0.01\Delta({r_t}^{bl} - \pi_t^e)_{[-1.94]} - 0.005\pi^e_{t[-1.62]} - 0.17 ec_{t-1[-2.53]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.98
Adjusted R-squared (ECM)	0.35
Residual diagnostics	
Residual normality (Jarque-Bera)	0.45 (0.80)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi2$ (7)	22.86 (0.002)***
No serial correlation (Breusch-Godfrey) $\chi2$ (4)	4.18 (0.38)
F-Bounds test	2.08

CUSUM test



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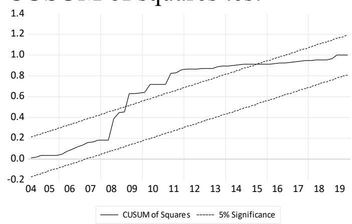


3. Government consumption

a. Long-run equation

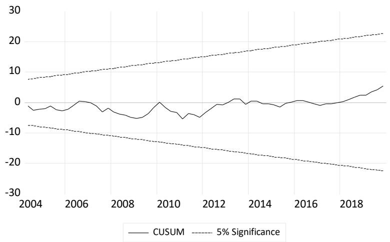
$$\log G_t = 0.36 \log XP^{PR}_{t[5.43]} + ec_t$$

b. ECM form

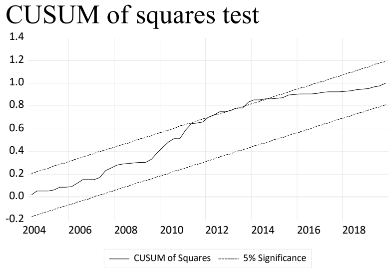
$$\Delta \log G_t = 0.006 Trend_{t[4.43]} + 0.03 \Delta \log G_{t-1[0.25]} + 0.19 \Delta \log XP^{PR}_{t[3.31]} - 0.02 \Delta \log XP^{PR}_{t-1[-0.26]} - 0.65 ec_{t-1[-4.33]} + 4.97_{[4.33]} + \epsilon_t$$

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) $\chi 2$ (6)	11.52 (0.07)*
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	4.11 (0.39)
F-Bounds test	9.24**

CUSUM test



CUSUM of squares test



4. Imports

a. Long-run equation

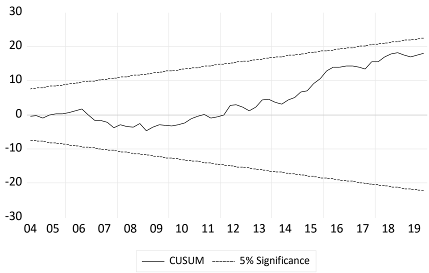
$$\log M_t = 0.58_{[0.91]} + 0.67 \log I_{t[7.11]} + 0.31 \log X_{t[2.53]} + ec_t$$

b. ECM form

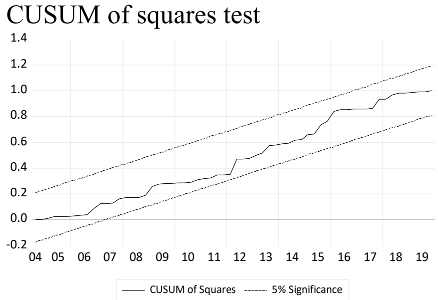
$$\Delta \log M_t = -0.37 \Delta \log M_{t-1[-5.24]} + 0.33 \Delta \log I_{t[9.23]} + 0.68 \Delta \log X_{t[11.03]} + 0.30 \Delta \log X_{t-1[3.97]} - 0.18 ec_{t-1[-4.29]} + \epsilon_t$$

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) $\chi 2$ (7)	8.44 (0.30)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	6.99 (0.14)
F-Bounds test	4.39***

CUSUM test



CUSUM of squares test



5. Exports

a. Long-run equation

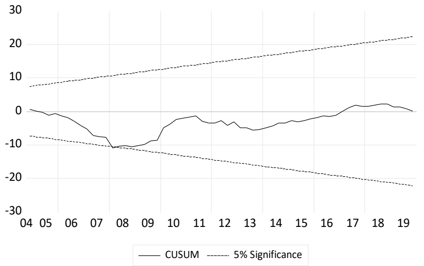
$$\log X_t = -46.75_{[-13.05]} + 4.16 \log Y^{WORLD}_{t[18.65]} + 0.37 \log xrr_{t[2.85]} + ec_t$$

b. ECM form

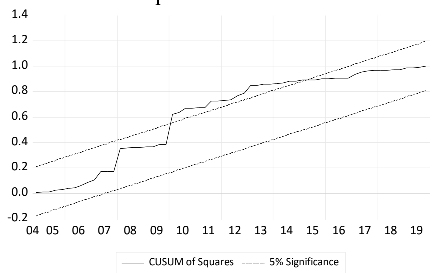
$$\Delta \log X_t = -0.20\Delta \log X_{t-1[-1.86]} + 2.53\Delta \log Y^{WORLD}_{t[4.11]} + 0.47\Delta \log xrr_{t[2.31]} - 0.32ec_{t-1[-3.98]} + \epsilon_t$$

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) $\chi 2$ (6)	6.25 (0.40)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	3.10 (0.54)
F-Bounds test	3.77**

CUSUM test



CUSUM of squares test



6. Employment rate

a. Long-run equation

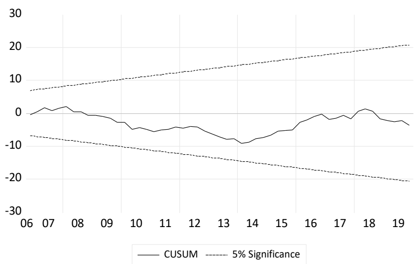
$$emp_t = 3.35 \log Y_{t[9.29]} + 43.07_{[8.02]} + ec_t$$

b. ECM form

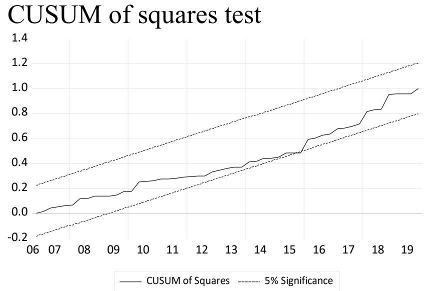
$$\Delta emp_t = -0.30\Delta emp_{t-1[-2.42]} - 0.58ec_{t-1[-3.77]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.83
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**

CUSUM test



CUSUM of squares test



7. Internal tax revenues

a. Long-run equation

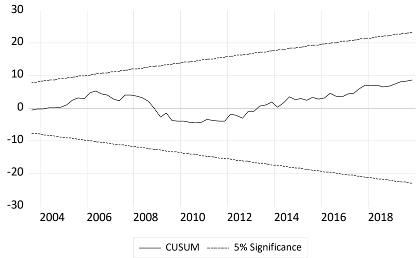
$$\log RV_t^{TXBIR} = 1.12 \log Y^N_{t[30.68]} - 3.96_{[-6.99]} + ec_t$$

b. ECM form

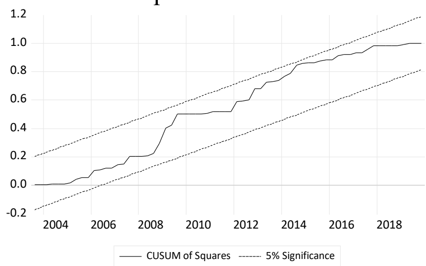
$$\Delta \log RV_t^{TXBIR} = -0.27 \Delta \log RV^{TXBIR}{}_{t-1[-3.03]} - 0.21 ec_{t-1[-7.60]} + \epsilon_t$$

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

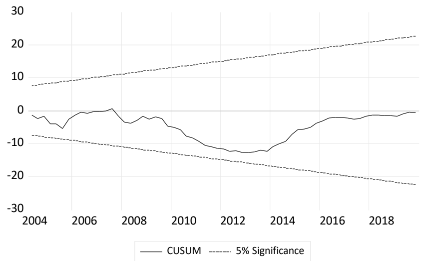
$$\log RV_t^{TXBOC} = 0.83 \log(P_t^Y M_t)_{[20.23]} + 0.35 \log oil_{t[4.18]} + 0.52 \log xr_{t[1.41]} - 7.44_{[-5.16]} + ec_t$$

b. ECM form

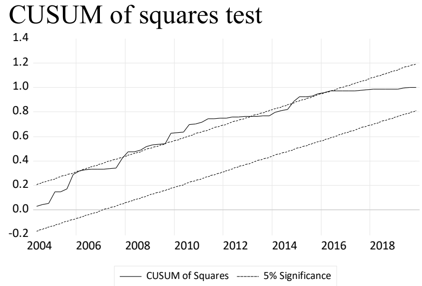
$$\Delta \log RV_t^{TXBOC} = -0.21 \Delta \log RV^{TXBOC}{}_{t-1[-2.45]} + 0.91 \Delta \log(P_t^Y M_t)_{[4.82]} - 0.44 ec_{t-1[-5.46]} + \epsilon_t$$

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

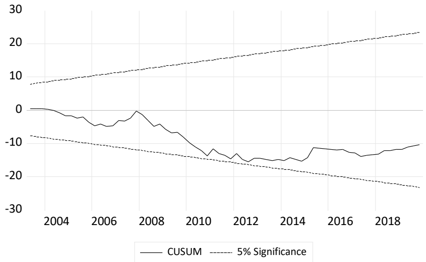
$$\log RV_t^{NTX} = -1.07_{[-1.17]} + 0.80 \log Y_{t[13.01]}^N + ec_t$$

b. ECM form

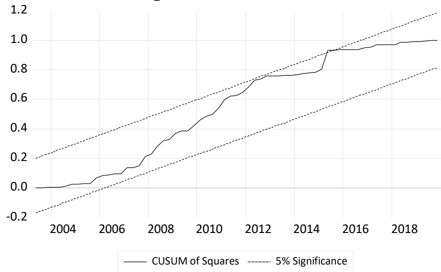
$$\Delta \log RV_t^{NTX} = -2.57 \Delta \log Y_{t[-2.38]}^N - 0.83 ec_{t-1[-7.19]} + \epsilon_t$$

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) $\chi 2$ (3)	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

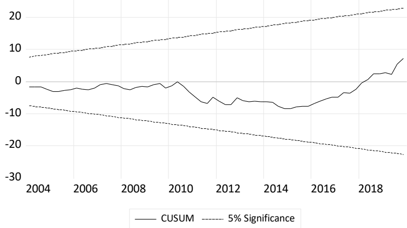
$$\log XP_t^{PR} = -0.007 \Delta DY_{t-4[-1.50]} + ec_t$$

b. ECM form

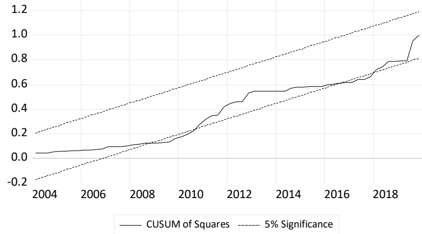
$$\Delta \log XP_t^{PR} = 0.13 Trend_{t[4.85]} + 6.76_{[4.78]} - 0.55 ec_{t-1[-4.77]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.98
Adjusted R-squared (ECM)	0.28
Residual diagnostics	
Residual normality (Jarque-Bera)	3.04 (0.22)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (3)	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

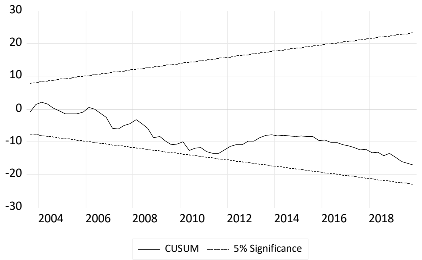
$$r_t^{dd} = 0.73_{[5.10]} + 0.13\, r_t^{t10y}{}_{[7.21]} + ec_t$$

b. ECM form

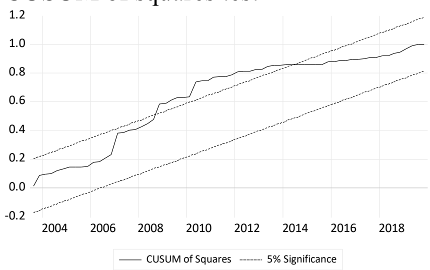
$$\Delta r_t^{dd} = -0.46 \Delta r_{t-1[-4.78]}^{dd} - 0.28\, ec_{t-1[-3.49]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.87
Adjusted R-squared (ECM)	0.42
Residual diagnostics	
Residual normality (Jarque-Bera)	9.75 (0.008)***
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (3)	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

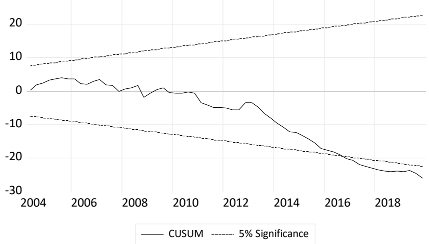
$$r_t^{df} = 0.60_{[4.98]} + 0.03 r_{t[0.59]}^{t10yUS} + 0.01 DY_{t[2.76]} + ec_t$$

b. ECM form

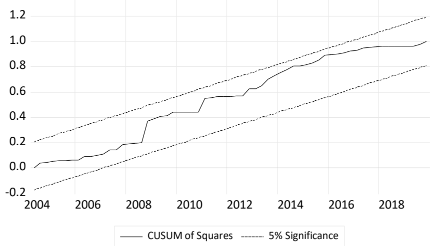
$$\Delta r_t^{df} = -0.36 r_{t-1[-3.74]}^{df} - 0.02 \Delta DY_{t[-0.97]} - 0.02 \Delta DY_{t-1[-1.43]} - 0.46 ec_{t-1[-4.07]} + \epsilon_t$$

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) $\chi 2$ (6)	7.49 (0.28)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	15.71 (0.003)***
F-Bounds test	3.95**

CUSUM test



CUSUM of squares test



13. Central bank policy rate

a. Long-run equation

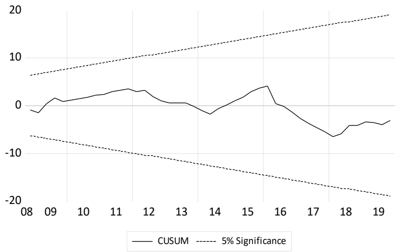
$$r_t^{cb} = 3.92_{[20.90]} + 0.44(\pi_t^e - \pi_t^T)_{[3.41]} + +ec_t$$

b. ECM form

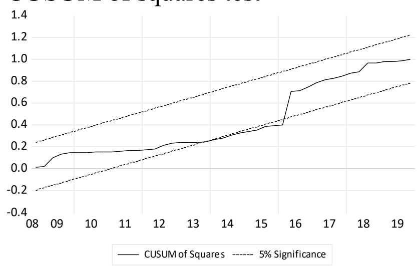
$$\Delta r_t^{cb} = 0.18\Delta r^{cb}{}_{t-1[2.02]} - 0.22ec_{t-1[-5.86]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.88
Adjusted R-squared (ECM)	0.51
Residual diagnostics	
Residual normality (Jarque-Bera)	20.48 (0.00)***
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (3)	1.67 (0.64)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	2.31 (0.68)
F-Bounds test	10.96***

CUSUM test



CUSUM of squares test



14. 91-day Treasury bill rate

a. Long-run equation

$$r_t^{t91d} = -3.48_{[-4.17]} + 1.29r_t^{cb}{}_{[6.31]} - 61.22movav\left(\frac{pb_t}{y_t}, 4\right)_{[-2.62]} + ec_t$$

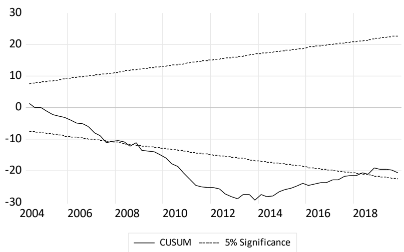
where $movav(pb_t/y_t, 4)$ is the simple moving average of the primary balance-to-GDP ratio for four quarters.

b. ECM form

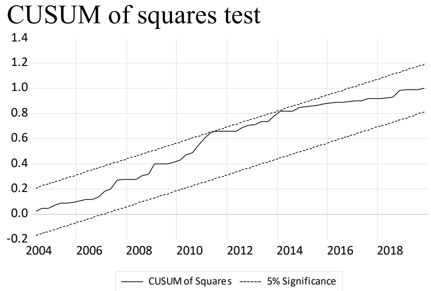
$$\Delta r_t^{t91d} = -0.25ec_{t[-4.88]} + 0.32\,\Delta r_{t-1}^{t91d}{}_{[3.17]} + 0.11\pi_t^e{}_{[4.30]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.95
Adjusted R-squared (ECM)	0.34
Residual diagnostics	
Residual normality (Jarque-Bera)	1.41 (0.49)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (5)	3.15 (0.68)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	3.10 (0.54)
F-Bounds test	5.69***

CUSUM test



CUSUM of squares test



15. 10-year Treasury bond rate

a. Long-run equation

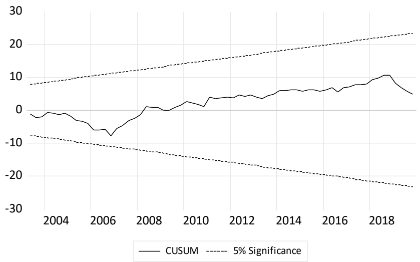
$$r_t^{t10y} = 1.11r^{t91d}{}_{t[3.24]} + 2.02_{[2.26]} + ec_t$$

b. ECM form

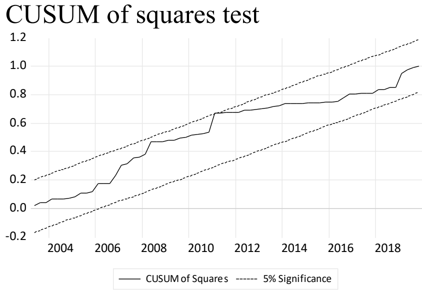
$$r_t^{t10y} = 0.01\pi^e_{t[0.43]} - 0.15ec_{t-1[-3.11]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.97
Adjusted R-squared (ECM)	0.12
Residual diagnostics	
Residual normality (Jarque-Bera)	4.32 (0.12)
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (3)	3.76 (0.29)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	3.41 (0.49)
F-Bounds test	5.84**

CUSUM test



CUSUM of squares test



16. Bank lending rate

a. Long-run equation

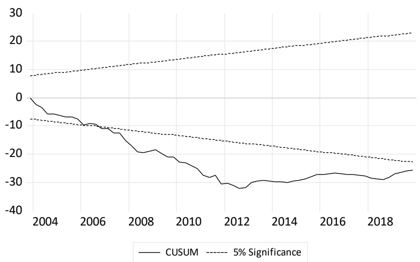
$$r_t^{bl} = 2.79_{[6.50]} + 0.53r^{t10y}_{t[9.01]} + ec_t$$

b. ECM form

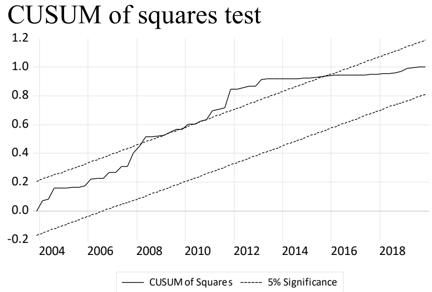
$$\Delta r_t^{bl} = 0.19\Delta r^{bl}{}_{t-1[2.20]} + 0.03\pi^e_{t[3.22]} - 0.19ec_{t-1[-4.91]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.97
Adjusted R-squared (ECM)	0.27
Residual diagnostics	
Residual normality (Jarque-Bera)	20.11 (0.00)***
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (4)	9.24 (0.06)*
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	9.25 (0.06)*
F-Bounds test	7.79***

CUSUM test



CUSUM of squares test

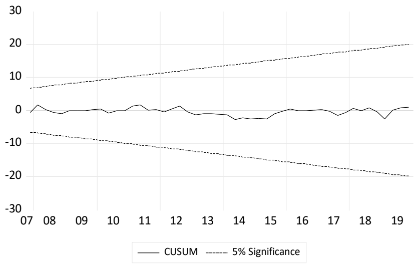


17. Consumer Price Index

$$\Delta \log CPI_t = 0.37\Delta \log CPI_{t-1[3.37]} + 0.30\Delta \log CPI_{t-2[3.21]} + 0.02\Delta \log p_t^{oil}{}_{[4.38]} + 0.05\Delta \log p_t^{rice}{}_{[4.36]} + 0.02\Delta \log p_{t-1}^{rice}{}_{[1.41]} - 0.02\Delta \log p_{t-2}^{rice}{}_{[-1.66]} + 0.05\Delta \log DD_{t[1.73]} + 0.09\Delta \log DD_{t-1[2.90]} + 0.06\Delta \log xr_{t[2.29]} + \epsilon_t$$

Adjusted R-squared (ARDL)	0.73
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



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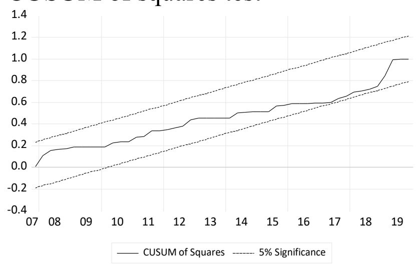


18. GDP deflator

a. Long-run equation

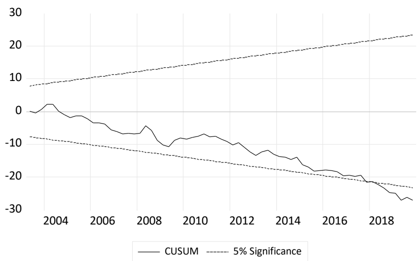
$$\log P_t^Y = 1.00_{t[3.61]} + 0.78 \log CPI_{t[12.67]} + ec_t$$

b. ECM form

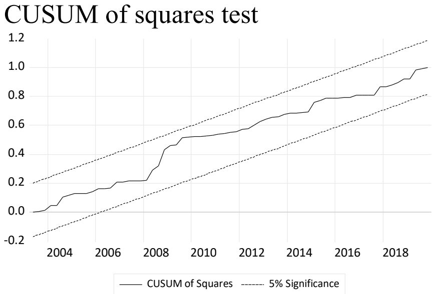
$$\Delta \log P_t^Y = 0.88\Delta \log CPI_{t[16.37]} - 0.10 ec_{t-1[-3.54]} + \epsilon_t$$

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

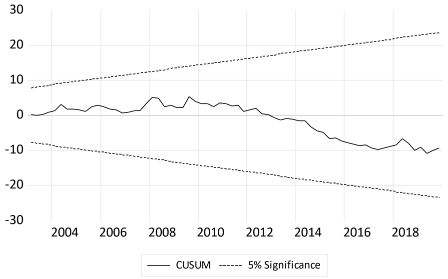


19. Inflation expectations

$$\pi_t^e = 0.81_{[3.89]} + 1.41\pi_{t[14.60]} - 0.62\pi_{t-1[-6.39]} + \epsilon_t$$
where $\pi_t^e = \pi_{t+1}$

Adjusted R-squared (ARDL)	0.843
Residual diagnostics	
Residual normality (Jarque-Bera)	8.98 (0.01)**
Homoskedasticity (Breusch-Pagan-Godfrey) $\chi 2$ (2)	0.62 (0.73)
No serial correlation (Breusch-Godfrey) $\chi 2$ (4)	16.64 (0.002)***

CUSUM test



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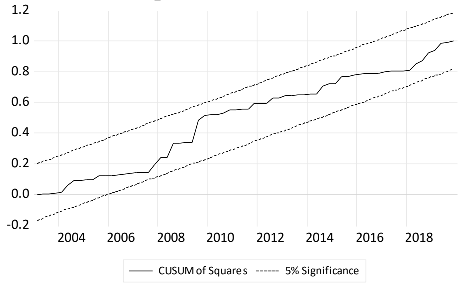
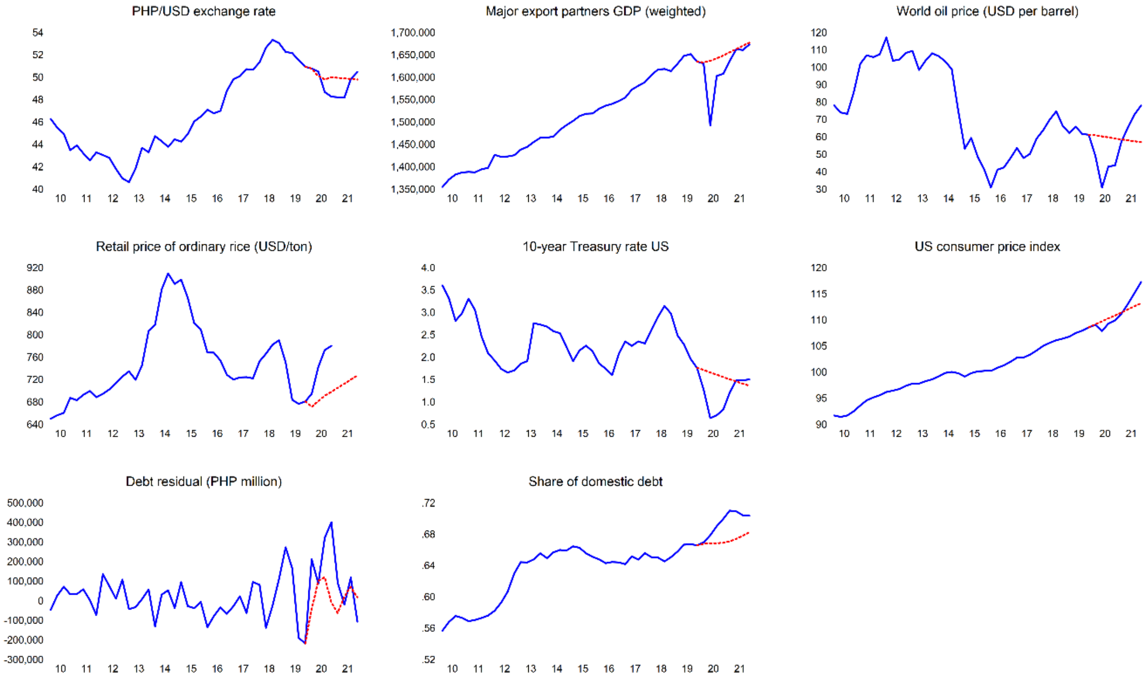


Appendix D. ARIMA forecasts of exogenous variables



Note: Blue lines depict actual data. Red broken lines depict the ARIMA forecast.

Source: Authors' calculations.