What do historical decompositions say? The Pandemic and the Philippine Macroeconomy

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Abstract: The Global Pandemic has spawned shocks, compounded existing economic issues, and provoked unprecedented societal reactions. Adverse demand and supply shocks have expectedly dampened growth performance, unleashing waves of financial distress and other forms of uncertainties that have overwhelmed firms and consumers and even policymakers.

Using quarterly data on real per capita gross domestic product, inflation, and T-bill rates from 2000 to 2020, this note presents estimates using the New Keynesian dynamic stochastic general equilibrium (NKDSGE) model. By estimating the parameters and undertaking historical decompositions, we find that monetary policy shocks appear to influence growth outcomes towards positive territory. This implies that monetary policy has been one of the factors that has robustly counteracted the negative effects of demand and supply shocks – not too successful though to prevent output growth from dipping considerably during the pandemic quarters.

Key Words: pandemic, historical decompositions, New Keynesian model, Philippines

1. INTRODUCTION

Invariably, the pandemic has spawned unprecedentedly deep and widespread macroeconomic distress, affecting both developed and developing economies in intolerably many ways. Growth has grounded to a halt or veered into unfamiliar negative territory; unemployment has been rising; and the proverbial V-shaped recovery has sputtered.

This note uses the 3 – equation New Keynesian DSGE model to estimate the parameters and undertake historical decompositions to ascertain the respective contributions of shocks pertaining to monetary, demand and supply processes to output growth.

While much of the recent literature has focused on a new generation of SIR – augmented DSGE models (e.g. Eichenbaum, Rebelo, and Trabandt, 2020), this note simply maintains the familiar modeling framework but uses two decades worth of data – long enough to provide a reliable set of estimates. This note focuses on the model properties of the NKDSGE model when influential data points are considered.[1]

I believe that the main contribution of this note is to enhance our understanding of macroeconomic processes and outcomes when Covid-19 – related datapoints are accounted for. It is beyond this note to formally include Covid – related processes

[1] The study is an attempt to understand the properties of a standard NKDSGE model would be affected by using influential datapoints that are explicitly connected to a different stochastic process.

that identifies the nature of demand and supply shocks. But it overlooks established connections between supply and demand shocks, and their respective nature in a period of pandemic.

Results show that the drop in quarterly growth of the real per capita gross domestic product during the pandemic period has been caused primarily by the collapse in demand as a result of quarantine policies that have severely restricted human mobility, as well as supply bottlenecks that were created in the process. In contrast, the Bangko Sentral ng Pilipinas (BSP) showed consistency in managing the monetary implications of the pandemic. The BSP has induced a reduction in the reverse repurchase rate (RRP) by 200 basis points, thereby showing that during extraordinary times, the BSP still conducts monetary policy through the Taylor rule. Due to the dramatic increase in risk aversion, however, a reduction in interest rates does not have the desired impact on bank lending, as evidence points to a slowdown in credit growth. The results also allude to the relative stability of the Taylor rule and the positive effects of monetary policy shocks during the entire pandemic period in terms of taming volatility, thereby ensuring stability in the monetary and financial sector.

This note is structured as follows: Section 2 details the model structure of the model, identifying key equations and results. Section 3 explains historical decompositions within the context of the New Keynesian framework. The last section concludes.

2. MODEL

2.1 Households

We use the familiar small-scale New Keynesian DSGE models (Rubaszek and Skrzypczyński, 2008; Schorfeide and An, 2007) to motivate key empirical questions[2]. The model consists of utility maximizing households, profit maximizing final and intermediate goods firms, and monetary policymakers.

The representative household indexed by $i \in (0,1)$ maximizes the expected sum of discounted utility that follows the constant relative risk aversion specification.

$$U_{i,t} = E_t \sum_{s=0}^{\infty} \epsilon_{t+s}^{D} \beta^{t+s} \left\{ \frac{\left(\frac{C_{i,t+s}^{h}}{A_{t+s}}\right)^{1-\sigma}}{1-\sigma} - \upsilon_L \frac{N_{i,t+s}^{1+\varphi}}{1+\varphi} \right\} \quad (1)$$

where ϵ_{t+s}^{D} is an AR(1) demand shock process, A_{t+s} is a technology process; $C_{i,t}$ is consumption while $C_{i,t+s}^{h}$ is habit – adjusted consumption with the following definition:

$$C_{i,t}^{h} = C_{i,t} - \theta_h (1+g) C_{t-1}$$

N_{t+s} is labor supply and σ and φ are the inverses of intertemporal elasticity of substitution and Frisch labor supply elasticity, respectively. Households' economic activities include consumption, bond – buying, and firm ownership.

The budget constraint is given by the following linear specification:

$$B_{i,t} + P_t C_{i,t} = R_{t-1} B_{i,t-1} + W_t N_{i,t} + \pi_{i,t} \quad (2)$$

where $B_{i,t}$ represents bonds purchased at time t; R_{t-1} is the applicable interest rate on bonds; W_t represents the wage and $\pi_{i,t}$ is just dividends or profits of the firm that goes to the household.

Maximizing with respect to bonds $B_{i,t}$, and using the first order condition on consumption $C_{i,t}$, the Euler equation is given by:

$$\left(\frac{C_{i,t}^{h}}{A_t}\right)^{-\sigma} = \beta E_t \left\{ \left(\frac{A_t}{A_{t+1}}\right) \left(\frac{\epsilon_{t+1}^{D}}{\epsilon_t^{D}}\right) \pi_{t+1}^{-1} R_t \left(\frac{C_{i,t+1}^{h}}{A_{t+1}}\right)^{-\sigma} \right\} \quad (3)$$

Labor is determined by the following first order condition which relates it to the real wage.

[2] The theoretical core heavily borrows Rubaszek and Skrzypczyński (2008).

$$\upsilon_L N_{i,t}^{\varphi} = \left(\frac{C_{i,t}^{h}}{A_t}\right)^{-\sigma} \frac{W_t}{A_t P_t} \tag{5}$$

As shown, labor supply depends positively on the real wage rate and negatively on consumption.

2.2 Firms

There are two types of firms, namely: the final goods and intermediate goods firms, with the latter indexed by $j \in (0,1)$. Final goods firms produce the final good (Y_t) by bundling intermediate goods $(Y_{j,t})$ using the following aggregator function:

$$Y_t = \left[\int_0^1 (Y_{j,t})^{1-\frac{1}{\theta}} dj\right]^{\frac{1}{1-\frac{1}{\theta}}} \tag{6}$$

where θ represents the elasticity of substitution in terms of intermediate inputs.

The firm maximizes profits $P_t Y_t - \int_0^1 P_{j,t} Y_{j,t} dj$, yielding the demand following demand function for the j[th] intermediate goods firm:

$$Y_{j,t} = \left[\frac{P_{j,t}}{P_t}\right]^{-\theta} Y_t \tag{7}$$

Because intermediate goods firms are monopolistically competitive, they price above marginal cost. The marginal cost of the j[th] firm is

$$MC_{j,t} = \frac{W_t}{A_t \epsilon_t^S} \tag{8}$$

Instantaneous profits are given by the $D_{j,t}$:

$$D_{j,t} = \left(P_t - MC_{j,t}\right)\left[\frac{P_{j,t}}{P_t}\right]^{-\theta} Y_t - \frac{P_t Y_t}{\theta} \tag{9}$$

Following the logic of Calvo (1980) pricing, firms may either set their prices optimally or rely on rule of thumb pricing rules. If a firm cannot change its price for s periods, Rubaszek & Skrzypczynski show that

$$P_{j,t+s} = \left(\frac{P_{t+s-1}}{P_{t-1}}\right)^{\iota} (\bar{\pi})^{s(1-\iota)} P_{j,t} \tag{10}$$

where ι is the indexation parameter; $\bar{\pi}$ is the target inflation.

Following Rubaszek & Skrzypczynski (2008), the firm maximizes the present value of discounted intertemporal profits.

$$\max_{\{P_{j,t}\}} E_t \ \zeta^s Q_t D_{j,t+s} \tag{11}$$

where $Q_t$is the firm's stochastic discount factor based on relative marginal utilities of the household; ζ is the fraction of firms unable to optimize their prices.

The price level is given by.

$$P_{,t} = \left\{\xi\left(P_{t-1}\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\iota}\bar{\pi}\right)^{1-\theta} + (1-\zeta)\left(\tilde{P}_{j,t}\right)^{1-\theta}\right\} \tag{12}$$

2.3 Monetary policy

The Taylor rule follows Rubaszek and Skrzypczyński (2008) and the alternative definition in Schorfeide and An (2007). We do not investigate the output gap, rather focus on output growth. Interest rate smoothing is given by γ, while γ_π measures how sensitive monetary policy is to deviations of inflation from its steady state. η_t^M is a stationary monetary policy shock.

$$\frac{r_t}{r} = \left(\frac{r_{t-1}}{r}\right)^{\gamma}\left[\left(\frac{\pi_t}{\pi}\right)^{\gamma_\pi}\left(\frac{Y_t}{Y_{t-1}}\right)^{\gamma_{\Delta y}}\right]^{1-\gamma} exp(\eta_t^M) \tag{13}$$

2.4 The 3-equation New Keynesian system

We follow Rubaszek and Skrzypczyński (2008) by log-linearizing the new IS curve, Phillips curve, and the Taylor rule. Applying system reduction methods, we have the familiar three equation system.

$$\hat{r}_t = \rho \hat{r}_{t-1} + (1-\rho)\left(i_\pi \hat{\pi}_t + i_{\Delta y}(\hat{y}_t - \hat{y}_{t-1})\right) + \sigma_i \epsilon_t^M \quad (13)$$

$$\hat{y}_t = \frac{1}{1+\theta_h}\hat{y}_{t-1} - \frac{1-\theta_h}{1+\theta_h}\sigma^{-1}\left(\hat{R}_t - \hat{\pi}_{t+1} + \epsilon_{t+1}^D - \epsilon_t^D\right) + \frac{1}{1+\theta_h}E_t\hat{y}_{t+1} \quad (14)$$

$$\hat{y}_t = \frac{\beta}{1+\iota\beta}E_t\hat{\pi}_{t+1} + \frac{\iota}{1+\iota\beta}\hat{\pi}_{t-1} + \frac{(1-\zeta\beta)(1-\zeta)}{(1+\iota\beta)\zeta}\left\{\frac{\sigma}{1-\theta_h}\hat{y}_t - \frac{\sigma\theta_h}{1-\lambda}\hat{y}_t + \varphi(\hat{y}_t - \epsilon_t^s) - \epsilon_t^s\right\} \quad (15)$$

As noted in Shorfeide and An (2007) and Guerron – Quintana and Nason (2012), the solution to the three equations has an autoregressive form.

$$\begin{bmatrix}\hat{r}_t\\ \hat{\pi}_t\\ \hat{y}_t\end{bmatrix} = \Phi_{yy}(\theta)\begin{bmatrix}\hat{r}_{t-1}\\ \hat{\pi}_{t-1}\\ \hat{y}_{t-1}\end{bmatrix} + \Phi_\epsilon(\theta)\begin{bmatrix}\epsilon_t^M\\ \epsilon_t^S\\ \epsilon_t^D\end{bmatrix}$$

where $\Phi_{yy}(\theta)$ and $\Phi_\epsilon(\theta)$ are nonlinear functions of structural parameters.

3. Empirical methodology and results

Estimating the parameters in a NKDSGE model relies on the construction of a likelihood function and the prior distribution. Given the data or observables, we would like to construct the log posterior density, which consists of the sum of two parts, namely: the log likelihood and the log prior. The value of the parameters at which the log posterior is maximized is known as the posterior mode. But the solution is not analytical, and estimation requires simulation methods, specifically the Metropolis – Hastings Markov Chain Monte Carlo, which specifies the posterior distribution as the target distribution. We generated 200,000 draws from the target posterior distribution, with a 25% burn -in rate. We formed two Markov Chains. Following usual procedures, the usual tests of convergence were implemented, leading to satisfactory results. The number of MCMC chains is pegged at 2. The posterior means as well as the 5 and 95 percentile values for all estimated parameters are reported in Table 1.

We used the full–likelihood approach. This means that the DSGE model is considered the data–generating process. There are three shocks (demand, supply, and monetary) and three observables (real per capita output growth, inflation, and T-bill rates). For the observables, we will compute for the year – on - year growth rate of per capita real gross domestic product (with 2018 base year), the inflation rate based on the implicit deflator, and 91–day treasury bill rates converted to quarterly frequency. All variables have been demeaned.[3]

3.1 Parameter estimates

First, the estimated discount factor β is moderately high, achieving a value of no less than 0.88 for the entire period.

Second, we observe a high habit persistence at around 0.86. Villaverde (2010) interpreted a high habit persistence as one that is associated with a slow response of the economy to shocks.

Third, our estimate of φ is equal to 2.28, implying that the Frisch elasticity of labor supply is equal to 0.48. This is in line with microeconomic evidence and shows the relatively low response of labor supply to changes in the wage rate.

Fourth, the estimates show the duration of the pricing cycle was affected by the inclusion of Covid19 datapoints. The Calvo and the indexation parameter estimates are quite high. With an estimate of ζ equal to 0.71, we have on average, a 3.5-quarter pricing cycle.

[3] The author benefited from the MATLAB and Dynare codes written by Matthias Trabandt, which was shared with participants in CEMFI's Summer School 2020 Course entitled: "Computational Tools for Macroeconomists. The said code has been modified to align it to Rubaszek & Skrzypczyński's model.

Fifth, the coefficients for the Taylor rule are consistent with what is observed in the literature and appear to bolster the claim of central bank efficiency during bad and good times. The coefficient of inflation shows stability, and we can say that the BSP respects the Taylor rule. This, of course, may be attributable to the inflation targeting framework employed by the BSP since 2002. The coefficient on output is quite low but it is still associated with a positive response. As remarked in Villaverde (2010), this is a sign that the central bank smooths changes in nominal interest rates over time.

Finally, the standard deviation estimates are quite high. These are specific to the standard deviation of the mark - up shock or supply shock.

Table 1 Structural parameter estimates.

Parameter	Prior	Prior mean	Posterior Mean	95% HPD Interval	
Calvo prices (ζ)	beta	0.75	0.71	0.61	0.81
Price indexation (ι)	beta	0.75	0.84	0.70	0.96
Discount factor (β)	beta	0.90	0.88	0.76	0.98
Habit persistence (θ_h)	beta	0.75	0.86	0.79	0.93
Inverse of elasticity of Substitution (σ)	gamm	2.00	1.52	0.80	2.33
Inverse of Frisch labor supply elasticity (φ)	gamm	2.00	2.28	1.33	3.31
Interest rate smoothing (ρ)	gamm	0.75	0.73	0.68	0.78
Inflation response (i_π)	gamm	1.50	1.59	1.42	1.76
Output growth response $\left(i_{\Delta y}\right)$	gamm	0.13	0.14	0.04	0.24
Monetary shock std (σ_i)	invg	2.00	0.90	0.74	1.06
Demand shock Std (σ_D)	invg	9.00	3.88	2.23	5.79
Supply shock Std (σ_S)	invg	6.00	2.76	1.56	4.21
Persistence parameter Demand (ρ_D)	beta	0.50	0.50	0.30	0.69
Persistence parameter Supply (ρ_S)	beta	0.50	0.50	0.31	0.70

Source: Author's calculations.

3.3 Historical decompositions

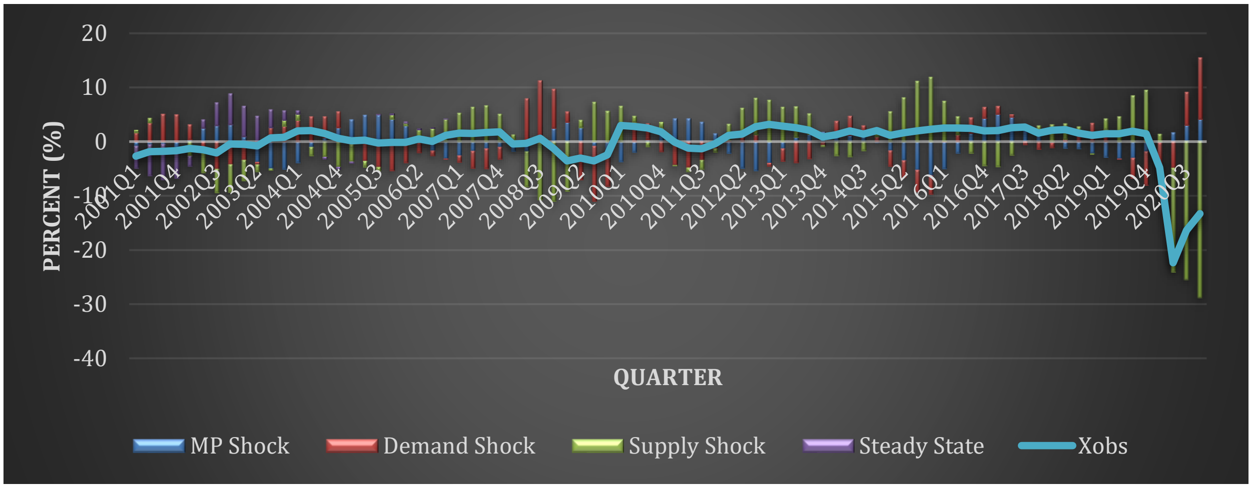
Fluctuations in output, inflation, and interest rates are affected by monetary policy and demand and supply shocks (Fackler and McMillin, 1998). We need to assess the shocks' relative importance using historical decomposition techniques.

As implemented, historical decompositions focus on the deviations of an endogenous variable from its steady state value, accounting for the respective contributions of demand, supply, and monetary policy shocks. Consistent with our objective, we only focus on output growth. Figure 1 shows the historical decomposition of output growth associated with each of the three shocks.

Prior to the pandemic and reflecting the relative stability in the growth rate, negative fluctuations were caused by demand shocks. It is obvious that a combination of demand and monetary shocks jolted the economy during the first Covid-19 quarters. Starting in the second quarter, however, monetary policy shocks took over, with supply and demand shocks still dragging the economy.

Note however that there is a fundamental difference between monetary and real shocks. Starting in the second quarter of the pandemic year, monetary policy shocks have appeared to be the only ones in positive territory. This implies that monetary policy has been a factor that has counteracted the negative effects of demand and supply shocks – not too successful though, to prevent output growth from dipping considerably during the pandemic quarters.

Figure 1 Historical Decomposition of Observed Year-on-Year Output Growth (Xobs)



4. CONCLUSIONS

Two features commonly discussed nowadays involve historical contributions of shocks. This note provides estimates of structural parameters in a parsimonious 3 – equation system of log – linearized equations endowed with normally distributed structural errors.

Estimating the parameters and undertaking historical decomposition, we found that monetary policy shocks appear to be positively robust during most of the pandemic year. This implies that monetary policy has been a factor that has counteracted the negative effects of demand and supply shocks – not too successful though, to prevent output growth from dipping considerably during the pandemic quarters.

There are several limitations associated with the study. First, the study did not explicitly model the pandemic as a rare disaster. Second, it adopted an approach that sought to understand how data points associated with the pandemic may affect volatility and parameter estimates. Third, this note did not account for the role of fiscal policy during the pandemic. Fiscal policy has been viewed to have strong complementarity effects, thereby augmenting monetary policy. These obvious shortcomings will be addressed in the near future.

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