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The macroeconomic effects of unconventional monetary policies in a commodity-exporting economy: Evidence from Mongolia

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Abstract

This paper examines the macroeconomic effects of unconventional monetary policies in Mongolia, a developing and commodity-exporting economy. Within a Bayesian structural vector autoregression framework, central bank balance sheet, policy rate, demand, and supply shocks are identified using a combination of sign and zero restrictions. An expansionary balance sheet shock stimulates bank lending and M2, decreases interest rate spread, leads to a depreciation of the domestic currency, and increases output and consumer prices. The estimated output and consumer price effects are qualitatively similar to the effects of conventional monetary policy, while the impacts on the exchange rate and foreign exchange reserves are different. We also find favourable evidence for the delayed overshooting response of the exchange rate to the balance sheet shock and reveal that financial friction amplifies the effects of demand and supply shocks on the Mongolian economy.

KEYWORDS

Bayesian VARs, central bank balance sheet, Mongolia, structural shocks, transmission mechanism, unconventional monetary policy

JEL CLASSIFICATION

C32, C53, E30, E44, E51, E52, E58, F32

1 | INTRODUCTION

In the wake of the global financial crisis and the COVID-19 global economic recession, many central banks around the world have employed unconventional monetary policy (UMP) measures to maintain economic and financial stability. Several papers (i.e., Boeckx et al., 2017; Burriel & Galesi, 2018; Gambacorta et al., 2014; Hesse et al., 2018; Kapetanios et al., 2012; Mouabbi & Sahuc, 2019; Schenkelberg & Watzka, 2013; Weale & Wieladek, 2016) have found that UMP measures implemented in advanced economies had significant positive macroeconomic effects. The COVID-19 pandemic led nearly 20 emerging market central banks to adopt, for the firsttime, UMPs in the form of asset purchase programs (Sever 2020). However, recent papers (i.e., Burriel & Galesi, 2018; Inoue & Rossi, 2019) argue that the effects of UMP measures substantially differ across countries. In the case of Mongolia, the Bank of Mongolia (BOM) has implemented UMP measures primarily focused on lending to banks since 2012. Since UMP measures are relatively new for developing small open economies such as

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Mongolia, there are uncertainties surrounding their effectiveness. For instance, the economies' currencies are not reserve currencies; therefore, an increase in central banks' balance sheets driven by UMPs may also lead to economic vulnerability through depleting foreign exchange reserves and excessively depreciating domestic currencies, which may hamper the effect of expansionary policy measures.

Mongolia differs from other emerging and commodity-exporting economies in some characteristics. First, after the collapse of the Soviet Union, Mongolia began its transformation from a centrally planned economy to a market-based economy in the early 1990s. Mongolia has pursued a ‘shock-therapy’ or ‘big bang’ transition to a market economy, entailing rapid liberalisation, de-regulation, and mass privatisation accompanied by a strict stabilisation policy. Second, Mongolia is currently a relatively small, landlocked, lower-middle-income economy in the heart of the Asian continent, bordered by Russia to the north and China to the south. It has population of 3.4 million, per capita GDP of around US$ 4060 in 2020, and total GDP of US$ 13.1 billion in that year. Mining is the dominant economic activity as its exports (copper, coal, gold, unrefined crude oil, iron ore, etc.) account for 90% of its total exports, which is about 40% of GDP. The commodity dependence co-existed with fiscal indiscipline typically brings about macroeconomic volatility, as the economy experiences boom and bust cycles driven by commodity price, commodity demand, and FDI shocks. Third, Mongolia has a bank-based financial system as the banking sector accounts for 95% of the financial system's assets. Therefore, banks play an important role in the transmission mechanism of monetary policy and in creating the money supply. The banking sector faces short maturities on financial liabilities and business loans, liability dollarization, unhedged exchange rate risk, low capital adequacy ratio, and high leverage ratio.

However, Mongolia has implemented UMP measures through the banking sector in the developing and commodity-exporting economy with no reserve currency, weak public governance, high shares of imported goods in both production and consumer basket, high exchange rate pass-through, and low foreign exchange reserve adequacy. In such a sense, Mongolia's UMP measures implemented with higher policy rates have different characteristics than other central banks' UMPs in advanced economies. Therefore, understanding the effects and transmission of UMP measures in Mongolia (as a case study) provides vital lessons in identifying policy responses to maintain macroeconomic stability for developing countries.

In this context, the present paper examines the macroeconomic effects of UMPs in Mongolia using Bayesian structural vector autoregression (SVAR) based on the approach proposed by Arias et al. (2018). As Mongolia is a developing and commodity-exporting economy, our VAR system includes several vital external and domestic variables. Hence, the Bayesian paradigm for estimation and inference is instrumental in dealing with over-fitting and identification problems. In the paper, we identify four structural shocks (UMP, conventional monetary policy [CMP], demand, and supply shocks) based on a combination of sign and zero restrictions.[1] Building on existing empirical facts and characteristics of the BOM's UMP measures, we propose a new identification scheme to isolate exogenous UMP (balance sheet) shocks. In this case, shocks are defined as simultaneous changes in the lending rate-policy rate spread and newly issued loans on the impact period of UMP measures. Since we employ the approach developed by Arias et al. (2018), prior and posterior distributions of the reduced-form VAR belong to the conjugate uniform-normal-inverse-Wishart family.[2] Their approach (algorithm) independently draws from the family of conjugate posterior distributions (i.e., normal-generalised-normal posteriors) over the structural parameterization when sign and zero restrictions are used to identify SVARs.

The paper extends the literature in two ways. First, as far as we are aware, this paper is one of the first attempts to assess the idiosyncrasies of domestic UMP and CMP implemented in developing small open economies such as Mongolia. Hence, it adds to the debate on whether UMP measures should be a regular part of the policy toolkit for developing economies. Second, the case study of Mongolia provides some implications on the potential effects and transmission of domestic UMP shocks for developing and small open economies. Hence, the paper offers an insight into choosing monetary policy measures (CMP or/and UMP) depending on the macroeconomic condition and nature of shocks for the economies.

Many theoretical and empirical works have been done to assess the effectiveness of UMP in advanced economies. Based on the lessons from the euro area, Japan, and the United Kingdom, Dell'Ariccia et al. (2018) emphasise that UMP tends to be more effective under three conditions such as (i) implemented in periods of heightened financial distress, (ii) deflationary pressures are not entrenched, and (iii) the central bank is credible in its attempt to provide sustained monetary accommodation. Different types of UMPs and their transmission mechanisms are well discussed by Joyce et al. (2012), Dell'Ariccia et al. (2018) and Papadamou et al. (2020) for advanced economies and by Fontaine et al. (2017) for a small open economy.

Papadamou et al. (2020) have provided an integrated overview of the empirical literature on the impact of UMPs on macroeconomic variables and markets. They have categorised the existing empirical studies by inflation expectations, portfolio rebalancing, signalling, liquidity, bank lending, and confidence channels of UMP. The existing literature (i.e., Lee & Kim, 2019; Moessner, 2015) suggests that monetary authorities' credibility is a crucial determinant of inflation expectations, affecting exchange rate changes. Studies focusing on non-US countries (i.e., Christensen & Krogstrup, 2019; Szczerbowicz, 2015) also find evidence of portfolio rebalance channel as UMPs led to lower long-term premia. Several papers underline the importance of signalling channel, highlighting the market's anticipation of lower short-term rates in the future when UMP is implemented (i.e., Bauer & Neely, 2014; Chadha & Waters, 2014). Studies on both the US and other economies (i.e., Carpenter & Eisenschmidt, 2014; Darracq-Paries & De Santis, 2015) show that UMPs led to higher liquidity, lower liquidity premia, and increased business lending from financial institutions. Though a few papers focus on the confidence channel, some papers (i.e., Chen et al., 2016; Lutz, 2015) highlight that UMP shocks exhibit a significant effect on the confidence of economic units. Many articles provide evidence of the substantial impacts of UMP (quantitative easing) on bank funding costs and bank lending in a range of countries (i.e., Bowman et al., 2015 for Japan, Wang, 2016 for the United States, and Churm et al., 2018 for the United Kingdom).

According to the empirical studies, exchange rates can be considered intermediate targets, but GDP and inflation are deemed final targets in UMP channels (Papadamou et al., 2020). Several papers (Glick & Leduc, 2012; Kenourgios et al., 2015) highlight that UMP announcements led to domestic currency depreciations in advanced economies. Papers focusing on US effects on currency values of emerging economies (i.e., Anaya et al., 2017; MacDonald, 2017) find a significant heterogeneity of US UMP effects on emerging market currencies' appreciation. Few papers have investigated the impact of domestic UMP on small open economies, particularly the role of the exchange rate in the transmission of UMP shocks. For instance, Schenkelberg and Watzka (2013) do not find any significant effect on the exchange rate and conclude that the portfolio rebalancing effects[3] of the QE have not been sufficient for the Japanese case. Burriel and Galesi (2018) find that UMP shock leads to a depreciation of the effective exchange rate, but the response is not significant for the euro area. However, using a novel identification procedure, Inoue and Rossi (2019) present that both CMP and UMP easing lead to a depreciation of the nominal exchange rate for the United Kingdom, the euro area, Canada, and Japan. They emphasise that the effects of monetary shocks on agents' expectations play an essential role in the exchange rate responses. Building on an estimated open economy DSGE model, Hohberger et al. (2019) reveal that ECB's QE programme leads to a depreciation of the real exchange rate, thereby increasing the trade balance in the euro area. Zlobins (2020) find evidence that the trade channel of the ECB's asset purchase program effectively works in the case of Latvia. Based on daily data, Sever et al. (2020) find that emerging market asset purchase announcements lowered bond yields, did not lead to a depreciation of domestic currencies, and did not affect equities. While the immediate effect of asset purchases appears positive, further consideration of unconventional monetary policies' risks and longer-term impact is needed. Studies on advanced economies show that UMP shocks lead to higher economic activity and consumer prices (i.e., Falagiarda, 2014 for the United States and the United Kingdom, Kapetanios et al., 2012 for the United Kingdom, Matsuki et al., 2015 for Japan and Darracq-Paries & De Santis, 2015 for the euro area). There is also evidence that the US UMP has triggered an expansion of domestic activities in emerging market economies. Based on the empirical studies on transmission channels, intermediate and final targets of UMPs, and characteristics of the Mongolian economy, we can expect the importance of liquidity and bank lending channels, a moderate depreciation of the domestic currency, and moderate effects of the UMP on inflation and GDP growth in the case of Mongolia.

Over the last decade, two main approaches have been actively used in quantifying the effects of UMP: New Keynesian dynamics stochastic general equilibrium (DSGE) models with financial frictions (i.e., Brunnermeier & Sannikov, 2014; Chen et al., 2012; Cúrdia & Woodford, 2009, 2011; Gambacorta & Signoretti, 2014; Gertler & Karadi, 2011; Hohberger et al., 2019; Mouabbi & Sahuc, 2019) and SVAR models. This paper relies on the Bayesian SVAR approach and focuses on the relevant literature review. In the structural shock identification, we follow a sign and zero restriction approach introduced in the SVAR.[4] Scholars (i.e., Schenkelberg & Watzka, 2013 for Japan, Darracq-Paries & De Santis, 2015 for the euro area) proposed new sign restrictions to identify quantitative easing (QE) shock. They conclude that UMPs, including QE and longer-term refinancing operations (LTROs), successfully stimulated real activity. Based on the mixture strategy of zero and sign restrictions employed by Peersman (2011)[5] and Eickmeier and Hofmann (2013), recent papers (i.e., Boeckx et al., 2017; Burriel & Galesi, 2018; Gambacorta et al., 2014; Hesse et al., 2018; Weale & Wieladek, 2016; Zlobins, 2020) identify UMP shocks. They find that policy measures expanding the central bank balance sheet had a significant positive impact on economic activity and consumer prices. However, some papers (i.e., Elbourne, 2019; Elbourne & Ji, 2019) have raised an issue on whether SVARs with the sign and zero restrictions can successfully identify UMP shocks, particularly in the euro area. As a response, Boeckx et al. (2019) have provided analytical explanations and concluded that the existing identification strategy for the UMP shocks is plausible. They also argue that the approach employed by Elbourne and Ji (2019) does not serve the purpose of evaluating identification strategies of SVARs. The debate suggests that the identification strategy must be interpreted carefully, and robustness checks must be conducted adequately when identifying UMP shocks using the SVAR approach.

For the VAR modelling, we employ Bayesian approach to handle problems faced with small-scale standard VAR models, such as omitted variable bias with adverse consequences for structural analysis and not reflecting the information available to central banks (Evgenidis & Rapadamou, 2018). To overcome these issues, several papers (i.e., Lenza et al., 2010, Peersman, 2011 and Zlobins, 2020 for the euro area, Kapetanios et al., 2012 for the United Kingdom, Hesse et al., 2018 for the United States and the United Kingdom, Evgenidis & Rapadamou, 2018 for the euro area) have previously utilised medium-scale Bayesian VAR approach to study the impacts and transmission mechanism of UMPs. Though several papers (i.e., Eickmeier & Hofmann, 2013; Evgenidis et al., 2019) also apply factor-augmented vector autoregressive (FAVAR) models to examine effects and international transmission of the US monetary policy, they primarily include many variables (e.g., Bernanke et al., 2005 observed 120 variables) in the VAR system. In addition to panel VAR (i.e., Darracq-Paries & De Santis, 2015), recent papers (i.e., Anaya et al., 2017; Burriel & Galesi, 2018; Chen et al., 2016; Zlobins, 2020) have used global VAR (GVAR) or GVECM to assess country-level effects of the ECB's UMPs. Some papers (i.e., Chung et al., 2012; Kapetanios et al., 2012; Matsuki et al., 2015) have employed MS-SVAR and TVP-SVAR to allow changes in regimes or parameters. In this paper, FAVAR or GVAR approach is not used since we consider medium-scale Bayesian SVAR models only consisting of 9–13 variables to examine the effects of monetary policy in an individual economy (Mongolia) rather than analysing multi-country spillover effects and international transmission of monetary policies implemented in advanced economies. MS-SVAR or TVP-SVAR is not also considered since we estimate our model over the period that the BOM implemented UMP measures.

The remainder of the paper is organised as follows. Section 2 provides an overview of the BOM's UMP measures and their influences on the central bank balance sheet. Section 3 presents a Bayesian structural VAR model for the Mongolian economy, particularly the benchmark specification and the identification strategy to isolate exogenous shocks. Section 4 reports the main findings of the benchmark estimations. Section 5 provides some robustness checks. Finally, Section 6 concludes the paper with policy implications.

2 | THE BALANCE SHEET OF THE BOM AND UMP MEASURES IN MONGOLIA

The BOM has operated an implicit inflation-forecast targeting regime since 2007. The BOM uses the policy rate (a short-term interest rate-its operation target) as its main policy instrument, adjusted frequently by its Monetary Policy Committee (MPC). In addition to targeting domestic price stability, Mongolia maintains a floating exchange rate regime. However, the BOM holds the right to intervene in foreign exchange markets to reduce excess volatility in the Mongolian Tögrög (MNT) exchange rate.

In response to the economic recession,[6] the BOM started implementing UMP measures, also classified by international financial institutions as quasi-fiscal policy activities (QFPA), in October 2012. As a backbone of the QFPAs, the government of Mongolia issued a sovereign bond of 1.5 billion USD at the end of 2012 and deposited the proceeds in the BOM. As reported by KPMG (2018), the BOM implemented 17 QFPAs (including housing mortgage and TARP programs) and disbursed 7.2 trillion MNT of funds (equivalent to 30.1% of 2016 GDP) from 2012 to 2016.

The BOM's UMP measures primarily focused on lending to banks and involved a massive expansion of the central bank's balance sheet. Figures 1–3 provide the BOM's assets, liabilities, and capital composition. The charts clearly show that the UMP measures have led to an expansion in the BOM balance sheet. The BOM started the QFPAs by introducing the Price Stabilization Program (PSP), in which the BOM provided cheap financing to banks that lent it to specific sectors at a low-interest rate. As a result, the PSP initially increased the BOM's claims on banks. Within the PSP, the BOM launched a Housing Mortgage Program (HMP) in June 2013 to stimulate housing demand. The HMP supported the construction sector and the economy as it pulled up housing demands. Under the HMP, the BOM provided mortgage financing to banks that gave mortgage loans to households at a subsidised interest rate of 8% (almost half of market lending rates), and the funding was repaid by mortgage-backed securities (MBS) issued by Mongolian Ipotek Corporation (MIK). Hence, the BOM's claim on other sectors increased from mid-2013. In addition, the PSP included some sub-programs that increased demand for imports (i.e., petroleum, construction materials, and household goods); hence foreign exchange reserves have been depleted since 2013.

On the liability, the BOM sterilised the effects of its unconventional policy on the monetary base mainly through the issuance of its central bank bills (CBBs), foreign exchange

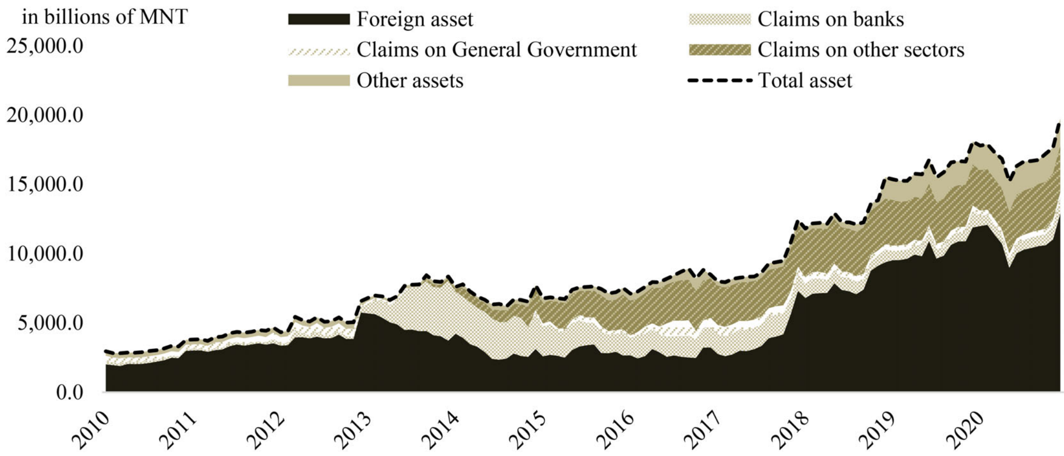

FIGURE 1 The Bank of Mongolia (BOM) assets [Colour figure can be viewed at wileyonlinelibrary.com]

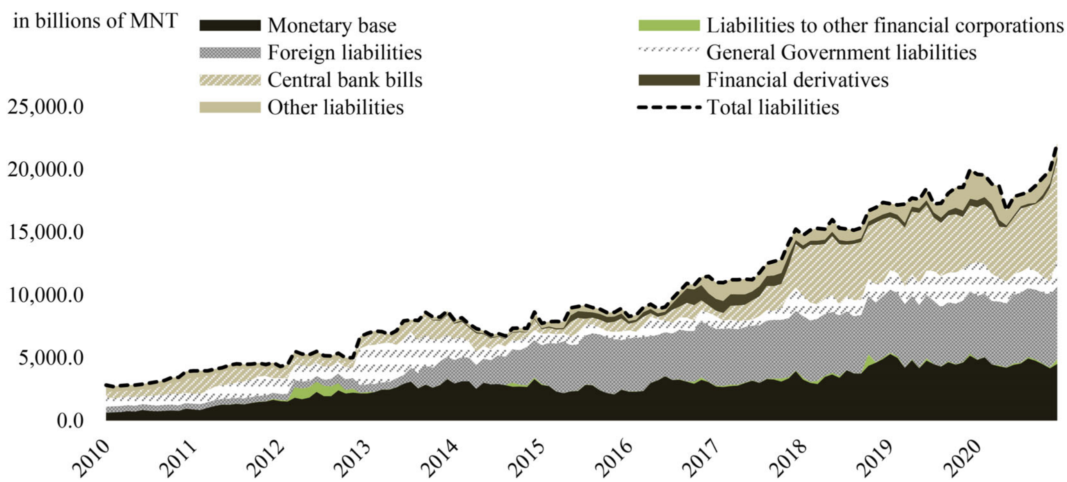

FIGURE 2 The Bank of Mongolia (BOM) liabilities [Colour figure can be viewed at wileyonlinelibrary.com]

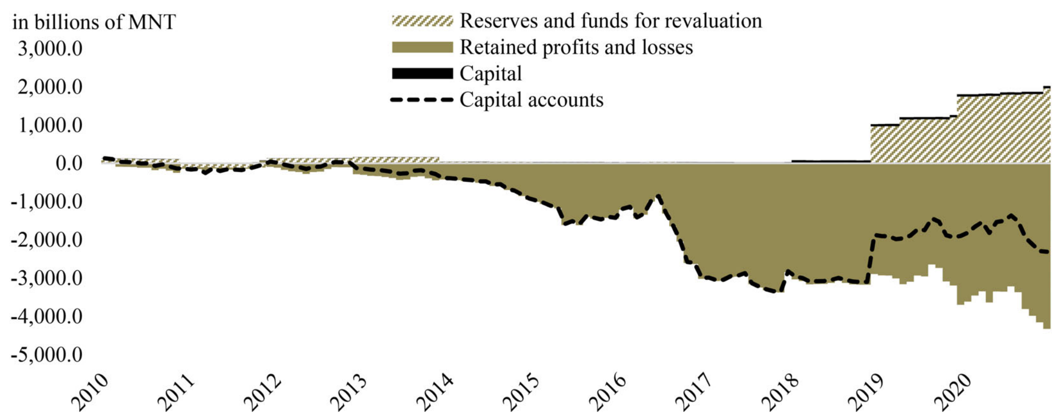

FIGURE 3 The Bank of Mongolia (BOM) capital. *Source*: The Bank of Mongolia [Colour figure can be viewed at wileyonlinelibrary.com]

intervention, and an increase in government deposits. For instance, the BOM's foreign currency (USD and RMB) selling in foreign exchange markets reduced banks' domestic currency reserves. In addition, the BOM also directly purchased long-term government bonds from 2014 to 2016 and monetized government debt below-market rate.

The increase in domestic assets led by the UMP measures significantly reduced the foreign exchange reserves. The BOM's foreign liabilities have continuously increased since mid-2013 since the BOM actively utilised the bilateral currency swap lines made with the People's Bank of China (PBoC) to slow down the depletion of gross foreign exchange reserves.

The BOM also made currency swap agreements with domestic banks at non-market conditions to raise gross foreign exchange reserves starting from 2015. A side impact of the unconventional measures on the balance sheet is that the BOM has posted losses. The losses have been due to below-market rates on domestic assets (UMP measures), relatively high-interest rates on the foreign exchange liabilities, low returns on the foreign exchange assets, increases in CBBs, and losses from foreign exchange swaps.

After Mongolia's parliamentary election in 2016, the BOM's QFPAs stopped, except for the HMP. The newly established government of Mongolia started to implement the IMF's Extended Fund Facility (EFF) program for 3 years, beginning in May 2017. During the EFF program years, the multi-donor financing, the BOM's foreign currency purchases, and the BOM's gold purchases have supported building up the foreign exchange reserves since 2017. Hence, the BOM's balance sheet expansion was mainly driven by foreign assets for 2017–2020. Since Mongolia is a gold-producing country, the BOM purchases gold from individuals and entities and converts it into monetized gold. Through this operation, the BOM directly injects MNT liquidity into the economy. However, we did not consider the operation within the BOM's UMP measure since it is regularly conducted to increase foreign exchange reserves.[7] On the liability side, the BOM absorbed excess MNT liquidity by issuing its own CBB to maintain market interest rates in line with the policy rate. In addition, the BOM's Treasury Fund assets were revalued at the end of 2018; hence other assets increased since the end of 2019.

The current account deficit to GDP in Mongolia averaged 16.1% from 2010 until 2020, reaching an all-time high of 27.4% in 2012. Though the current account balance (percent of GDP) has fluctuated substantially in recent years, it has decreased since 2018. As a result of persistent current account deficits, Mongolian external debts in both private and public sectors are accumulated, reaching 240% of GDP, and Mongolian Tögrög continues to depreciate against the US dollar. Fluctuations in current account balance mainly reflect commodity (copper, gold, coal, and other minerals) demand and commodity price shocks.

The BOM has revived its active UMP measures since the first quarter of 2020. The parliament of Mongolia passed a law on the one-time payment of civil pension loans by the government in January 2020. According to the law, the BOM must purchase the company bond issued by state-owned Erdenes Mongol LLC, which owns the Salkhit silver and gold mining. The principal and interest of the bond will be repaid by silver and gold. The BOM has purchased the bond through banks; hence its claims on other sectors increased over time. As the economy faced a sharp recession because of the COVID-19 pandemic, the parliament passed the COVID-19 law and resolution, permitting the BOM to implement UMP measures in May 2020. As implementation of the law and resolution, the BOM provided financings to banks for loans to gold mining sectors and introduced targeted longer-term refinancing operations (TLTROs). The financings are reflected in claims on banks of the BOM asset. The amounts of TLTROs are determined by MPC each quarter, and banks are required to use the TLTRO financings for small and medium-sized enterprises (SMEs) and non-mining exporting sector loans.

To account for these factors, we choose the BOM domestic asset excluding other assets as a UMP indicator in the empirical analysis. Figure 4 shows the dynamics of UMP measures (the BOM domestic asset excluding other assets), the monetary base (a liabilities-based measure), and the CMP measure (the policy rate).

From Figure 4, it is evident that the monetary policy loosened through unconventional measures for the period 2013–2016. For instance, the UMP indicator (asset-based measure) increased seven times for 2013–2014 and peaked in September 2016. However, the monetary base did not rise for the same period, implying that it is insufficient to proxy the UMP. For the CMP, the policy rate was kept at relatively high levels to maintain price stability. Another visual observation is a negative relationship between the policy rate and the monetary base. The unconventional policy measures with a high policy rate are distinct from the Mongolian case as advanced economies only implement UMPs when interest rates are near zero. At this point, central banks have fewer tools to influence economic growth. It raises a couple of questions: Why was an expansionary CMP (policy rate cut) not implemented to stimulate the economy alone? How much is a change in policy rate needed to achieve effects in real GDP and CPI resulting from the expansionary UMP (balance sheet)? Do implications of the same amount of change in GDP (and CPI) be accomplished through CMP or UMP vary for other macroeconomic and financial variables? Since answers to the questions help choose policy instruments depending on the economic situation, these issues are quantitatively examined in Section 4.2.2.

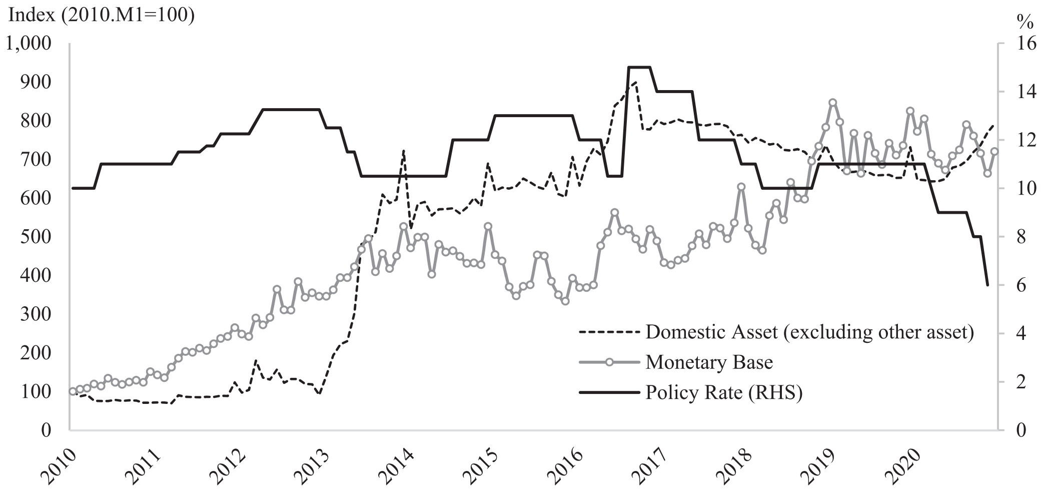

FIGURE 4 Indicators of conventional monetary policy (CMP) and unconventional monetary policy (UMP) measures. *Source*: The Bank of Mongolia

During the EFF program years, the asset-based measure has gradually declined, and the policy rate was above 10%. However, as a response to the COVID-19 recession, the balance sheet indicator has increased, and the policy rate has significantly reduced since 2020. Therefore, this paper's findings will help examine the effectiveness of the recent UMP measures on the economy.

3 | A STRUCTURAL VAR MODEL FOR THE MONGOLIAN ECONOMY

SVAR models have been extensively used to examine the macroeconomic effects of CMP and UMP shocks. Examples of identifying UMP shocks include Gambacorta et al. (2014) for panel VAR, Boeckx et al. (2017) for SVAR of the euro area, Burriel and Galesi (2018) for global VAR.

3.1 | Benchmark specification

In examining the macroeconomic effects of CMP and UMP, the following SVAR(p) with general form is considered:

$$\boldsymbol{y}_t'\boldsymbol{A}_0 = \boldsymbol{c} + \sum_{\ell}^{p} \boldsymbol{y}_{t-\ell}'\boldsymbol{A}_\ell + \boldsymbol{\varepsilon}_t' \text{ for } 1 \leq t \leq T, \tag{1}$$

where $\boldsymbol{y}_t$ is a $n \times 1$ vector of endogenous variables, $\boldsymbol{\varepsilon}_t$ is an $n \times 1$ vector of structural shocks, $\boldsymbol{A}_\ell$ is an $n \times n$ matrix of parameters for $0 \leq \ell \leq p$ with $\boldsymbol{A}_0$ invertible, $\boldsymbol{c}$ is a $1 \times n$ vector of parameters, p is the lag length, and T is the sample size. The vector $\boldsymbol{\varepsilon}_t$, conditional on past information and the initial conditions $\boldsymbol{y}_0, \ldots, \boldsymbol{y}_{t-p}$, is Gaussian with mean zero and covariance matrix $\mathbf{I}_n$, the $n \times n$ identity matrix. The model described in Equation (1) can be compactly written as

$$\boldsymbol{y}_t'\boldsymbol{A}_0 = \boldsymbol{x}_t'\boldsymbol{A}_+ + \boldsymbol{\varepsilon}_t' \text{ for } 1 \leq t \leq T, \tag{2}$$

where $\boldsymbol{A}_+' = \left[\boldsymbol{A}_1' \cdots \boldsymbol{A}_p' \, \boldsymbol{c}'\right]$ and $\boldsymbol{x}_t' = \left[\boldsymbol{y}_{t-1}' \cdots \boldsymbol{y}_{t-p}' \, 1\right]$ for $1 \leq t \leq T$. The dimension of $\boldsymbol{A}_+$ is $m \times n$, where $m = np + 1$. The reduced-form representation implied by Equation (2) is

$$\boldsymbol{y}_t' = \boldsymbol{x}_t'\boldsymbol{B} + \boldsymbol{u}_t' \text{ for } 1 \leq t \leq T, \tag{3}$$

where $\boldsymbol{B} = \boldsymbol{A}_+\boldsymbol{A}_0^{-1}$, $\boldsymbol{u}_t' = \boldsymbol{\varepsilon}_t'\boldsymbol{A}_0^{-1}$ is the reduced-form error terms, and $E\left[\boldsymbol{u}_t\boldsymbol{u}_t'\right] = \Sigma = \left(\boldsymbol{A}_0\boldsymbol{A}_0'\right)^{-1}$ is the covariance matrix of the error terms. The matrices $\boldsymbol{B}$ and Σ are reduced-form parameters, while $\boldsymbol{A}_0$ and $\boldsymbol{A}_+$ are structural parameters.

In the benchmark specification, the vector of endogenous variables, $\boldsymbol{y}_t$, comprises 12 variables.

Several remarks about the benchmark VAR model and selection of variables are worth mentioning. First, as Boeckx et al. (2017) emphasised, agents and markets in the economy may behave differently in the crisis when central banks explicitly use their balance sheet as a policy tool to influence macroeconomic and financial conditions compared to the pre-crisis period. Hence, to adequately assess the effects of policy measures, we choose the sample period covering when UMP measures are undertaken.

Second, the benchmark specification should capture the empirical facts. As Mongolia is a small commodity-exporting economy, almost 50% of GDP fluctuations are explained by external shocks such as FDI, copper price, and Chinese growth (Gan-Ochir & Davaajargal, 2019). Gan-Ochir and Davaajargal (2022) also find that external variables (i.e., China's growth, China's inflation, and change in copper price) play an essential role in forecasting Mongolian inflation. Therefore, we include foreign variables, such as copper price, FDI inflows, and China's GDP, in the VAR system to account for these facts.

Third, the benchmark specification should capture the main macroeconomic, financial, and monetary interactions. The dynamics of domestic GDP, CPI, exchange rate, foreign exchange reserve, and M2[8] are supposed to capture the macroeconomic developments in the sample period. As employed by recent papers (i.e., Burriel & Galesi, 2018; Schenkelberg & Watzka, 2013), the inclusion of exchange rate and foreign exchange reserve captures an open economy dimension of the economy, and it allows us to analyse the effect of the UMP on these variables.[9] The paper expresses the exchange rate as the local currency value of a foreign currency. The policy rate captures CMP. The central bank balance sheet variable capturing UMP is BOM's domestic assets (excluding other assets), whose dynamics closely resemble the balance sheet measures discussed in Section 2. As the BOM's total asset depends on the foreign asset movements driven by gold purchases and foreign exchange interventions, we observe the balance sheet's composition to identify UMP shocks accurately. Gambacorta et al. (2014) discussed that the monetary base, a liabilities-based measure, does not accurately capture UMPs. Hence, we do not include the monetary base in the benchmark specification. However, in the robustness analysis, the BOM total assets are used as the balance sheet indicator to measure the effects of all unconventional measures (i.e., including gold purchases and FX intervention).[10]

Fourth, we include newly issued loans and the spread between the lending rate and policy rate in the benchmark specification to identify exogenous UMP shocks (balance sheet shocks). In contrast to Boeckx et al. (2017), we did not include a financial stress indicator because no such observable variable is available in the case of Mongolia. However, the lending rate-policy rate spread reflects macroeconomic and financial risks, and conditioning on the spread is vital to disentangle exogenous changes in the central bank balance sheet indicator from endogenous responses to financial risks and uncertainties. Moreover, the UMP measures of the BOM have been intended to increase credit supply and reduce lending rates during the credit crunch period rather than responding to financial turbulence. Given a bank-centric financial system, the BOM's UMP (i.e., large-scale subsidised lending to the real sector through banks) can stimulate the economy by increasing new loans and reducing lending rates. The inclusion of the financial variables helps reflect the fact that the banking system's solvency plays an essential role in UMP's effectiveness. If banks are capital constrained and have financial fragility issues, they cannot convert the extra liquidity into more lending to the private sector. Though the central bank injects liquidity, banks are not able or willing to lend to households and firms due to their fragility; thereby, the effects on economic activity are more subdued. For instance, Boeckx et al. (2017) find that countries with a weakly capitalised banking system react less to the ECB's UMPs. Based on dynamic panel regressions, Mamatzakis and Bermpei (2016) show that UMP negatively relates to bank performance (return on asset, return on equity, net interest margin, pre-tax operating income as a percentage of average total assets). The negative association is mitigated for banks with a high level of asset diversification and low deposit funding.

3.2 | Identification of structural shocks

In this model, we identify four structural shocks: a UMP shock (balance sheet shock), a CMP shock (interest rate shock), a demand shock, and a supply shock. These shocks are identified using a combination of sign and zero restrictions as shown in Table 1, hence the results are unaffected by the ordering of the variables in the VAR system.

A UMP shock is identified as an exogenous innovation to the BOM balance sheet indicator. In isolating balance sheet shocks, we follow the identification strategy employed by Gambacorta et al. (2014), Boeckx et al. (2017), and Burriel and Galesi (2018), which use a combination of zero and sign restrictions on the matrix $\boldsymbol{A}_0$ of Equation (1). Within the strategy, the exogenous balance sheet shocks are identified as follows. First, like other existing papers, we assume there is only a lagged impact of shocks to the BOM balance sheet on output, consumer prices, and foreign exchange reserves. As a monthly data set is used in the estimation, the assumption is valid as the transmission of central bank liquidity support to the real economic activity (i.e., central bank liquidity injection to banks, lending from banks to the private sector, and spending and investment of private sector) will take time. Hence, the contemporaneous impact on these variables is restricted to zero. Second, we put a zero restriction on the policy rate to distinguish balance sheet changes from CMP. Third, we assume that an expansionary balance sheet shock does not increase the lending

TABLE 1 Identification of structural shocks

Horizons	Balance sheet shock $h=0$	Balance sheet shock $h=1,2$	Interest rate shock $h=0$	Interest rate shock $h=1,2$	Demand shock $h=0$	Demand shock $h=1,2$	Supply shock $h=0$	Supply shock $h=1,2$
BOM domestic assets	≥	≥	0	?	0	?	0	?
Lending rate-policy rate spread	≤	≤	?	?	?	?	?	?
Newly issued loans	≥	≥	≥	≥	≥	≥	?	?
Policy rate	0	?	≤	≤	0	≥	0	≥
Output	0	?	0	?	≥	≥	≤	≤
Consumer prices	0	?	0	≥	≥	≥	≥	≥
Other variables in the system[a]	?	?	?	?	?	?	?	?

Note: ≥ indicates that response is restricted to be non-negative, ≤ to be non-positive, ? is left unrestricted. h implies horizons, and 0 to be zero at the impact period ($h=0$), sign restrictions are imposed on the first and second months after the shock ($h=1,2$).
[a]An exception is that 0 restriction is set for foreign exchange reserve on the impact period when balance sheet shock is identified.

rate-policy rate spread (i.e., financial distress) and does not reduce newly issued loans.[11] The notion that exogenous innovations to the balance sheet have a lower effect on the lending rate-policy rate spread (financial risks) is required to disentangle such innovations from the endogenous balance sheet response to financial distress. Cúrdia and Woodford (2011) show that central bank lending can stabilise the economy by increasing the private sector's credit and lowering credit spread (i.e., lending rate-policy rate spread). Hofmann et al. (2020) find evidence that ECB's UMPs significantly lowered retail lending and deposit rates in Germany, France, Spain, and Italy. Moreover, several papers (i.e., Abbassi & Linzert, 2012; Chen et al., 2012; Lenza et al., 2010) have documented UMP measures' effectiveness in lowering longer-term interest rates and risk premium. These restrictions are also motivated by the fact that BOM's unconventional policy measures mostly focus on lending programs that aim to provide cheaper (subsidised) loans to final borrowers (households and companies) through banks, as discussed in Section 2. Finally, zero restrictions are imposed on the impact period. Sign restrictions are set on the first and second months after the shock and implemented in a weak form (i.e., smaller/larger than or equal to zero). It allows for the possibility that a UMP measure, for example, influences the BOM assets only with a lag. The time lag accommodates the fact that some monetary policy decisions are announced before they are in place.

In the case of identifying CMP shock, we use similar sign restrictions employed by other papers (i.e., Burriel & Galesi, 2018; Darracq-Paries & De Santis, 2015; Granziera et al., 2018; Kapetanios et al., 2012). Notably, the sign restrictions only used for CMP shock identification of the papers are considered here. A commonly used identification assumption for CMP shocks is that real economic activity variables such as output and consumer prices cannot respond to policy rate changes within one period (Christiano et al., 1999; Kremer, 2016). In implementing the assumption, the contemporaneous impact on output and consumer prices is restricted to zero. To disentangle CMP and UMP shocks, we require that the BOM's balance sheet indicator does not react on the impact period. To assess the effect of CMP shock on output, we did not set any restrictions on output for the period beyond the impact period. To identify the CMP shock, we further assume that lowering the policy rate does not reduce newly issued loans for $h=0,1,2$ and consumer prices for $h=1,2$ periods. The zero and sign restrictions on output, consumer prices, and newly issued loans align with Granziera et al. (2018).

Demand and supply shocks are identified using zero and sign restrictions in line with the existing papers (i.e., Baumeister & Benati, 2013; Kapetanios et al., 2012; Schenkelberg & Watzka, 2013; Weale & Wieladek, 2016; Zlobins, 2020).[12] We assume that (i) a positive demand shock does not reduce the newly issued loan, output, and consumer prices,[13] and (ii) a negative supply shock does not lead to a fall in prices and a rise in output. As a monthly data set is employed, CMP and UMP are not able to respond to these shocks since policymakers may not observe the shocks within the period, and the MPC regularly meets quarterly. To account for this fact, we impose a zero restriction on the balance sheet indicator and policy rate for the impact period. The restrictions are also helpful in disentangling demand and supply shocks from monetary policy shocks. As Taylor-type rules advocate, CMP responds to output and consumer prices with a time lag. Hence, we allow the non-negative response of the policy rate to both shocks for the first and second months after the shock. We did not set any further restrictions beyond the impact period for the UMP by assuming that the BOM does not actively respond (or does not follow specific rules) to the shocks using unconventional measures. The responses of the rest of the variables to aggregate demand and supply shocks are left unrestricted.

4 | DATA AND BENCHMARK ESTIMATION RESULTS

4.1 | Data

Our benchmark VAR is estimated using monthly data in (log) levels over the sample period October 2012–September 2020.[14] In the benchmark specification, the vector of endogenous variables, Y_t, comprises the following 12 variables: The log of China real GDP (GDP_{CH}), the log of the copper price (P_{copper}), the log of seasonally adjusted FDI inflows (FDI), the log of seasonally adjusted real GDP (GDP_{M}), the log of CPI (CPI), the log of the nominal exchange rate (expressed in MNT/USD) (ER), the log of foreign exchange reserves (FXR), the log of central bank's domestic assets excluding other assets (DA), the (annual) policy rate (PR), the spread between the lending rate and policy rate (SP), the log of seasonally adjusted newly issued loan (L), and the log of M2 ($M2$). China's GDP[15] is observed from the data.oecd.org database, while copper price (grade A cathode, LME spot price) is collected from the Bloomberg database. Domestic GDP, industrial product, and CPI are retrieved from the National Statistical Office. All remaining data are obtained from the Statistical Bulletin of the BOM.

A relatively short sample size (96 observations) and 12 variables are used in the VAR estimation, leading to the small sample size problem (or over-fitting problem) when applying the classical econometric approach. However, the Bayesian approach is better equipped to estimate a larger VAR model based on a relatively small sample.

4.2 | Benchmark estimation results

Following Arias et al. (2018), we use the Bayesian approach for estimation and inference. The prior and posterior distributions over the orthogonal reduced-form parameters ($\boldsymbol{B}$ and Σ) belong to the conjugate uniform-normal-inverse-Wishart family. For the approach combining sign and zero restrictions, draws from the conjugate posterior are transformed into the structural parameters, and the transformation induces a normal-generalised-normal posterior (a family of conjugate posterior distributions) over the structural parameters ($\boldsymbol{A}_0$ and $\boldsymbol{A}_+$). For details of the estimation procedure and implementation of restrictions, we refer to Arias et al. (2018). The estimations and implementation of restrictions are done using *ZeroSignVAR* package, a flexible MATLAB routine developed by Breitenlechner et al. (2019).

Before estimating benchmark VAR, the optimal lag length must be selected. The misspecification of lag-length causes a large inconsistency in the impulse response functions and variance decomposition (Braun & Mittnik, 1993). As argued by Lütkepohl (1993), selecting a higher-order length than the true lag length increases the chances for the mean-square forecast errors of the VAR. Likewise, selecting the lower order lag length than the true lag length often generates autocorrelated errors. Lag length is determined based on the formal Bayesian model comparison, where the ratio of posterior probabilities is used as the main criteria. Log marginal likelihoods for $\mathcal{M}_1$:BVAR(1), $\mathcal{M}_2$:BVAR(2), $\mathcal{M}_3$:BVAR(3), and $\mathcal{M}_4$: BVAR(4) are estimated as 545.29, 537.84, 544.01, and 536.85, respectively, hence log of posterior ratios are found as $\log_{10}(R_{12}) = 7.45$, $\log_{10}(R_{13}) = 1.28$, and $\log_{10}(R_{14}) = 8.44$. According to Jeffreys (1961)'s guideline, there is decisive support for $\mathcal{M}_1$ compared to $\mathcal{M}_2$ and $\mathcal{M}_4$ models and strong evidence for $\mathcal{M}_1$ when comparing with $\mathcal{M}_3$, thereby lag length is selected as $p = 1$. BVAR(2) model is also estimated, and results have been robust as shown in Section 5. Ten thousand draws from the posterior are used to produce empirical results.

4.2.1 | Time series of exogenous CMP and UMP shocks

We first examine the time series of the identified shocks before discussing the dynamic effects and transmission mechanism of the balance sheet and policy rate shocks. Analysing the shocks' time series should help interpret their exact source more carefully and assess whether the estimated innovations capture the BOM's significant UMP measures. Figure 5 presents the median cumulative time series of the balance sheet and policy rate shocks. We add dates of important UMP and CMP measures into the figure based on 'Special Review of Quasi-Fiscal Policy Activities' report prepared by KPMG (2018), MPC statements, and the BOM's annual reports.

For UMP, a rise in the cumulative shock series implies an expansionary shock; however, a decline reflects a tightening of the balance sheet relative to the average endogenous response to the other shocks hitting the economy. However, for CMP, a rise in the cumulative shock implies a tightening of policy, while a decline represents an expansionary shock.

Figure 5a shows that the identified balance sheet shocks capture the dates of main policy measures. As

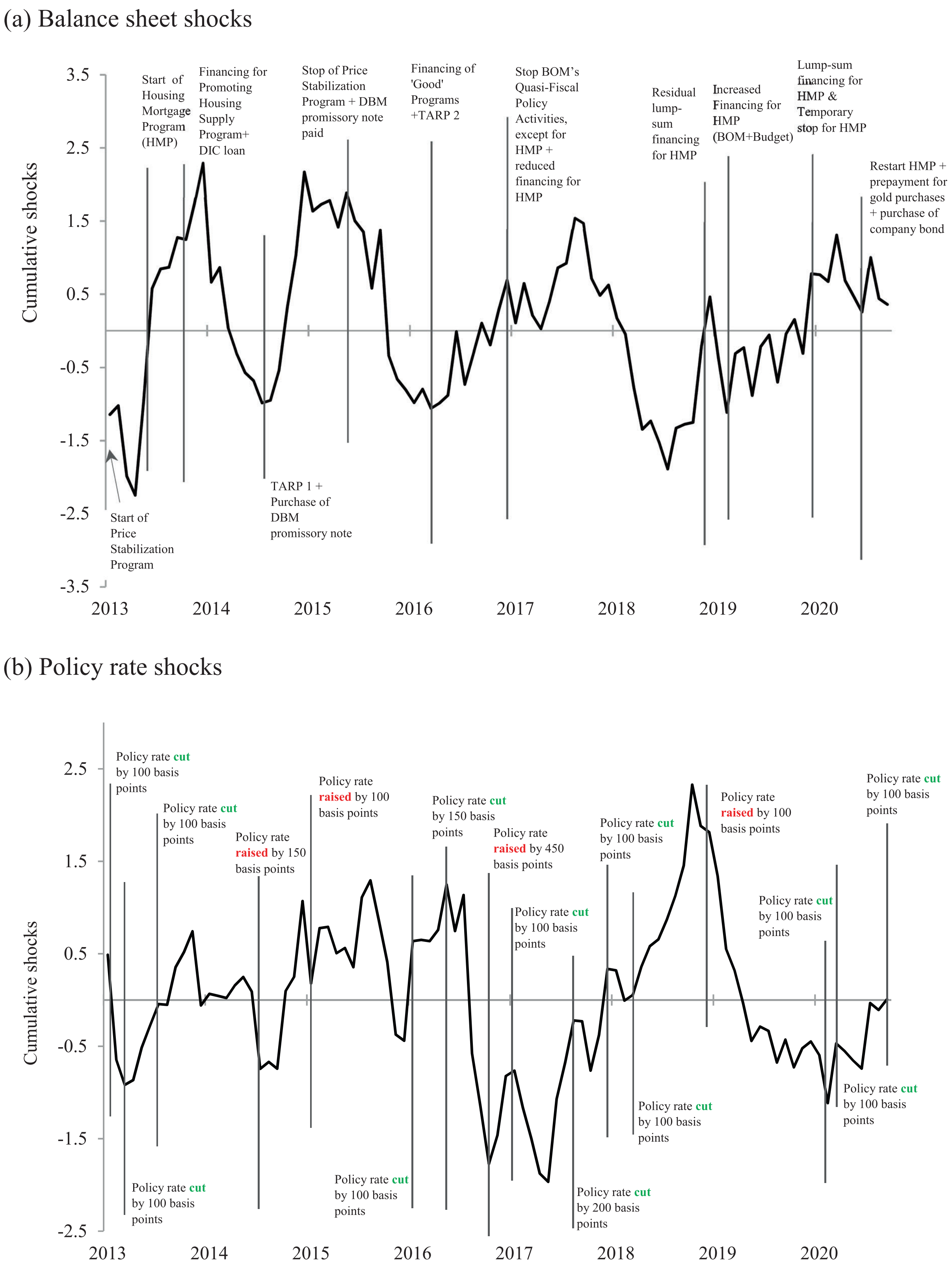

FIGURE 5 Time series of cumulative identified balance sheet and policy rate shocks. (a) Balance sheet shocks. (b) Policy rate shocks [Colour figure can be viewed at wileyonlinelibrary.com]

most decisions of UMP measures (i.e., amount of disbursement) have somewhat an unexpected component, this implies that our identification strategy is plausible.

For example, a series of expansionary balance sheet shocks captured the launch of the PSP at the end of 2012, the first series of HMP in June 2013, Promoting Housing

Supply Program and Deposit Insurance Corporation (DIC) loan in the second half of 2013, Troubled Asset Relief Program (TARP) 1 and purchase of Development Bank of Mongolia (DBM) bond in the second half of 2014, Good programs and TARP 2 in the first half of 2016, increased financing for the HMP in 2019, and relaunch of HMP, prepayment for gold purchases and purchases of Erdenes Mongol LLC bond in 2020. The series of contractionary balance sheet shocks also captures the discontinuation of PSP and payment of DBM bond in the mid-2015, discontinuing BOM's quasi-fiscal policy activities, except for HMP since the third quarter of 2016 temporary discontinuation of HMP for the first 5 months of 2020.

Figure 5b reveals that the identified interest rate shocks also capture key dates of CMP actions. As shown in the figure, the shocks drop following the policy rate cut while they raise (or are maintained at a higher level) after increasing the policy rate. Overall, we can conclude that the identified balance sheet and interest rate shocks make sense and capture the most important monetary policy measures of the BOM during the sample period. Figure 5a,b show that both UMP and CMP measures were expansionary at the beginning of the sample period, while these policies have been in opposite directions between the mid of 2014 and the mid-2016. For instance, UMP was expansionary, while CMP turned into a contractionary stance for most of the period. As a requirement of the IMF's EFF program, the BOM stopped the UMP measures except for the HMP, and the UMP has been in a relatively neutral stance (i.e., somewhat expansionary in 2017, somewhat contractionary in 2018) for the period 2017–2018. As the HMP continued, the balance shocks have been primarily dependent on disbursements from the BOM for the program since 2019, and the balance sheet policy has been on the expansionary side since the end of 2019. The CMP was expansionary between the mid of 2016 and the end of 2017, while it has been contractionary for 2018. The CMP has been on the looser side since the second quarter of 2019.

4.2.2 | Impulse response analysis

This section aims to answer two crucial questions: (i) what are the effects of CMP and UMP shocks on macroeconomic and financial variables? and (ii) Does a 1% change in GDP and CPI either through CMP (policy rate) or UMP (balance sheet) have different implications for other macroeconomic and financial variables?

To address the first issue, we examine the impulse responses of the identified structural shocks. Figure 6 reports impulse responses to a 1-*SD* policy rate innovation. The solid lines are the median impulse responses of posterior distributions, while the shaded areas represent the estimated responses' 68% posterior confidence interval. The shock is characterised by a decline in policy rate between −0.33 and −0.06 percentage points (with a median of −0.18 percentage points), diminishing after about 5 months. CPI is assumed to have no response on the impact period and to rise in the first months after the shock. The response of CPI shows a significant increase for about 13 months. It takes about a year before the policy rate shock has its peak effect of 0.2% increase on CPI. It gradually returns to the value it would have taken without the monetary policy shock. The estimated transmission lags of CMP and effects on CPI are entirely in line with the findings obtained by Havranek and Rusnak (2013) that show transmission lags tend to be 10–12 months for post-transition economies and maximum effects on prices reach 0.9% on average after a 1 percentage point change in the policy rate.

The median response of real GDP displays an increase after a decline in the policy rate. However, the response of output is statistically insignificant. The result is in line with the findings highlighted by Nguyen (2020), and he emphasises that the majority of the findings focused on output effects of CMP in emerging and developing countries are statistically insignificant. According to his results, over 72% of the reported effects are statistically insignificant, and CMP is less effective in an economy with high inflation volatility and an underdeveloped financial system, which is the case for Mongolia. Moreover, as advocated by Brandao-Marques et al. (2020), the Mongolian economy's insignificant output effects can be due to weaknesses in adopting inflation targeting, an independent central bank, and a transparent monetary policy.

Though weakly imposed by the sign restriction on the impact and the first 2 months after the shock, the policy rate shock leads to a significant increase of newly issued loans that lasts for 5 months. Consistent with the rise in the volume of newly issued loans, M2 is also raised with peak effect after 5 months of ∼0.6%. The insignificant appreciation response of nominal exchange rate in response to a CMP loosening is also found by Burriel and Galesi (2018) and is consistent with the result obtained by Hnatkovska et al. (2016) for developing countries. Their model formalised three effects of lowering interest rates—a lower fiscal burden, a positive output effect, and a negative effect on liquidity demand. The first two effects tend to appreciate the domestic currency, while the last tends to depreciate it. They empirically show that the first two effects dominate the last for developing economies where money-to-GDP ratio is relatively lower. The positive but insignificant response of foreign

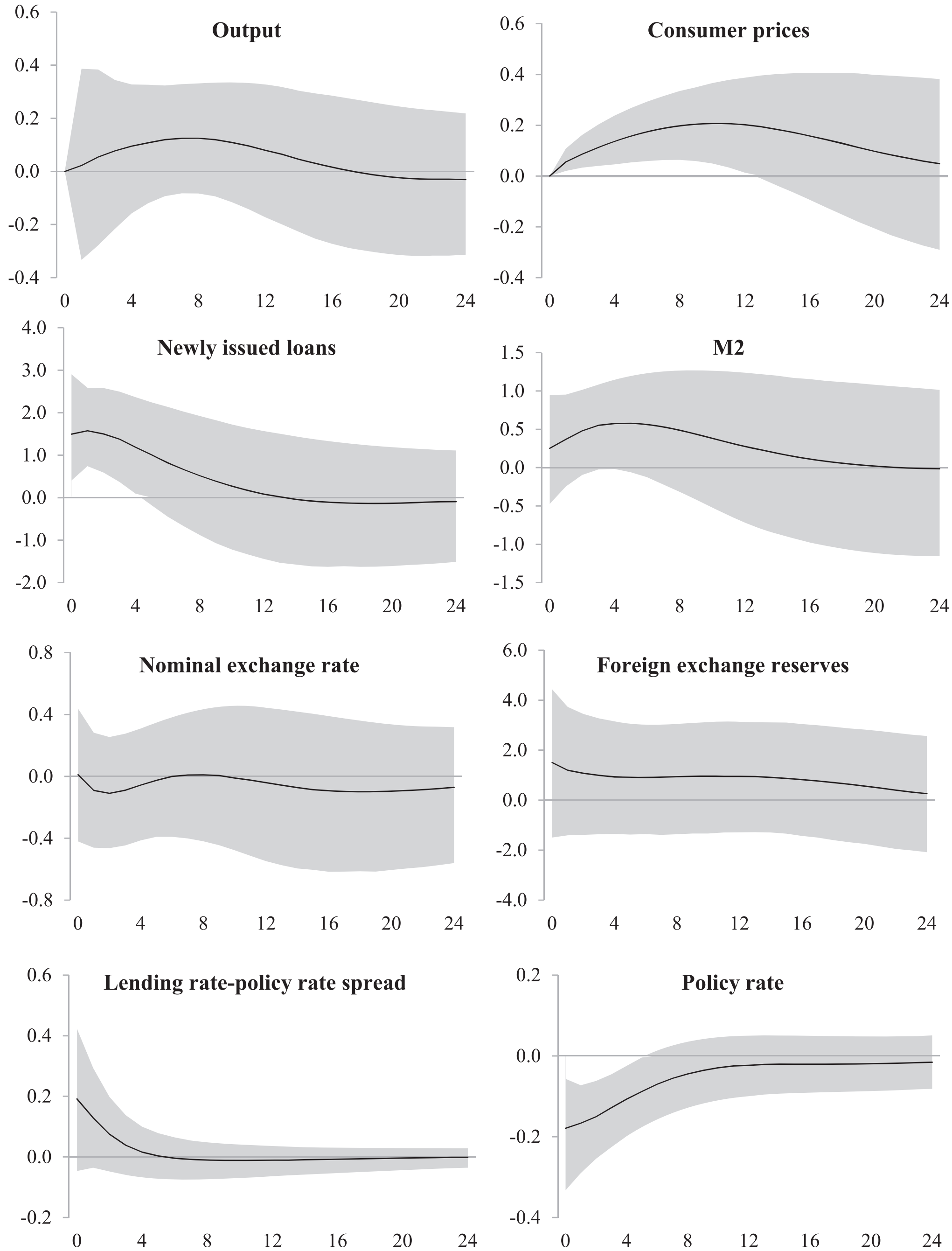

FIGURE 6 Impulse responses to a policy rate shock. Figures show median responses, together with 16th and 84th percentiles of the posterior distributions. Horizon is monthly

exchange reserves is also in line with the empirical finding shown by Wu and Lee (2018) that the decrease in domestic interest rates can strengthen the positive effects of public debt, trade openness, and economic growth on international reserves. Moreover, the spread between the lending rate and policy rate intends to increase mainly due to the drop in the policy rate. The analysis reveals that the bank lending channel of the monetary transmission mechanism is operative for the CMP.

Figure 7 shows impulse responses to a 1-*SD* balance sheet innovation. The shock is characterised by an increase in the BOM domestic assets (excluding other assets) between 1% and 5% (with a median of 3%), which fades out after about 5 months. An expansionary balance sheet shock leads to a significant decline in the spread between the lending rate and policy rate that lasts 6 months. The result supports the existence of the portfolio rebalancing channel of UMP in Mongolia as the BOM

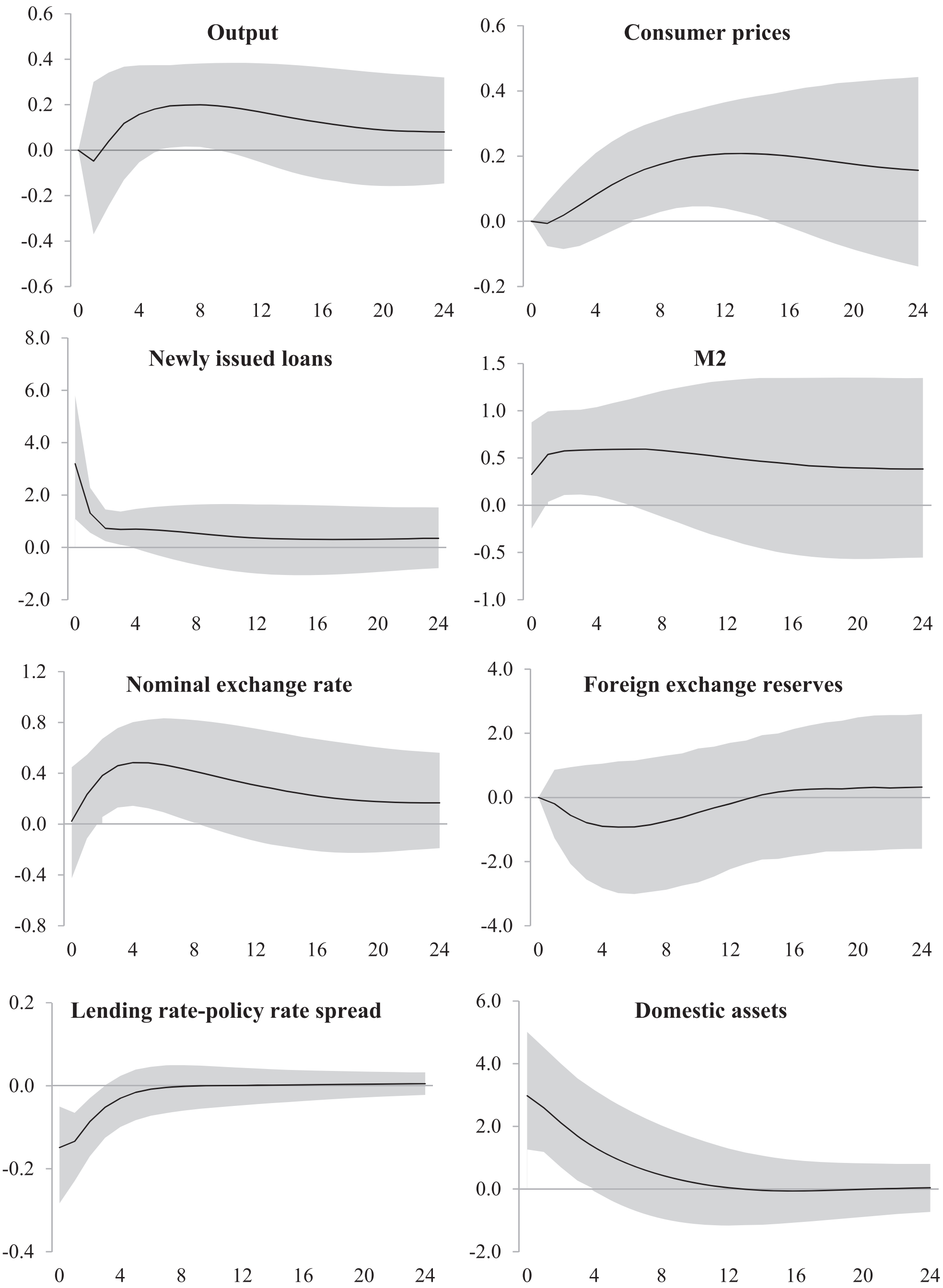

FIGURE 7 Impulse responses to a balance sheet shock. Figures show median responses, together with 16th and 84th percentiles of the posterior distributions. Horizon is monthly

purchase of private sector assets (e.g., mortgage-backed securities and corporate bonds) directly reduced market risk premiums. However, the signalling channel is not operative in Mongolia since the BOM does not give forward guidance and has not kept the policy rate low for a prolonged period.

The newly issued loan is assumed to increase on impact and the first 2 months but significantly increases for 5 months. There is a significant rise in M2 after an expansionary innovation to the BOM's balance sheet. The statistically significant increases in M2 and newly issued loans are empirical evidence for both liquidity and bank lending channels of UMPs in Mongolia. The evidence that these channels are vital in a bank-centric financial system aligns with findings obtained by Churm et al. (2018) and Darracq-Paries and De Santis (2015).

The dynamics of real GDP and CPI indicate that the BOM's UMPs were somehow effective in supporting the macroeconomy. Both variables show a significant increase after expanding the BOM balance sheet. The delayed significant positive responses of real GDP and CPI to a positive central bank balance sheet shock is entirely consistent with the existing literature (i.e., Schenkelberg & Watzka, 2013 for Japan, Gambacorta et al., 2014 for panel group of Canada, the euro area, Japan, Norway, Switzerland, Sweden, the United Kingdom and the United States, Boeckx et al., 2017 and Burriel & Galesi, 2018 for the euro area, Weale & Wieladek, 2016 for the United States and the United Kingdom). Real GDP rises with a peak effect after about 8 months of 0.2% and gradually returns to its value without the shock. CPI increases with a peak effect after about 13 months of 0.2%. The long lagged peak effects of UMPs on CPI are commonly observed in the literature (i.e., Schenkelber & Watzka, 2013; Weale & Wieladek, 2016). Except for the initial negative insignificant response of output, the response pattern of real GDP turns out to be qualitatively very similar to the response of policy rate shock. The impact on CPI is somewhat different. For example, the significant effect of the balance sheet shock on the price level is observed after some periods; however, its effect is more persistent than those of the policy rate shock.

The nominal exchange rate and foreign exchange reserves' responses also raise questions about whether central banks can continuously conduct the UMP in developing countries whose currencies are not reserve currencies. For instance, the nominal exchange rate significantly depreciates between 2 and 9 months after the shock, and its peak effect of 0.5% deprecation is occurred after about 6 months. Inoue and Rossi (2019) also find that a UMP easing leads to a depreciation of the country's nominal exchange rate in line with Dornbusch's overshooting hypothesis for the United Kingdom, the euro area, Canada, and Japan. However, our result supports the finding obtained by Kenourgios et al. (2015) that the delayed depreciation response of the nominal exchange rate is observed after a UMP shock. In the case of Mongolia, a potential explanation for the delayed response of the nominal exchange rate is that the BOM's foreign exchange intervention (or tightening of CMP) mitigates the UMP shocks' initial effects on the exchange rate. The shocks' effects are more prolonged than that of the intervention; thus, the maximum effect is delayed. The depreciation is expected to have strong expansionary effects on output for advanced economies, while the effect is very limited for the case of Mongolia since mining exports are less sensitive to the exchange rate movements. Instead, the depreciation leads to higher inflation in Mongolia since imported goods account for higher shares (40%) in the current CPI basket (Gan-Ochir & Davaajargal, 2019).

As explained by Gagnon et al. (2017), when the exchange rate is fixed using intervention (i.e., net official flows), UMP (i.e., quantitative easing) has a negative effect on the current account. Under a flexible exchange rate, there are two offsetting channels: (i) UMP lowers long-term interest rates, which depreciates the exchange rate and boosts exports, and (ii) lower long-term interest rates increase domestic demand, which boosts imports. Only the second channel operates when the exchange rate is fixed via intervention, implying a negative effect on the current account.[16] Therefore, the overall effects of UMPs on foreign exchange reserves depend on net capital inflows, and UMPs may lead to a decrease in the reserves under lower (or negative) net capital inflows. In Figure 7, the UMP shock has negative effect in foreign exchange reserves for the first 5 months after the shock. The result implies that the BOM had actively intervened in the foreign exchange market to mute depreciation driven by a high current account deficit for 2012–2016 when the BOM aggressively implemented the UMP measures. However, no statistically significant effects on the foreign exchange reserves may reflect that both the government and BOM heavily borrowed from abroad, increasing the external debt to a record high level to finance the intervention in the foreign exchange market.

Figure 8 displays impulse responses to a 1-*SD* demand shock. The shock is characterised by an increase in the real GDP between 0.4% and 2.1% (with a median of 1.3%), which fades out after about 5 months. While imposed by the sign restriction on impact and the first 2 months after the shock, the positive demand shock leads to a significant increase in the CPI for the first 9 months. The peak effect, a 0.15% increase in the CPI, occurred after about 5 months. The sign restriction is imposed for the first 2 months; however, newly issued loans increase for the 4 months. Consistent with the rise in the loans, there is a significant increase of M2 between impact and 4 months after a positive demand shock.

The positive feedback between the financial and real sectors shown in Figures 7 and 8 suggests that the financial accelerator is operative in the economy. As stressed by Bernanke et al. (1999) and Iacoviello (2005), the presence of the financial accelerator tends to amplify the economic effects of any shock that has a pro-cyclical impact on economic activity. Since balance sheet, interest rate, and demand shocks move output and price level in the same direction, the accelerator channel works to propagate and amplify the shocks' effects on the macroeconomy. For instance, a positive demand shock increases newly issued loans and M2, which in turn raises both output and consumer prices. The negative response of

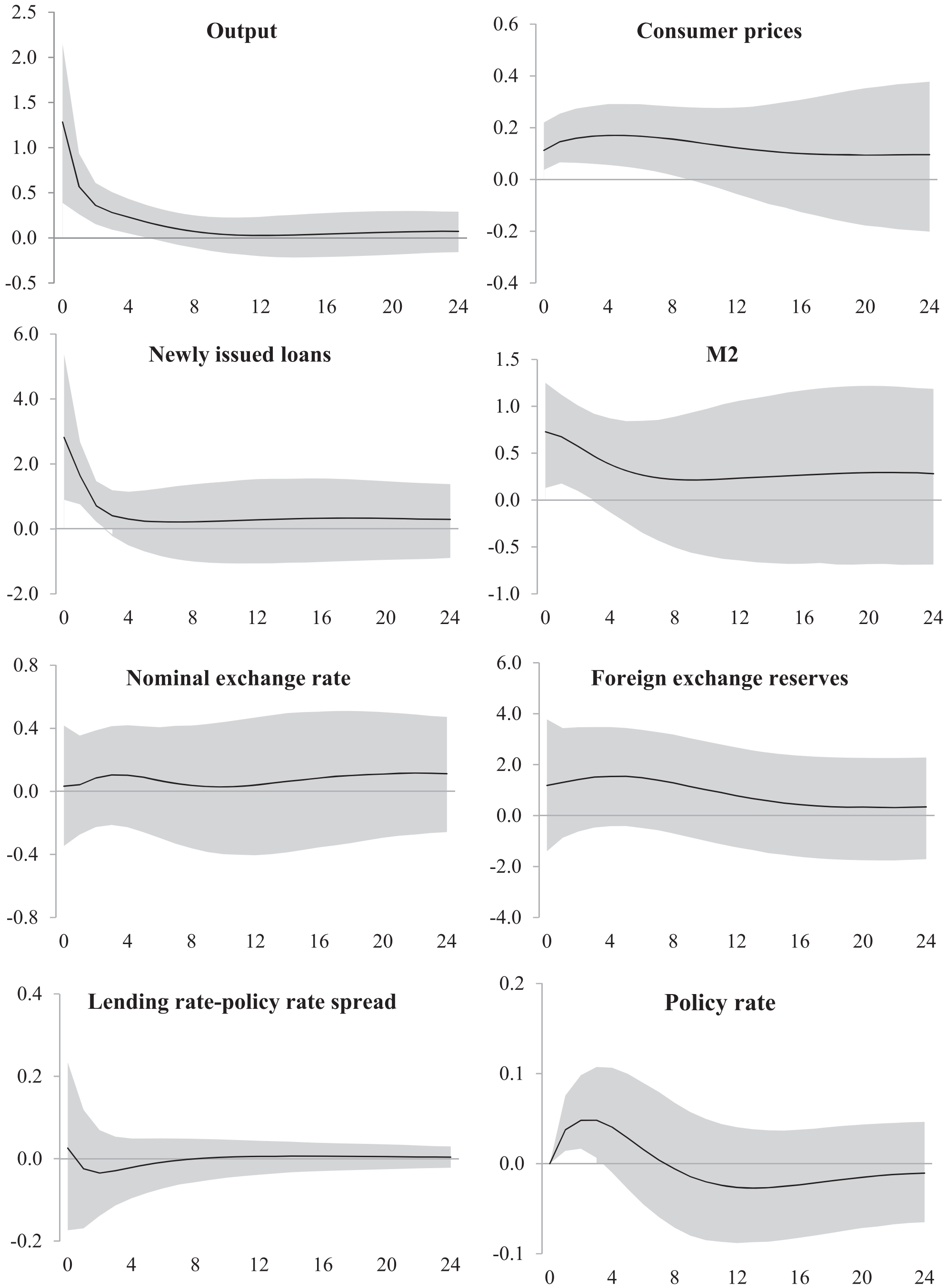

FIGURE 8 Impulse responses to a positive demand shock. Figures show median responses, together with 16th and 84th percentiles of the posterior distributions. Horizon is monthly

the spread between lending and policy rate to positive demand shock, starting from the second month, supports the presence of a financial accelerator mechanism. There are no significant effects of demand shocks on the nominal exchange rate and foreign exchange reserves. The result can be explained by the facts that (i) the BOM has heavily intervened in the foreign exchange market for the most period of the sample, and (ii) foreign shocks such as commodity prices, China's GDP, and FDI play an essential role in the Mongolian business cycle fluctuations (Gan-Ochir & Davaajargal, 2019, 2022). For instance, the positive demand shocks increase FX inflows into the economy, thereby accumulating foreign reserves, while FX intervention aiming to stabilise exchange rate fluctuations driven by import growth slows the reserve accumulation. As a result, we observe a tightening of monetary policy for 4 months, reflecting the CMP reaction function (i.e., stabilising output and inflation fluctuations).

Figure 9 shows impulse responses to a 1-*SD* supply shock. The shock is characterised by an increase in the CPI between 0.05% and 0.3% (with a median of 0.2%), which fades out after 4 months. The real GDP drops by 0.6% on impact, and its significant negative response occurs for the first 4 months. As consumer price increases and output drops, the policy rate increases over time. There is also evidence that the financial friction amplifies the effects of supply shocks such as the COVID-19 shock (i.e., a significant drop in labour supply) on the macroeconomy. For instance, the negative supply shock reduces the output, and the drop in output can weaken borrowers' balance sheets, impeding their ability to obtain financing.

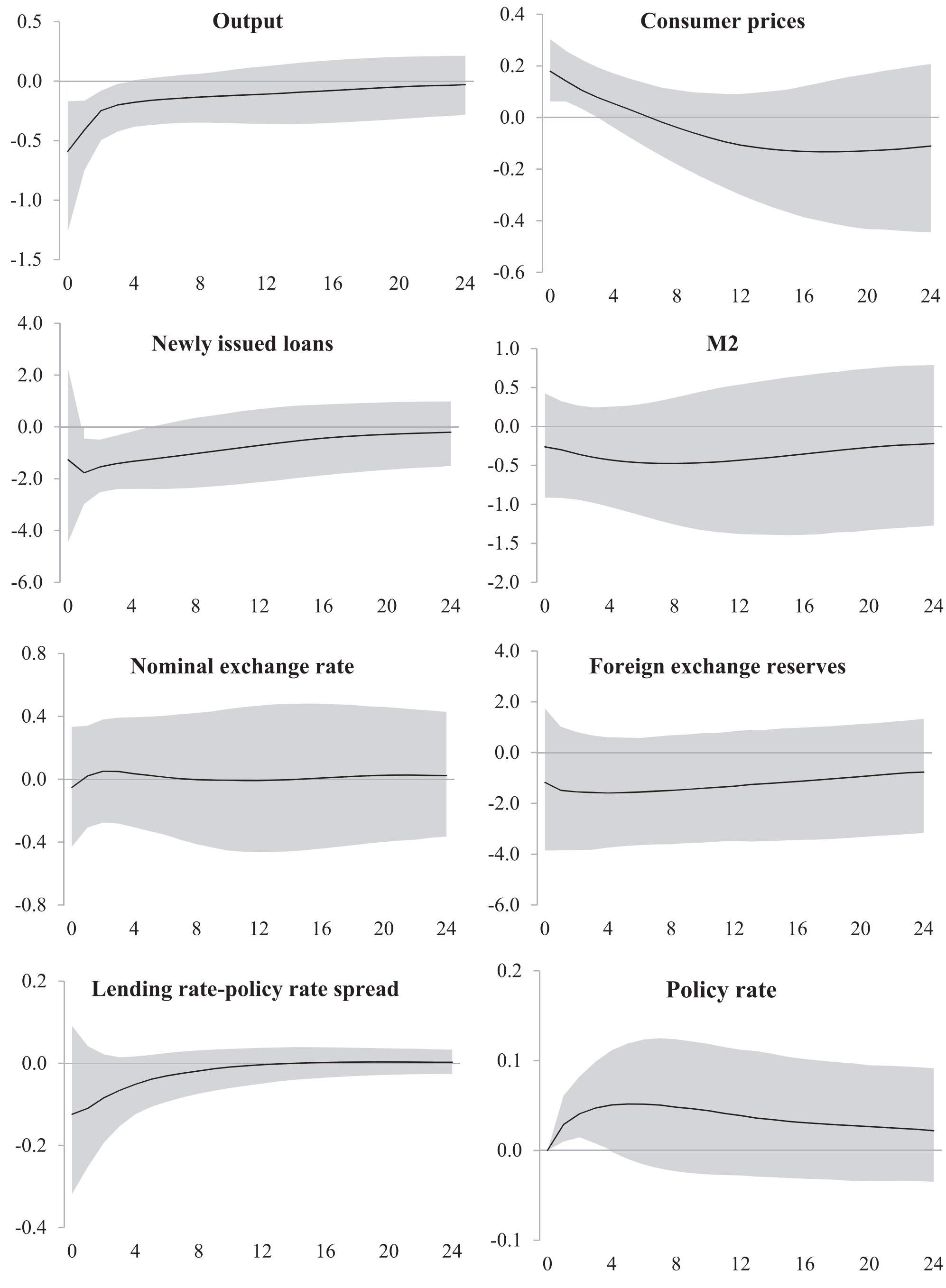

FIGURE 9 Impulse responses to a negative supply shock. Figures show median responses, together with 16th and 84th percentiles of the posterior distributions. Horizon is monthly

TABLE 2 Quantitative impacts of CMP and UMP shocks

	Balance sheet shock		Policy rate shock		Balance sheet shock		Policy rate shock	
GDP_M	+1	p	+1	p	1.43	p	0.66	p
CPI	0.70	p	1.53	p	+1	p	+1	p
PR	0.01	pp	−1.36	pp	0.03	pp	−0.89	pp
DA	13.08	p	3.67	p	18.72	p	2.41	p
L	8.69	p	13.98	p	12.44	p	9.16	p
*M*2	4.78	p	6.05	p	6.84	p	3.96	p
ER	3.26	p	−0.48	p	4.66	p	−0.31	p
FXR	−5.64	p	12.92	p	−8.08	p	8.46	p
SP	−0.46	pp	0.59	pp	−0.66	pp	0.39	pp

Note: p and pp stand for percent and percentage points, respectively. The numbers shown refer to the variables' median responses at the initial stages of the shock (impact and the first 8 months).
Abbreviations: CMP, conventional monetary policy; UMP, unconventional monetary policy.

In this case, such supply shock can adversely affect the demand through the financial sector. In line with this view, the combination of the fall in real GDP and the rise in policy rate leads to a significant decrease in newly issued loans between two to 5 months after the shock. As seen in Figure 7, the loan decline can adversely affect the output; hence, the output response remains negative for more extended periods. Moreover, as the drop in output persists, lenders are also expected to impose stricter lending standards resulting in tighter financial conditions. The tighter condition leads to a persistent negative response of the loan. In line with the loan and output responses, nominal M2 decreases, but the response is insignificant. Under the intervention in the FX market, there is no significant response of the nominal exchange rate, and an oil price increase shock (i.e., a negative supply shock) tends to reduce foreign exchange reserves as Mongolia imports 100% of its demand for petroleum. However, the response of reserves is insignificant. For example, the insignificant response can be explained by the fact that Mongolia also exports unrefined oil, which neutralises the effects on reserves when oil prices increase.

To compare the quantitative impacts of CMP and UMP, we assess how much change is required in the policy rate and balance sheet indicator to increase real GDP and CPI by 1% and their implications for other macroeconomic and financial variables. Table 2 reports how a 1% increase in the real GDP and CPI (to abolish the effects of adverse demand and supply shocks) can be achieved either through a tightening of the policy rate or balance sheet indicator and the impact of the required loosening on other variables.

All reported values are averages over the impact and the first 8 months. The 1% rise in the real GDP can be achieved through a 13.1% increase in the BOM's domestic asset excluding other assets or a 1.4% cut in the policy rate. The results imply that a one percentage point cut in the policy rate is equivalent to a 9.6% increase in the BOM balance sheet indicator regarding the real GDP's impact. Changes in the two instruments have different effects on other macroeconomic and financial variables. The impact of policy rate change (i.e., 1.36% cut) on CPI (1.53% rise), newly issued loans (about 14% increase), and M2 (6% increase) is stronger compared to the change in the balance sheet indicator. Nominal exchange rate, foreign exchange reserves, and the spread between lending rate and policy rate move in opposite directions. Notably, an expansion in the BOM balance sheet leads to a 3.3% depreciation of the nominal exchange rate and a 5.6% drop in foreign exchange reserves. The amount of UMP measure decreases the spread (i.e., lending rate) by 0.5 percentage points, while the loosening of CMP increases the spread. The exercise also suggests that a 9%–14% increase of newly issued loans (or 5%–6% rise in M2) is required to achieve each 1% increase in real GDP.

We are also interested in how a 1% increase/decrease in CPI can be achieved either through policy rate or balance sheet indicator and their effects on other variables. The 1% increase/decrease in the CPI can be achieved through an 18.7% increase/decrease in the BOM's domestic asset excluding other assets or a 0.9% cut/increase in the policy rate. The amount of an expansion in the BOM balance sheet leads to a 4.7% depreciation of the nominal exchange rate and an 8.1% drop in foreign exchange reserves. The impact of policy rate change (0.9% cut) on real GDP (0.66% rise), newly issued loans (about 9% increase), and M2 (4% increase) is weaker compared to the UMP measure.

Comparing the quantitative effects of the alternative policy instruments suggests that the UMP is more effective than the CMP in promoting real GDP growth; however, the CMP is more effective in controlling inflation. For instance, the UMP can achieve a 1% increase in real GDP with less pressure on consumer prices than the CMP instrument. Moreover, the exercise also suggests that if exchange rate and foreign exchange reserves are concerns of a central bank in developing economies like Mongolia, then the CMP can be a better choice in loosening the monetary policy stance. However, credit growth and real GDP growth are the focus of a central bank (i.e., an economy is hit by shocks such as COVID-19 shock), then the UMP can be considered for a certain period.

4.2.3 | Variance decomposition

In the previous section, we have found that the BOM can stimulate economic activity and raise inflation by lowering policy rates and expanding its balance sheet. This section examines the forecast error variance decomposition (FEVD) to investigate the role of identified shocks in driving fluctuations of domestic variables. The FEVD analysis can assess the contribution of each shock 'relative' to other shocks. Table 3 reports the FEVD of domestic variables evaluated at the posterior median. As commonly found in the literature (i.e., Benati, 2014; Kremer, 2016), unanticipated interest rate and balance sheet shocks account for a small portion of real GDP and CPI variance. Note that FEVD indicates the importance of unanticipated policy shocks, but do not allow any statements about the importance of systematic policies. Unanticipated balance sheet shocks account for about 5% and 6% of the 24-month ahead prediction error in real GDP and CPI, respectively.

Unanticipated interest rate shocks contribute 7% to the 24-month prediction error in the CPI. According to the FEVD, the balance sheet shocks play an essential role in fluctuations of the newly issued loans (10% in 24-month), M2 (21% in 24-month), the nominal exchange rate (32% in 24-month), and the spread between the lending rate and policy rate (22% in 1-month). As Faust and Rogers (2003) found, the interest rate shocks account for 30% of the variance of 1-month exchange rate movements. These results suggest that both CMP and UMP shocks effectively affect movements of financial variables such as the spread and exchange rates. The difference is that CMP is useful for exchange rate and foreign exchange reserve movements in the short horizon; hence the UMP is important for variances of M2 and exchange rate in the medium term.

Domestic demand shocks explain negligible frictions of real GDP variance as we explicitly include important external variables (such as copper price, FDI, and China GDP growth) into the benchmark specification. This result is entirely in line with findings from Gan-Ochir and Davaajargal (2019), showing that domestic variables explain small fractions of real GDP fluctuations when external variables are explicitly included in the VAR system. Supply shocks explain about 10% of real GDP movements. However, both demand and supply shocks explain significant frictions of CPI fluctuations, not only in the short term but also in the medium term. The results imply that supply factors are also the primary sources of consumer price movements in the economy. As demand shocks play a significant role in the M2 movement, the demand shocks pass to consumer prices through the financial sector.

Another novel finding is that supply shocks significantly contribute to fluctuations in the newly issued loan (about 30% in 24-month), M2 (about 30% in 24-month), and foreign exchange reserves (over 20% in 24-month). The finding supports the view that supply shocks such as the COVID-19 shock (i.e., a significant drop in labour supply) can lead to credit supply disruptions and financial friction amplifies their macroeconomy effects.

5 | ROBUSTNESS CHECKS

We conduct several robustness exercises to determine whether our results are overestimated due to omitted/redundant variable bias or misspecification.

5.1 | Variations to the benchmark model

We consider three variations to the benchmark VAR to assess our results' robustness to alternative modelling choices. Precisely, we assess the robustness of our results to using (i) the BOM total asset as the UMP instrument instead of domestic assets excluding other assets, (ii) industrial production instead of real GDP as the measure of aggregate output, and (iii) total imports instead of foreign exchange reserves. In Figures 10–16, impulse response functions of selected variables for benchmark and alternative models are compared to evaluate the robustness of the results. Dashed lines and grey areas represent confidence intervals of alternative and benchmark models, respectively. When the confidence intervals overlap in a qualitative manner, we can say that our results on the effects and transmission of monetary policy shocks are robust. As emphasised in Section 3, the BOM total assets

TABLE 3 Forecast error variance decomposition for the benchmark VAR

		Contribution of shocks (%)			
Variable	**Horizon**	**Balance sheet shock**	**Interest rate shock**	**Demand shock**	**Supply shock**
GDP_M	1	0.0	0.0	0.0	3.2
	6	0.3	0.9	0.7	7.8
	12	0.8	1.2	1.3	9.1
	24	4.8	1.5	1.4	10.6
CPI	1	0.0	0.0	37.6	31.9
	6	0.9	4.4	28.0	17.0
	12	0.4	7.2	23.3	11.5
	24	5.6	7.0	16.6	21.1
PR	1	0.0	6.3	0.0	0.0
	6	3.2	2.6	0.1	1.6
	12	4.1	2.0	0.8	4.7
	24	4.0	2.0	1.6	6.4
DA	1	6.8	0.0	0.0	0.0
	6	3.0	0.4	0.1	0.2
	12	2.5	0.3	0.1	3.2
	24	3.0	0.3	0.2	5.8
L	1	0.1	0.8	4.7	1.3
	6	1.6	1.5	3.1	23.8
	12	1.9	1.4	2.6	32.4
	24	9.6	1.4	2.1	29.5
$M2$	1	0.8	0.1	19.5	11.5
	6	1.6	2.1	20.0	25.4
	12	7.2	3.3	14.4	31.8
	24	20.6	3.7	8.9	29.9
ER	1	3.6	29.6	4.2	0.9
	6	25.0	10.5	0.9	0.9
	12	30.8	6.2	0.5	1.9
	24	32.0	4.3	0.4	3.6
FXR	1	0.0	11.5	0.0	1.2
	6	0.6	5.4	0.8	23.3
	12	0.7	3.9	1.3	22.1
	24	2.8	3.7	1.7	20.8
SP	1	21.5	10.5	2.1	0.6
	6	14.7	16.9	1.6	5.2
	12	13.7	15.8	1.8	7.3
	24	12.9	17.6	1.7	7.7

Note: Numbers in the table indicate median contributions of the posterior distributions. Horizon is monthly.
Abbreviation: VAR, vector autoregression.

reflect not only UMP measures but also other unconventional measures, including gold purchases and foreign exchange intervention. Moreover, other studies focused on advanced economies (i.e., the United States Euro area, and Japan) choose central bank total assets as the UMP instruments. Hence, we use the BOM total assets instead of the domestic assets excluding other assets to assess the robustness.

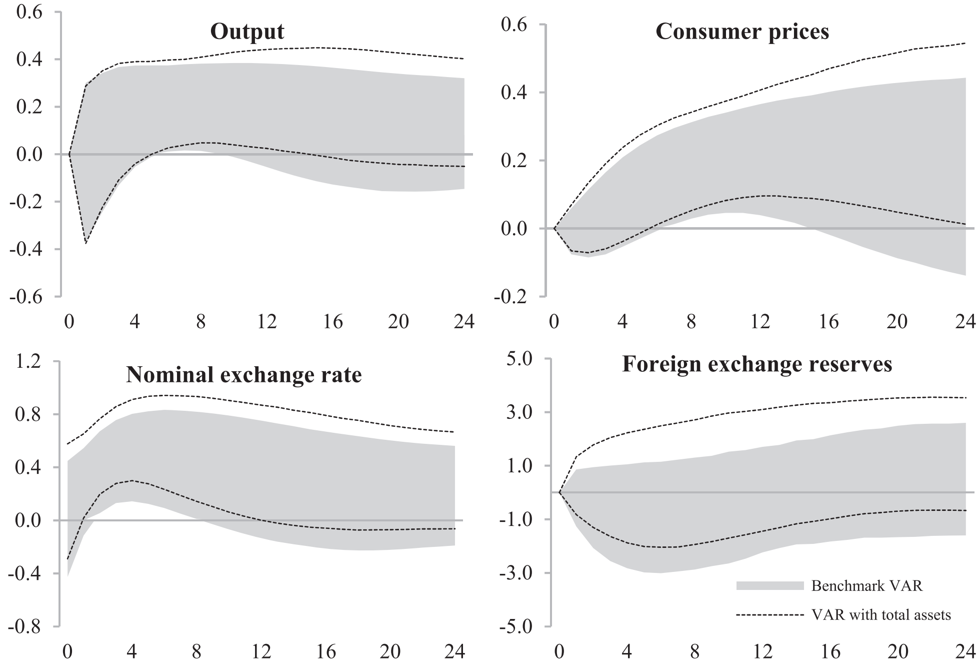

FIGURE 10 Impulse responses to a balance sheet shock: vector autoregression (VAR) with the Bank of Mongolia (BOM) total assets

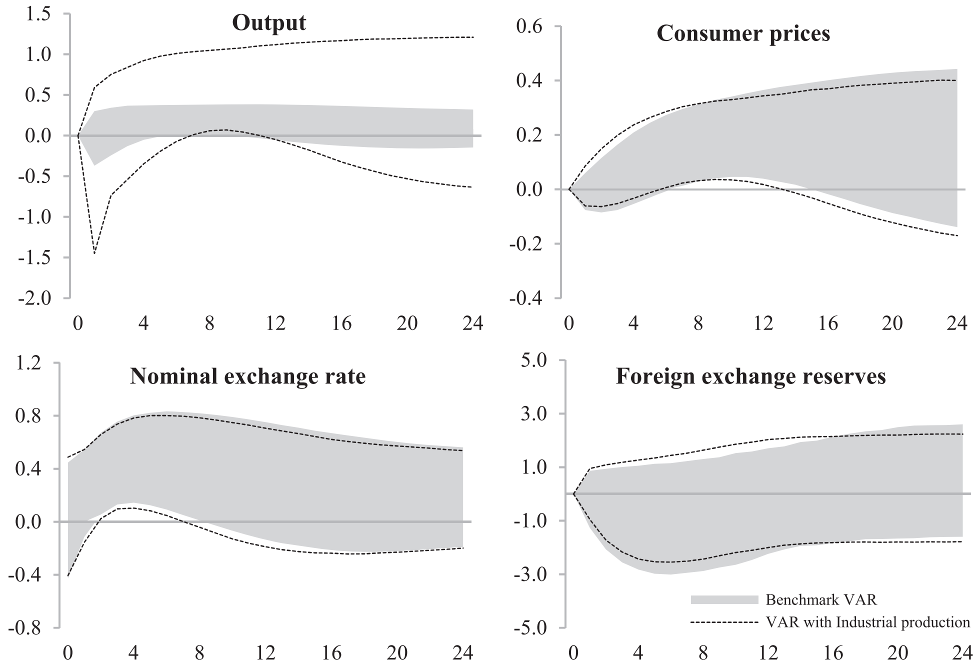

FIGURE 11 Impulse responses to a balance sheet shock: vector autoregression (VAR) with industrial production. Figures show 16th and 84th percentiles of the posterior distributions. Horizon is monthly

Figure 10 shows that our findings, except for foreign exchange reserves responses, are qualitatively robust regarding the type of balance sheet indicator used. The effects on real GDP, CPI, and nominal exchange rate are somewhat more persistent and quantitatively somewhat larger. However, foreign exchange reserves' response to the total asset shock is mostly positive (i.e., a median response is identified as positive), opposite to the domestic assets. This finding is consistent because the BOM's gold purchasing and FX intervention (i.e., purchasing USD) increase foreign exchange reserves and the BOM's total assets.

Moreover, this result implies that our identification strategy successfully identifies UMP shocks as it deals with an identification issue raised by Elbourne and Ji (2019).[17] For instance, different observed variables for

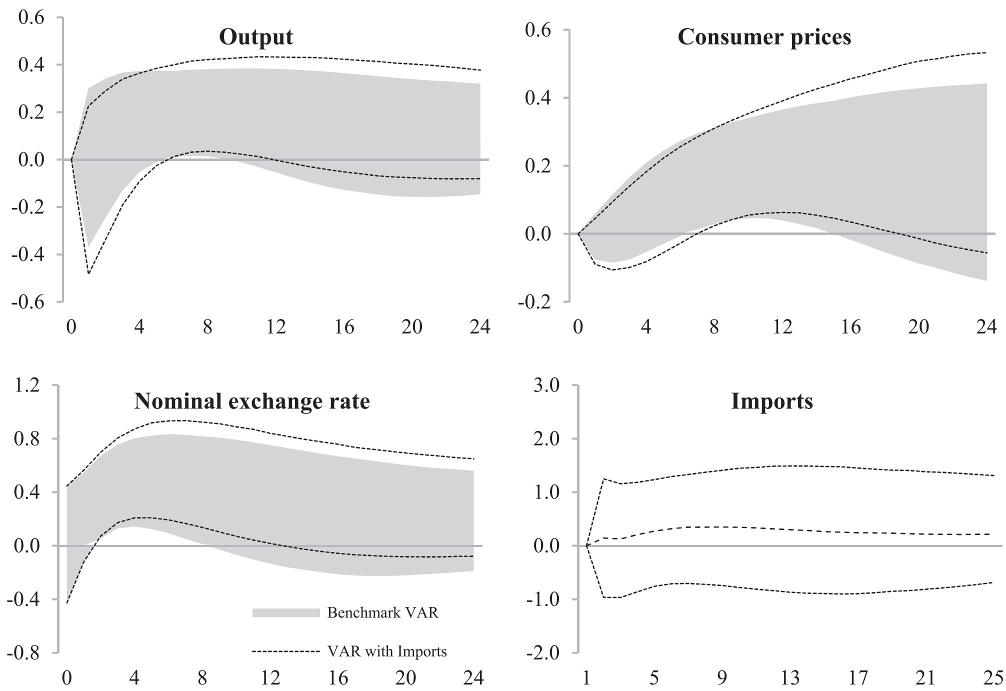

FIGURE 12 Impulse responses to a balance sheet shock: vector autoregression (VAR) with imports. Figures show 16th and 84th percentiles of the posterior distributions. Horizon is monthly

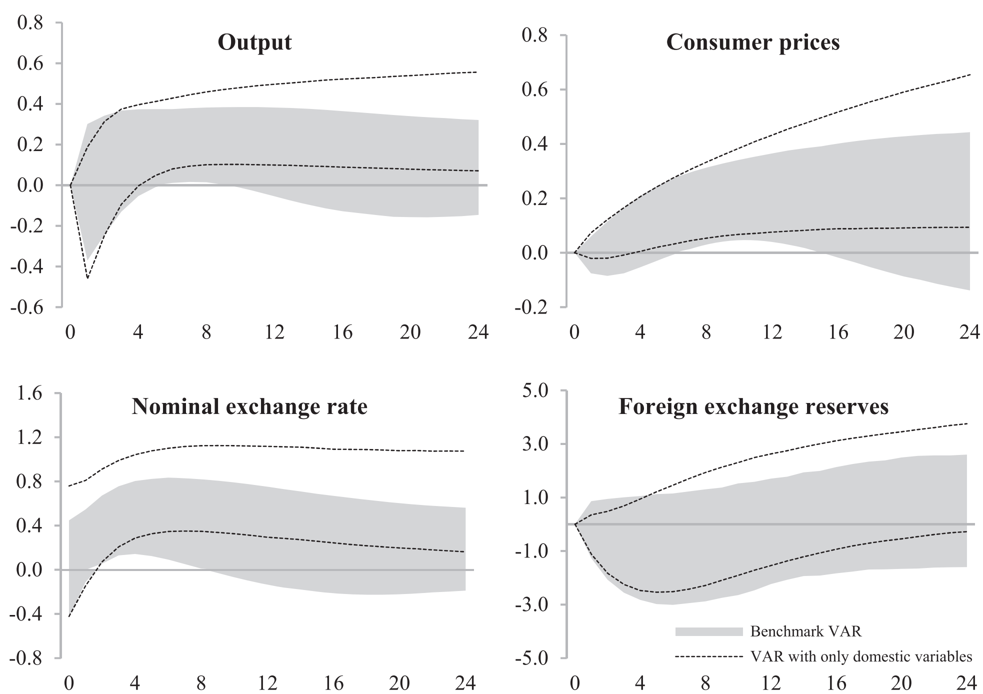

FIGURE 13 Impulse responses to a balance sheet shock: vector autoregression (VAR) with only domestic variables

the UMP measures produce statistically distinguishable impulse responses.

When industrial production is used as a measure of output, the results shown in Figure 11 are virtually unaffected. The only difference is that the output reaction is somewhat more extensive, and the confidence interval is somewhat broader. This finding is in line with the existing literature on the transmission of interest rate shocks (i.e., Gambacorta

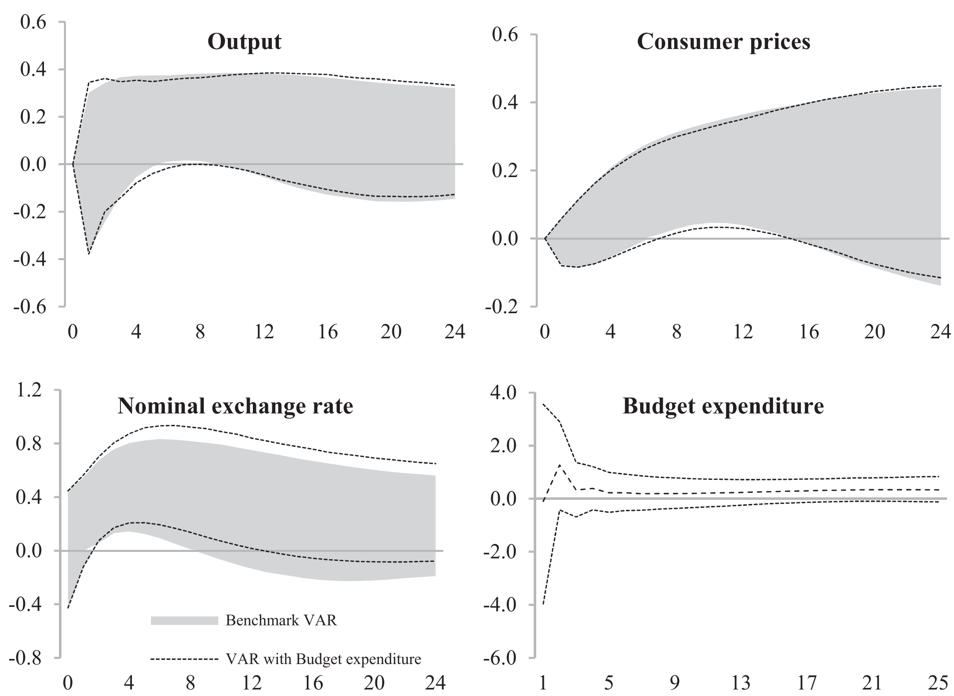

FIGURE 14 Impulse responses to a balance sheet shock: vector autoregression (VAR) with budget expenditure. Figures show 16th and 84th percentiles of the posterior distributions. Horizon is monthly

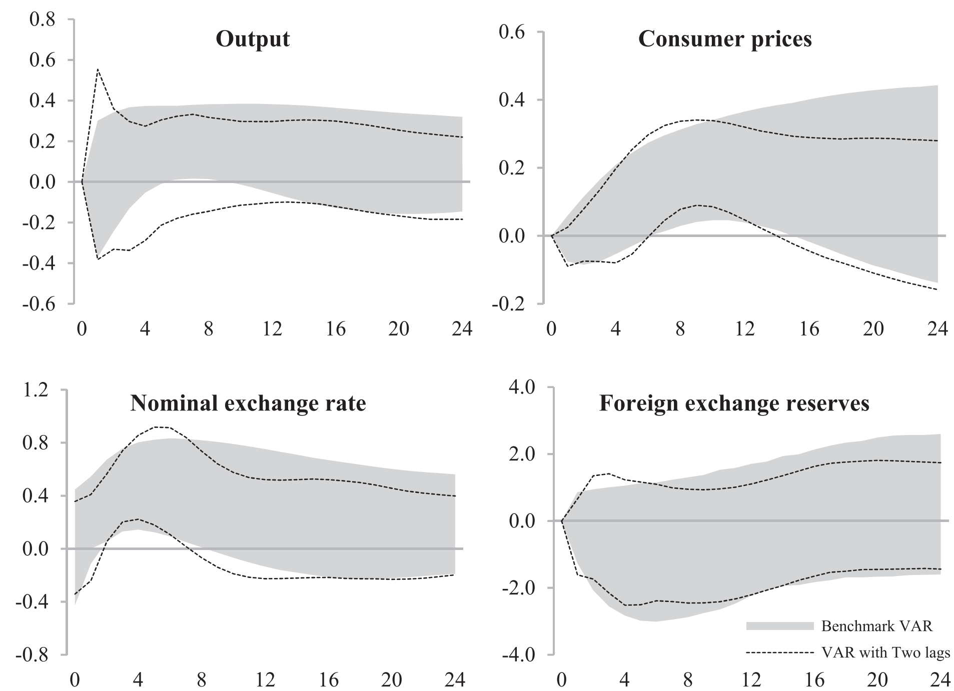

FIGURE 15 Impulse responses to a balance sheet shock: vector autoregression (VAR) with two lags ($p = 2$)

et al., 2014), highlighting a higher industrial production response to monetary policy shocks.

Finally, we replace the foreign exchange reserve variable with imports. The purpose is to capture the fact that the BOM's UMPs implemented for 2012–2016 increased imports, thereby reducing the foreign exchange reserves. The responses, shown in Figure 12, are similar to the benchmark results. The minor difference is that the reactions of output, consumer prices, and nominal exchange rate are more persistent and significant for extended periods. As expected, total imports mainly increase (with a positive median response) in response to the UMP shock; however, zero is included in the confidence interval.

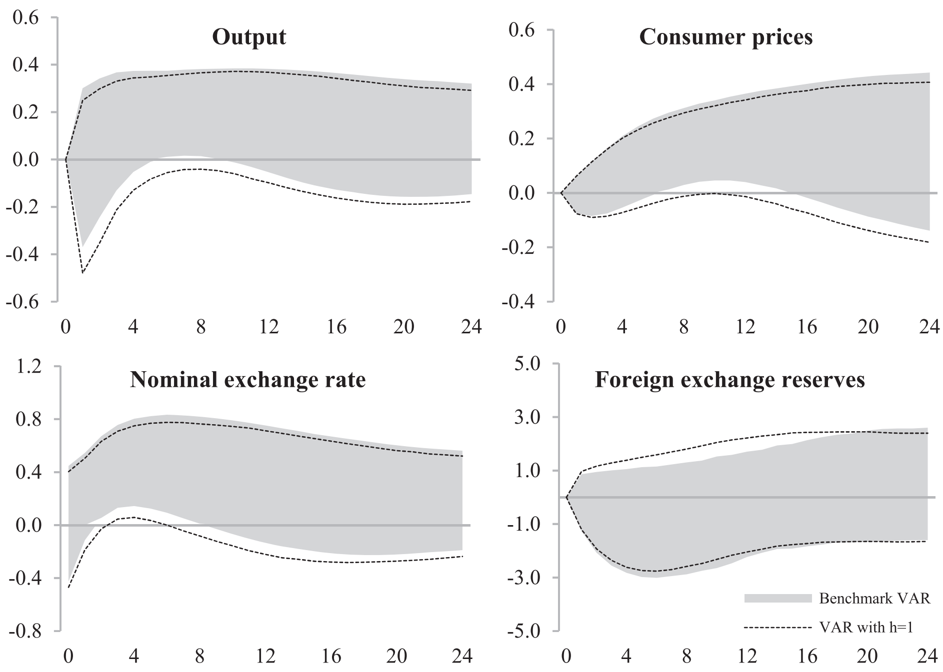

FIGURE 16 Impulse responses to a balance sheet shock: Periods of sign restrictions ($h = 1$). Figures show 16th and 84th percentiles of the posterior distributions. Horizon is monthly

5.2 | Model extension/contraction

We also assess the benchmark results' robustness to the inclusion and exclusion of some variables that might bear the analysis. Particularly, we consider two changes of the benchmark model: (i) excluding external sector variables such as copper price, FDI, and China GDP growth and (ii) adding the government expenditure, which often plays a complementary role to expansionary monetary policy.

As our model is for a small open and commodity-exporting economy, we include the relevant external sector variables. However, some existing papers (i.e., Schenkelberg & Watzka, 2013 for Japan, Weale & Wieladek, 2016 for the United Kingdom, Boeckx et al., 2017 for European Union member countries) for an open economy only include domestic variables (containing exchange rates) in the VAR model. Therefore, we estimate the model with only domestic variables to assess the robustness of our results. Figure 13 shows the responses to the balance sheet shock obtained from the narrowed model together with the responses from the benchmark model. The charts show that our findings are qualitatively robust. The only differences are that (i) responses of output, consumer prices, and nominal exchange rate are significant for more extended periods, and (ii) the effects on these variables are more persistent and quantitatively somewhat larger.

As a model extension, we consider potential overlaps of monetary and fiscal policies. Government stimulus can play an essential role in economic recoveries. Since monetary policy easing often coincides with expansionary fiscal policy, excluding a control for this variable could overestimate monetary policy's effect on the economy (Rossi & Zubairy, 2011). We estimate an extended model adding government expenditure to address this potential caveat. The responses to a balance sheet shock in this extended model, shown in Figure 14, are similar to those from the benchmark model. The only minor difference is that the output response is almost insignificant, but the two models' response confidence intervals overlap. The median response of government expenditure is positive, but the confidence interval includes zero. The positive response reflects positive feedback effects of the shock-induced increase in output on public finances, as Gambacorta et al. (2014) found.

5.3 | Alternative specification

We also examine the robustness of the benchmark results when (i) increasing time lags to two ($p = 2$) and (ii) reducing the periods of sign restrictions to one ($h = 1$). When we set the VAR model's time lag as $p = 2$ instead of $p = 1$, the responses to a central bank balance sheet shock, which are shown in Figure 15, are qualitatively robust. The only notable differences are (i) output response is now insignificant, but the response confidence intervals of the two models overlap and (ii) the effects on CPI and nominal exchange rate are quantitatively somewhat more extensive, especially for periods where the responses are significant.

We are also interested in whether the results will change if periods of sign restrictions are reduced to one ($h = 1$). In such a case, the responses to a balance sheet shock, shown in Figure 16, are very similar. The only difference is that responses of output and consumer prices are now insignificant.

Overall, the analysis confirms that the results are robust to variations in the benchmark model, model extension/contraction, and model specifications (i.e., number of lags and periods of sign restrictions).

6 | CONCLUSION

This paper has examined the effectiveness and transmission of UMPs in Mongolia, a small open and commodity-exporting economy. Based on a SVAR framework, we have identified four structural shocks (central bank balance sheet, policy rate, demand, and supply shocks) and estimated the dynamics effects on the macroeconomy. We find that output and consumer prices rise, and the nominal exchange rate depreciates with time lags after an increase in the BOM's domestic assets (excluding other assets). The effects on newly issued loans, M2, output, and consumer prices are qualitatively similar to the policy rate's impact. However, the effects of CMP and UMP shocks on the nominal exchange rate and foreign exchange rate differ significantly. For instance, expansionary UMPs decrease foreign exchange reserves and exchange rate depreciation, while loosening of CMP appreciates exchange rate and increases foreign exchange reserves. As a novelty, we also find empirical evidence in favour of the delayed overshooting response of the exchange rate to the balance sheet shock. In terms of the monetary transmission mechanism, the bank lending channel is operative for the CMP; however, bank lending and liquidity channels of UMP measures are evident in Mongolia. Therefore, financial markets and banks play an essential role in passing the UMP measures to the real economy. The results remain robust to variations in the benchmark model, model extension/contraction, and model specifications (i.e., number of lags and periods of sign restrictions). The robustness analysis also reveals that (i) an increase in imports is a crucial channel explaining why UMP actions lead to currency depreciation and decline in foreign exchange reserves, and (ii) there exist positive feedback effects of the UMP shock-induced increase in output on public finances.

Positive feedback between the financial and real sectors suggests that the financial accelerator is operative in the economy. As balance sheet, interest rate, and demand shocks move output, consumer price, newly issued loans, and M2 in the same direction, the accelerator channel propagates and amplifies the shocks' effects on the macroeconomy. Moreover, we find evidence that the financial friction amplifies the impact of supply shocks such as the COVID-19 shock (i.e., a big drop in labour supply) on the economy. For instance, a negative supply shock can adversely affect the demand through the financial sector because the shock reduces the output, thereby weakening borrowers' balance sheets and impeding their ability to obtain financing. Variance decomposition analysis also supports the view that shocks like COVID-19 can lead to disruptions in credit supply, and the financial friction amplifies their effects on the economy. For example, supply shocks account for 30% of newly issued loans and M2 fluctuations.

Finally, these findings imply that monetary policy actions should be different depending on the macroeconomic condition and nature of shocks, particularly for small open and developing economies. UMP actions may stabilise the economies during the recession, coinciding with credit disruptions at the costs of currency depreciation and depletion of foreign exchange reserves. When exchange rate/foreign exchange reserves and consumer prices are concerns, then the CMP instrument can be considered for the first stage in changing monetary policy stance towards internal and external balance.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in [Mongolbank Statistics Data] at [https://stat.mongolbank.mn/?lang=en] and [Mongolian Statistical Information Service] at [https://www.1212.mn/default.aspx].

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ENDNOTES

[1] Recently, SVARs identified with sign and zero restrictions have become prominent. When using sign and zero restrictions, a commonly used algorithm is penalty function approach (PFA) developed by Mountford and Uhlig (2009). However, Arias et al. (2018) find that the PFA adds restrictions, so identification does not solely come from the sign and zero restrictions considered in the identification scheme and argue that the additional restrictions generate biased impulse response functions and artificially narrow confidence interval around them. Alternatively, they propose an importance sampler approach, used in this paper, and state that their approach is only one drawing from the correct distribution of sign restrictions conditional on zero restrictions.

[2] A family of distributions is conjugate if the prior distribution being a member of this family implies that the posterior distributions is a member of the family. The uniform-normal-inverse-Wishart posterior over the orthogonal reduced-form parameterization has been prominent after the work of Uhlig (2005).

[3] Central bank money injection leads to a rebalancing of investors' optimal portfolios, and investors prefer to hold assets denominated in foreign currency since domestic currency interest rate is near zero. A surge in demand for these assets leads to real exchange rate depreciation, thereby helps to increase output ad prices.

[4] The key literature includes Faust (1998), Canova and De Nicoló (2002), Uhlig (2005), Rubio-Ramírez et al. (2010), and Baumeister and Hamilton (2015).

[5] He identifies three shocks (credit multiplier, interest rate and non-standard policy shocks) affecting to bank lending using a mixture of zero and sign restrictions on the impact period and find that central bank balance sheet shocks have positive effects on output and prices, while negative effects on credit multiplier.

[6] After the economic expansion driven by foreign direct investment (FDI) in Phase 1 of Oyu Tolgoi project, the Mongolian economy is hardly hit by the adverse external shocks, including sudden stop of FDI and global commodity price shocks, starting from the end of 2012.

[7] In robustness check section, we use the BOM assets as a balance sheet indicator to measure effects of changes in the BOM balance sheet.

[8] Gan-Ochir and Davaarjargal (2019, 2022) show that M2 is one of the best domestic determinants of GDP and CPI fluctuations in Mongolia.

[9] The literature on monetary policy at the ZLB for an open economy (i.e., Coenen & Wieland, 2003; McCallum, 2000) stresses the role of the exchange rate in the transmission of unconventional policy. The studies imply a real depreciation of the domestic currency following a base money injection because portfolio rebalancing effects.

[10] The results prove to be robust when we use the BOM total asset as the balance sheet indicator.

[11] Same sign restriction on interest rate is also imposed by Weale and Wieladek (2016) in identifying asset purchase shock.

[12] In contrast to Schenkelberg and Watzka (2013), we assume a standard upward slowing aggregate demand curve as the interest rate is not bound by the zero-lower bound for the Mongolian economy.

[13] The non-negative response of newly issued loan to the positive demand shock is in line with restrictions and results shown by Kapetanios et al. (2012).

[14] Estimation in (log) levels allows for implicit cointegration relationships in the data (Hamilton, 1994; Sims et al., 1990). Given the short sample available, we do not perform an explicit analysis of the long run behaviour of the economy. A monthly measure of real GDP is constructed using a Chow-Lin interpolation procedure and monthly industrial production as a reference series.

[15] China quarterly GDP at current is observed from FRED economic data of Federal Reserve Bank of St. Louis, and China quarterly GDP growth is collected from data.oecd.org. Then we calculate China quarterly real GDP (at constant 2010 prices) using the quarterly GDP growth series. A monthly measure of real GDP for China is also constructed using a Chow-Lin interpolation procedure and monthly industrial production as a reference series.

[16] Moreover, when the exchange rate is fixed using CMP, policy rate rises to keep the exchange rate fixed, and this directly offsets the stimulus to domestic demand from UMP through long-term rates.

[17] They argue that replacing all information about the stance of monetary policy with random numbers produces statistically indistinguishable impulse responses and time series of purported monetary policy shocks.

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