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Effect of remittances on the macroeconomy: A Structural VAR study of Nepal

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Abstract

The paper examines the short-term macroeconomic impact of remittances using a case study of Nepal, one of the highest remittance-receiving countries in the world as a share of GDP. Despite the massive inflow of remittances during the turn of the century, the quantitative impact of remittances on the Nepali economy remains largely unexplored. Furthermore, macroeconomic modelling of the Nepali economy is at the infant stage primarily due to the unavailability of reliable data. Hence, using novel quarterly GDP data, this paper aims to fill both gaps by examining the effects of remittance and other macroeconomic variable shocks on the small open economy of Nepal between 2004 and 2019. Employing an SVAR model, the study finds that the impact of remittance shock on output (GDP) is not significant, but remittances significantly increased money supply and prices and appreciated the real exchange rate. These findings solve the price and exchange rate puzzles found in the earlier studies on Nepal. While foreign partners' output primarily drives the remittance inflows to Nepal, the real exchange rate also plays a non-trivial role, but the domestic GDP or the interest rate do not appear to have a significant impact on the remittance inflows. Most of the macroeconomic variables do not respond to the policy rate; additionally, the reaction of money supply in response to a positive shock to inflation is not significant, which poses a further challenge to the policymakers in Nepal. Despite the monetary authorities in Nepal using money supply as the primary monetary policy tool, the transmission channel remains impaired.

Keywords

remittance shock, Nepal, macro-economy, small open economy, structural VAR,

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ABSTRACT

The paper examines the short-term macroeconomic impact of remittances using a case study of Nepal, one of the highest remittance-receiving countries in the world as a share of GDP. Despite the massive inflow of remittances during the turn of the century, the quantitative impact of remittances on the Nepali economy remains largely unexplored. Furthermore, macroeconomic modelling of the Nepali economy is at the infant stage primarily due to the unavailability of reliable data. Hence, using novel quarterly GDP data, this paper aims to fill both gaps by examining the effects of remittance and other macroeconomic variable shocks on the small open economy of Nepal between 2004 and 2019. Employing an SVAR model, the study finds that the impact of remittance shock on output (GDP) is not significant, but remittances significantly increased money supply and prices and appreciated the real exchange rate. These findings solve the price and exchange rate puzzles found in the earlier studies on Nepal. While foreign partners' output primarily drives the remittance inflows to Nepal, the real exchange rate also plays a non-trivial role, but the domestic GDP or the interest rate do not appear to have a significant impact on the remittance inflows. Most of the macroeconomic variables do not respond to the policy rate; additionally, the reaction of money supply in response to a positive shock to inflation is not significant, which poses a further challenge to the policymakers in Nepal. Despite the monetary authorities in Nepal using money supply as the primary monetary policy tool, the transmission channel remains impaired.

1. Introduction

Despite the growing literature on the effect of remittances on the macro-economy, empirical studies are still limited compared to other financial inflows, such as foreign aid and foreign direct investment (FDI). Amuedo-Dorantes & Pozo (2004); Lartey, Mandelman & Acosta (2012); Chami, Fullenkamp, Cosimano, Gapen, Montiel & Barajas (2008) have shown that remittances lead to the inflationary effect and long-term appreciation of the real exchange rate and thus contribute to Dutch disease-like symptoms. However, Ball, Lopez & Reyes (2013) control for the 'change in exchange rate regimes' and find that the effect of remittances on the gross domestic product (GDP), the real exchange rate, inflation, and money supply vary according to the exchange rate regimes. Notably, they find that remittances increase inflation, GDP, and money supply, leading to the appreciation of real effective exchange rate (REER) in fixed exchange rate countries. In contrast, in flexible exchange rate countries, remittances decreased inflation, increased GDP, and appreciated REER but did not affect the nominal money supply. As the debate continues on the macroeconomic impact of remittances in developing countries, remittances have become the largest financial flow to developing countries, surpassing FDI in 2019 (World Bank, 2019). As global migration continues to surge, remittances are expected to increase further and play a significant role in the economies of remittance-receiving developing countries. Hence, it is crucial to understand the macroeconomic impact of remittances in developing countries.

Nepal has one of the largest remittances per capita in the world. While the post-2000 period saw a massive increase in remittances in Nepal, from 3% of GDP in early 2000 to 25% of GDP in 2019, this period coincided with an enormous change in Nepal's macroeconomic landscape and structural changes in the economy. The tradable sector share declined from 44% to 27% of GDP, while the non-tradable sector rose from 44% to 53%. The real exchange rate appreciated significantly, about 30% during this period. Exports have been decimated by one-third, from 20% to 7% of GDP (Fig. 1). Imports during the same period increased from 29% to 41% of GDP.

In parallel, the boom in domestic credit has been extraordinary, increasing from 30% of GDP in 2004 to 80% of GDP in 2019. Total international reserves as a percentage of external debt increased enormously from 30% to 200% of GDP, and broad money (M2) increased from 50% to more than 100% of GDP. The increase in public and private investment in Nepal has also been the highest in history. The total gross fixed capital formation (GFCF) increased from approximately 18% in 2004 to 33% of the GDP in 2019 (Fig. 2). Similarly, Nepal is one of the few low-income countries where domestic revenue has increased from approximately 10% to more than 22% of GDP (Fig. 1). Several events, such as the Maoist conflict, political upheavals, the 2015 earthquake, and the blockade by India, shaped Nepal's

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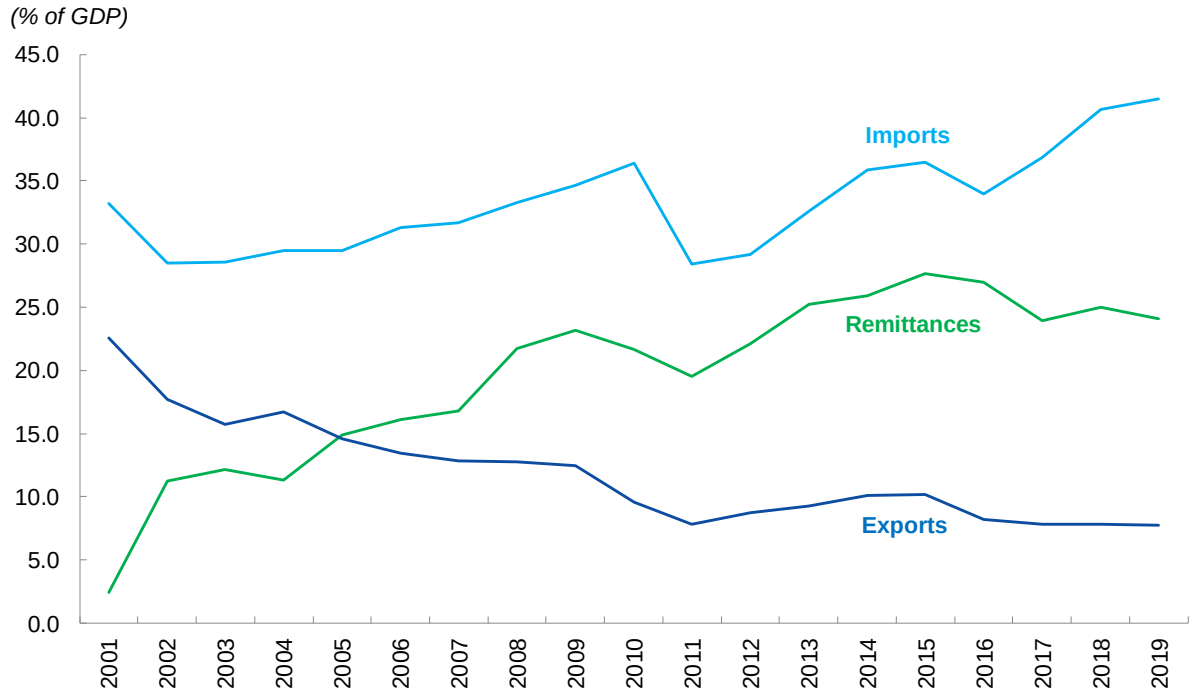

Figure 1: Imports, exports and remittances for Nepal between 2001-2019

Source: WDI, World Bank

economic landscape during this period. However, remittances have been a significant part of the economic changes that occurred in the Nepali economy (Sapkota, 2013; Pant, 2014; Cosic, Dahal, Rana & Bajracharya, 2016b; Uematsu, Shidiq & Tiwari, 2016; Cosic, Dahal & Kitzmuller, 2017).

Remittances have also contributed more to poverty reduction than foreign aid or other external flows combined (Uematsu et al., 2016; Wagle & Devkota, 2018). In 2018 remittances were ten times larger than foreign aid and three times larger than total exports (Cosic et al., 2016b). Hence, remittances are Nepal's most prominent external inflows, with wide-reaching macroeconomic implications, both in the short and long term. For example, between 2007 and 2011, Nepal witnessed a period of accommodative monetary policy driven by unsterilized remittance inflows to the Nepali economy. This period coincided with weak banking supervision and excessive lending in the real estate market (World Bank, 2018). Following the 2008 global financial crisis, the slowing down of remittances led to an acute liquidity crunch and triggered the early 2011 real estate bubble collapse (Cosic et al., 2016b). The severe banking crisis was averted due to swift policy measures from the central bank and the resurgence of remittance inflows.

Despite the preponderance of remittances in the Nepali economy, empirical research on its macroeconomic impact remains limited. Additionally, quantitative macroeconomic models, including vector autoregression (VAR), have been very thin (NRB, 2018a). Some in-house models used by the central bank (Nepal Rastra Bank) and international financial institutions relied primarily on annual data, mainly because of quarterly real sector data unavailability (See the bi-annual Nepal Economic Updates by the World Bank and the Asian Development Bank). Furthermore, notably absent from the VAR system is the real exchange rate in many macroeconomic studies in Nepal.

Hence, this study attempts to contribute to the literature by constructing an SVAR model for Nepal's economy from 2004 to 2019 using the recently published quarterly GDP data to address four main research questions. First, how do remittance shocks affect macroeconomic aggregates, including real variables in Nepal? Second, how does the Nepali economy respond to foreign and domestic macroeconomic shocks? Third, how do remittance inflows react to Nepal's macroeconomic aggregate? Finally, how do monetary authorities respond to remittances and macroeconomic shocks?

To my knowledge, this is the first study to analyze the impact of remittances on Nepal's macroeconomic aggregates using quarterly GDP data published by the Central Bureau of Statistics (CBS) of Nepal. Some studies have attempted to examine the macroeconomic impact of remittances using either a single equation (Portugal & Zildzovic, 2016b) or VAR (Dhungel, 2018; Bhatta, 2013). However, there is a critical difference between the VAR and SVAR. Although SVAR is one of the most widely used modelling techniques in quantitative macroeconomics, including theory and country-specific features, few empirical studies Panday (2014a,b) apply this technique to study Nepal's economy. Furthermore, due to the unavailability of data, none of these studies has used published quarterly GDP data, an important variable

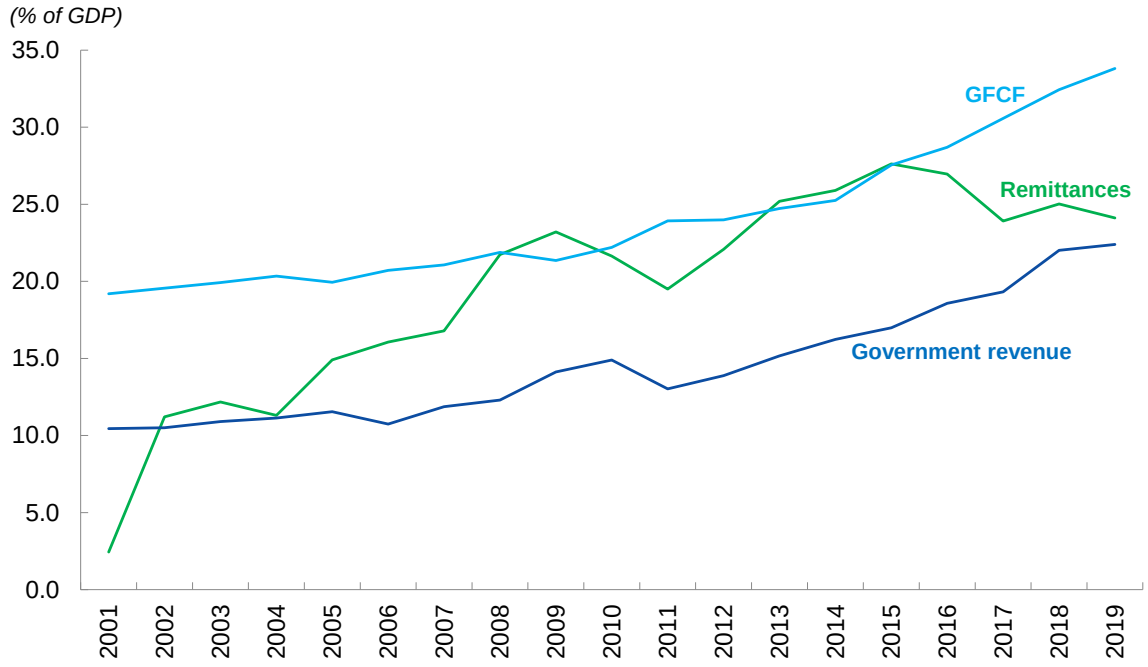

Figure 2: Investment, government revenue and remittances for Nepal between 2001-2019

Note: GFCF is Gross fixed capital formation
Source: WDI, World Bank

when studying macroeconomic aggregates. Panday (2014b) uses quarterly GDP data but extracts data based on a linear interpolation of annual GDP, not the same as the GDP published by the CBS of Nepal. Therefore, this study aims to close these gaps by building an SVAR model of the Nepali economy based on quarterly data, including the real sector, to understand the role of various shocks in the Nepali macroeconomy.

This study finds new evidence while reinforcing earlier findings on the impact of remittances on the Nepali economy. The study finds foreign partners' output primarily drives remittances, and the positive shock to foreign output significantly increases remittances to Nepal. However, remittances are also affected by some of the domestic macroeconomic aggregates in Nepal. Specifically, the study finds that REER significantly affects the remittance inflows to Nepal. The interest rate and GDP do not appear to affect remittance inflows. Hence, unlike in some other countries (e.g., the Philippines, see Burgess & Haksar (2005)), the study does not find evidence of remittance being pro-cyclical to the domestic economy; that is, the impact of GDP or interest rate on remittance inflows is not significant. This finding provides further evidence that the "welfare motive" (also known as the "altruistic" motive) appears to be the dominant reason for sending remittances by the migrants than the "investment motive" during the study period.[1]

[1]For literature on the motive to send remittances see (Chami et al., 2008; De, Islamaj, Kose & Reza Yousefi, 2019; Amuedo-Dorantes & Pozo, 2004; Frankel, 2011)

However, remittances play a nontrivial role in the Nepali economy. Interestingly, the study does not find that remittances significantly impact the GDP. The finding aligns with previous studies (Barajas, Chami, Montiel, Gapen & Fullenkamp, 2009; Clemens & McKenzie, 2018), and the complex transmission channels of remittances on GDP (both positive and negative) may have played a role. The study finds that remittances contribute to a significant increase in the money supply. A positive shock to remittances also has an inflationary effect on the Nepali economy, which solves the price puzzle found in earlier studies (NRB, 2018a; ADB, 2011). A positive shock to remittances increases the real effective exchange rate, which solves the exchange rate puzzle found in some of the existing studies on Nepal (Panday, 2014b; ADB, 2011). Appreciation of the REER has been associated with negatively impacting Nepal's tradable and export sectors, indicating Dutch disease symptoms (Portugal & Zildzovic, 2016b). However, because of the constraint on quarterly data availability, the study could not analyze the impact on the tradable and non-tradable sectors in this study.

On the other macroaggregates, a positive shock to inflation leads to REER appreciation. At the same time, the study does not find a positive shock to REER significantly impacts GDP. The money supply positively and significantly impacts inflation, along the lines of the studies that show that the money supply's influence on price is moderate in Nepal. Nepal's inflation is primarily determined by Indian inflation and international oil prices (IMF, 2011; Ginting, 2007; IMF, 2014; Shrestha & Bhatta, 2019).

The study finds that the effectiveness of monetary policy has been limited in Nepal, consistent with previous studies (IMF, 2014; Maskay & Pandit, 2010; NRB, 2005). The currency peg with the Indian rupee limits the flexibility of monetary policy operations in Nepal. Hence, unlike many other countries, the interest rate is not the nominal anchor (NRB, 2018b) and largely remains unable to impact macroeconomic variables in Nepal. Nepali authorities rely on the money supply as one of the main tools of monetary policy (NRB, 2005; Budha, 2015). However, this study shows that the effect of money supply on inflation is insignificant; hence, the role of money supply in implementing effective monetary policy also remains impaired. As the Nepali authorities grapple with managing macroeconomic challenges created by remittances, these findings are likely to help policymakers not only in Nepal but also in other remittance-dependent economies worldwide.

The remainder of this paper proceeds as follows. Section 2 reviews the literature. Section 3 describes the empirical model and data. Section 4 presents the results and discussion of impulse responses, variance decomposition, and historical decomposition. Section 5 discusses the robustness checks. Section 6 concludes the paper.

2. Literature review

While the study of Nepal's remittances has attracted growing interest, only a few research have studied the simultaneous relationship between remittances, prices, monetary policy, exchange rate, and the real economy. One of the earlier studies on the macroeconomic impact of remittances on Nepal was Sapkota (2013). This exploratory study showed that remittances have been associated with a decline in the tradable sector, appreciation of the real exchange rate, and hence Dutch disease-like symptoms in the economy, but did not employ any empirical models to support this assertion. Bhatta (2013) used an error correction model and found that remittances led to higher imports and trade deficits in Nepal. Bhattarai & Joshi (2009) carry out an error correction model to study the relationship between macroeconomic variables and the asset market in Nepal but do not use any real sector or exchange rate variables.

Using 41 observations of annual data ranging from 1975 to 2016, the central bank of Nepal found that money supply, t-bill rate, and Indian inflation positively impact Nepal's CPI, whereas output shock negatively impacts CPI (NRB, 2018a). The t-bill's positive impact on CPI is a puzzle in this study, which also found that an increase in the nominal exchange rate (depreciation) negatively impacts CPI, which is yet another puzzle. Finally, the study finds no significant impact of remittances on inflation. Hence, the NRB (2018a) does not fully explain the exchange rate, interest rate, and price puzzles found in the study.

Panday (2014b) conducted SVAR modelling, which analyzed India's GDP shock in Nepal using a three-variable model. Despite the close relationship between the Nepali and Indian economies, various studies, including Panday (2014b), have empirically found the relationship weak. Post-2000, the Nepali economy has become increasingly dependent on remittance inflows beyond India; hence, global shocks are likely to have been transmitted through remittance channels, weakening the Indian economy's effect on the Nepali economy post-2000.

Studies on Nepal have shown that monetary policy barely affects output or inflation in Nepal. The central bank started to announce the policy rate in 2002, but the use of the central bank's policy rate remained minimal (NRB, 2015; IMF, 2014). Consequently, interest rate pass-through remains underdeveloped and has been extremely weak in Nepal (Maskay & Pandit, 2010; NRB, 2018b). Hence, the central bank continues to rely on the money supply to conduct monetary policy targets (Maskay & Pandit, 2010; NRB, 2005, 2018a), but the money supply's effectiveness remains impaired.

Khatiwada (2005) found no significant impact of money supply on inflation in Nepal. Many studies on Nepal's economy have examined monetary policy using a single equation model (Khatiwada, 2005). However, single-equation studies have difficulties analyzing the effects of monetary policy. Only a partial measure of the monetary policy impact can be analyzed because many of the variables on the right-hand side of the equation are also affected by an interest rate change (Dungey & Pagan, 2000). Recent researches have shown a significant, albeit modest, impact of money supply on inflation in Nepal (Ginting, 2007; IMF, 2011, 2014). Shrestha & Bhatta (2019) further found that the money supply had a positive and growing impact on inflation in the post-2000 period, besides Indian inflation. Due to pegged exchange rates, open borders, and high import reliance on India, it is no surprise that inflation in Nepal has been driven by Indian prices and has been empirically found to be significant.

In 2011, the Asian Development Bank (ADB) developed the Nepal macroeconomic model (NMEM). In this model, the Wholesale Price Index of India is the only economic variable that influences the price in Nepal. No other variables, especially excess demand pressures, were found to have a significant relationship with price. Although M2 is included in the price equation to interlink monetary and real sectors, the elasticity of M2 with the price is marginal. This means that price affects other variables in the model but not vice versa. The Wholesale Price Index of India is an exogenous variable that can influence the overall model by policy variable. The NMEM also found that an increase in net foreign assets contributes to an increase in M2. The model also assessed the increase in remittances in its policy scenarios. Despite the massive increase in remittances during the study period, the REER still depreciates in the model and boosts export, which has not happened in the past 20 years in Nepal. Export is one sector that has unambiguously declined in Nepal since 2000 (see Fig. 1). The ADB's NMEM exemplifies that the complex model may not necessarily provide correct results in data-scarce countries such as Nepal.

From the literature review, it can be concluded that empirical macroeconomic research in Nepal is at an infant stage. Previous studies have not included some essential variables such as domestic GDP, foreign output, or REER in their models. Finally, the price, interest rate, and exchange puzzles remain largely unexplained in these studies.

3. Empirical approach and data

Since its introduction by Sims (1980), the VAR model has been the standard empirical method for studying the impact of macroeconomic variables. Over the years, there has been a wide extension in VAR and identification schemes to study short-term macroeconomic impacts. Bernanke (1986) and Sims (1986) permitted no recursive structures in the model. Initially, several VAR models were used in the case of the US (Bernanke & Blinder, 1992; Sims, 1992; Kim & Roubini, 2000), which were later expanded to analyze other countries. Block exogeneity procedures were developed by Cushman & Zha (1997) and used to study the case of Canada. Dungey & Pagan (2000) developed an SVAR model for Australia, which was further refined by Dungey & Pagan (2009) and Dungey & Fry (2009) to combine stationary and nonstationary variables in the model. Recently, SVARs have become popular for studying macroeconomic variables in developing countries (Bhattacharya, Patnaik & Shah, 2011; Panday, 2014b; Afrin, 2017). SVAR models have advantages over systems and structural models in countries with scarce data. Generally, they use a small number of crucial variables for countries such as Nepal, where the availability of time-series data is always a challenge. Hence, this study follows a recursive identification method, as suggested by Cushman & Zha (1997); Dungey & Pagan (2000), and Caldara & Kamps (2008), using recursive SVAR.

Due to the limitation of quarterly GDP data availability, this study's period is from 2004Q3 to 2019Q4. First, the variables are recursively arranged and the second stage involved the specification of the functional form of each equation. The impulse response functions document the transmission of foreign output, remittances, and domestic macroeconomic shocks in a small open economy environment.

The interest rate (policy rate) is only included in the robustness check exercises. First, the nominal anchor of the central bank in Nepal remains the exchange rate (NRB, 2018b). Policy rates have largely remained flat in Nepal. Hence, the quarterly impact on other macroeconomic variables cannot be studied effectively. The central bank has relied mainly on the money supply to implement monetary policy targets (NRB, 2005; Maskay & Pandit, 2010; NRB, 2018a). Therefore, interest rate pass-through remains underdeveloped and has been extremely weak in Nepal (NRB, 2005; Maskay & Pandit, 2010). The t-bill rate is used instead of the policy rate, aligning with previous studies on Nepal (NRB, 2018a), and many other developing countries (Afrin, 2017). For example, Maskay & Pandit (2010) finds that the policy rate (known as the bank rate in Nepal) has been ineffective in influencing Nepal's market rates.

The importance of the interest rate (t-bill rate) on the macroeconomic variables of Nepal is tested using the Granger causality test, which further reinforces the relative unimportance of the interest rate in the Nepali economy (see Table B.5 in Appendix 3 for the test results). The policy rate does not Granger cause several of the variables in the system (at the 5% significance level). The likelihood ratio (LR) test further confirms this, where the result fails to reject the null of "no interest rate." See Table B.6 for the LR ratio test results. Hence, the interest rate is used only in the robustness section of this study. Including the interest rate only in the robustness check also helps preserve the degrees of freedom in the main benchmark model.

Asset prices are also not included in the model. First, real estate price data are not available, and the central bank has only started tracking real estate price data in 2021. The stock market has expanded considerably over the last few years. However, it is relatively underdeveloped, and only a small share of the population is connected to it, making it less relevant to the Nepali economy. Even in developing countries, where the stock market is better developed than in Nepal, studies show the relative exogeneity of the stock market (see Afrin (2017) for the case of Bangladesh; Gunasekarage, Pisedtasalasai & Power (2004) for the case of Sri Lanka).

3.1. Model

An SVAR model is developed to estimate the effect of remittances on output, money supply, price, and real exchange rate. The model includes two foreign variables: foreign output (*fy*) and remittances (*remit*), and four domestic macroeconomic variables: domestic output (*y*), money supply (*ms*), the real effective exchange rate (*reer*), and price(*cpi*). The interest rate (*t-bill*) is added to the model in robustness check exercise in Section 5. The general ordering of the variables is followed as per Eq. (1):

$$X_t = [fy \;\; remit \;\; y \;\; ms \;\; cpi \;\; reer]' \tag{1}$$

where X_t represents a (6 x 1) vector of endogenous variables, as ordered in Eq. (1).

The SVAR model is:

$$B_0 X_t = B_1 X_{t-1} + ... + B_4 X_{t-4} + \epsilon_t \tag{2}$$

B_1 to B_4 in Eq. (2) represent 6×6 matrices of coefficients for lagged endogenous variables and ϵ_t is a (6×1) vector of structural shocks, and they are assumed to be independent and identically distributed (i. i.d.), that is, $E(\epsilon_t \; \epsilon'_{t+s})$=0 and $E(\epsilon_t \; \epsilon'_t)$ =D. B_0 represents the contemporaneous relationships between the variables and is nonsingular and normalized to have unit values on the diagonal. The diagonal matrix D contains the variances used to calculate the structural shocks. For convenience, the constant term is suppressed.

3.1.1. Identification

The identification restrictions for SVAR are devised based on economic theories, existing literature, and intuition. It is implemented through short-run restrictions on the

recursive relationships between variables in Eq. (2). Contemporaneous and lag identification restrictions are specified in Eqs (3) and 4, respectively:

$$\left[B_0 X_t\right] = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 \end{bmatrix} \begin{bmatrix} fy \\ remit \\ y \\ ms \\ cpi \\ reer \end{bmatrix} \quad (3)$$

For $j = 1,2,3,4$

$$\left[B_j X_{t-j}\right] = \begin{bmatrix} b^j_{11} & 0 & 0 & 0 & 0 & 0 \\ b^j_{21} & b^j_{22} & b^j_{23} & b^j_{24} & b^j_{25} & b^j_{26} \\ b^j_{31} & b^j_{32} & b^j_{33} & b^j_{34} & b^j_{35} & b^j_{36} \\ b^j_{41} & b^j_{42} & b^j_{43} & b^j_{44} & b^j_{45} & b^j_{46} \\ b^j_{51} & b^j_{52} & b^j_{53} & b^j_{54} & b^j_{55} & b^j_{56} \\ b^j_{61} & b^j_{62} & b^j_{63} & b^j_{64} & b^j_{65} & b^j_{66} \end{bmatrix} \begin{bmatrix} fy_{t-j} \\ remit_{t-j} \\ y_{t-j} \\ ms_{t-j} \\ cpi_{t-j} \\ reer_{t-j} \end{bmatrix} \quad (4)$$

As Nepal is a small, open economy, it has little influence on the world economy. Hence, the domestic block of variables was placed after the foreign block. Within the foreign block, remittance inflows to Nepal are placed after foreign output because the remittance inflows are primarily determined by the economic condition of the partner countries and not vice versa. Hence, the foreign output is not affected by remittance inflows to Nepal or the domestic economy block, which is ensured with additional lag restrictions to satisfy the assumption that remittance inflows and domestic variables have no contemporaneous or lagged effects on foreign output.

Remittance inflows to Nepal affect all domestic variables. The economic reasoning for this is based on the following argument: external inflows play an essential role in driving macroeconomic conditions. In Nepal, other foreign earnings (FDI, exports, aid) are tiny compared to remittances. In 2019, FDI, aid, and exports accounted for 1%, 3%, and 5% of GDP, respectively, while remittances accounted for 25%. The output, money supply, exchange rate, and price of the home country (Nepal) have relatively small effects on the remittances received by the home country. Therefore, the domestic variables are placed after remittances. A Granger causality test is conducted to check the importance of these variables to remittance inflows in Nepal. All the domestic variables in the system Granger cause remittances and are significant at the 5% level (see Table B.5 in Appendix 3). As the t-bill is not significant at the 5% level, it is not included in the main model.

The error term of foreign output will be equal to its structural error term, and a change in foreign output will have a contemporaneous effect on all variables in the system. The second variable is remittances, which does not respond contemporaneously to any changes in the Nepali economy but is contemporaneously affected by foreign output. The third variable is domestic output, which is influenced by foreign output and remittances only, but not by other domestic variables simultaneously. The fourth variable is money supply, which is influenced by foreign output, remittances, and domestic output, but not by CPI and REER contemporaneously. The fifth variable is CPI, which is contemporaneously influenced by foreign output, remittances, domestic output, and money supply, but not by REER. The sixth variable is the real exchange rate, which is contemporaneously affected by all variables in the system.

Additionally, three dummy variables are used. The first dummy is for the 2008 global financial crisis in the foreign and domestic variable equations. The second dummy is for the 2015 Nepal earthquake in domestic variable equations. The 2015 earthquake caused billions of dollars of damage and loss to the Nepali economy (Cosic, Dahal, Bajracharya, Rana, Shrestha & Pandey, 2016a). The third dummy is for the "taper tantrum" of 2013 for both the foreign and domestic variable equations. The "taper tantrum" of 2013 occurred when the US fed raised the interest rate, which led to a sharp depreciation of the Indian rupee, reaching 18% at the peak (Basu, Eichengreen & Gupta, 2014). As the Nepali rupee (NPR) is pegged to the Indian rupee, this led to a very sharp depreciation of the NPR.

For the benchmark model, lag 4 is used based on the results from the lag length criteria (see Table B.2 in Appendix 3) and considering the features of the Nepali economy. Three of the five lag length criteria show four lags as the optimal lags. The shorter lag length, which is desirable because of the small sample size in the study, may not capture the critical cyclical patterns of the Nepali economy. For example, two-thirds of public investment occurs in the first and second quarters (third and fourth quarters of the Nepali fiscal year). In contrast, agricultural output is highly dependent on the monsoon occurring in the first and second quarters of the Nepali fiscal year. Additionally, four lags also resolved the autocorrelation and some non-normality problems, and the VAR was stable (see Tables B.3, B.4 and B.1, respectively in Appendix 3). Nonetheless, lags 2 is used in the robustness check in Section 5.

3.2. Data

The variable definitions, data sources, and construction are described in Appendix A. All data are in constant 2001Q2 prices.

Quantitative macroeconomic research on Nepal is scarce primarily because of the lack of quarterly GDP data. Several in-house macroeconomic models used by the central bank and international financial institutions have primarily relied on either annual real sector data or frequency-converted real sector data (annual to quarter conversion using statistical software) until very recently [2]. Hence they do not capture

[2] See NRB (2018a) on the evolution of macroeconomic models in Nepal. The World Bank uses macroeconomic model known as MFMOD. The IMF uses financial programming model. However, all these models up

the intra-year relationships, which are crucial in studying macroeconomic relationships. With the support of the ADB, Nepal's CBS had been calculating quarterly GDP data for several years but had not released the data for public use. In mid-2020, the CBS released quarterly GDP data for Nepal, making it possible to conduct quantitative macroeconomic modelling exercises more accurately.

Based on the availability of quarterly GDP data, the study period was 2004Q3–2019Q4. Quarterly GDP data were obtained from CBS July 2020 vintage. Foreign output was constructed as a simple average of the trade-weighted real GDP of Nepal's top ten trading partners. Quarterly real GDP in constant USD for partner countries was obtained from the Global Economic Monitor (GEM) of the World Bank. Trade weights (constant average 2004–2019) were calculated from the IMF's Direction of Trade Statistics (DOTS). The sample countries cover around 84% of the total trade over the sample period. India, China, and the United States, the top three trading partners, constitute around 75% of the total trade. The remittance-weighted real GDP of top remittance-sending countries would potentially have been a better variable but could not be constructed due to data unavailability for the study period.

Remittance inflows to Nepal, CPI, and M2 are obtained from the IMF's International Finance Statistics (IFS) database. The source of the REER data is the Bruegel dataset. The Bruegel database defines an increase in REER as an appreciation of the home currency against the basket of trading partners' currencies (Zsolt, 2021). The t-bill (91 days) data used in the robustness check section were obtained from the CEIC.

All variables are in real terms (2001Q2 constant price), except the money supply and t-bill rates in nominal terms. All variables were seasonally adjusted using the X13 methodology and expressed in natural logarithmic form, and all the series were de-trended following Dungey & Pagan (2000). Hence, this study focuses only on cyclical components. Finally, the model is estimated in levels, as previous studies (Sims, Stock & Watson, 1990; Sims, 1992) have argued that the variables lose important information in the data if they are differenced. All variables used in the model are plotted in Fig. B.1 in Appendix 3. Unit root tests of the de-trended variables find that all variables are stationary except the CPI.

4. Results and discussions

The impact of a shock on any variable in the system can be analyzed using the estimated model. This section presents the impulse response functions (IRF) of foreign output, remittances, money supply, CPI, and REER shocks on the rest of the economy. For brevity, domestic GDP is excluded in this section. However, the entire IRFs from the model are presented in Fig. B.2 in the Appendix. Each IRF figure shows the effect of a one-time positive shock on the present and future values of the variables. The confidence intervals measured by dotted lines are at the 95% level.

until 2020 relied on annual data for the real sector analysis. Also, see the Nepal Development Update series published by the World Bank and the Article IV reports of the IMF.

4.1. Impulse responses

4.1.1. Impulse responses to a foreign output shock

Fig. 3 shows the response of the macroeconomic variables to a one standard deviation shock to foreign output. Remittances increase due to positive foreign output shocks, and the effect is significant. The response of remittances to foreign output is relatively large, peaking at 4.5% above the baseline after seven quarters. This finding is consistent with previous literature, which shows that remittances are procyclical to the world economy (Frankel, 2011). This result reinforces that the impact of foreign GDP on remittances to Nepal is large.

The response of money supply to foreign output is also positive and significant, peaking 2% above the baseline after nine quarters. The impact of a positive shock to foreign output on domestic GDP is negative. The impact of the foreign output shock causes the domestic CPI to decline immediately and is significant for three quarters. The price response is along the line of the Phillips curve, which states that the inflation rate depends on expected inflation, the level of output, and supply shocks. When there is an adverse global supply shock, such as an increase in the price of goods and energy in the world economy, it will also lead to a decline in foreign output but will cause inflationary pressure on the domestic economy (Blanchard & Galí, 2007; Ball, Chari & Mishra, 2016). Conversely, when there is a favourable supply shock (i.e., prices of goods and energy decline), foreign output increases, but this is also associated with declining price pressure in the domestic economy. This may explain a price decline in the Nepali economy when foreign output increases. This is also largely true in the case of India, where Nepal imports a large part of its inflation. Studies show that supply-side shocks strongly influence aggregate inflation and output in India (Ball et al., 2016).

4.1.2. Impulse responses to a remittance shock

Fig. 4 shows the response of macroeconomic variables to a one standard deviation structural shock to remittances. The effect of remittances on domestic GDP is not statistically significant. Several previous studies have indicated that the impact of remittances on Nepal's GDP may have been negative (Cosic et al., 2017; Sapkota, 2013), but the empirical results form this study do not confirm those findings.

There could be several reasons why remittances do not positively impact GDP. First, while remittances affect GDP positively via consumption, the effect is negated due to high imports in a country like Nepal, where imports have reached 41% of GDP. Second, remittances may not translate into an investment due to several supply-side constraints in developing countries like Nepal (Cosic et al., 2017). Third, the effect of remittances on the labour market is also not straightforward. Previous studies explain the impact of remittances on output through the Dutch disease mechanism. Chami, Ernst, Fullenkamp & Oeking (2018) conducted a

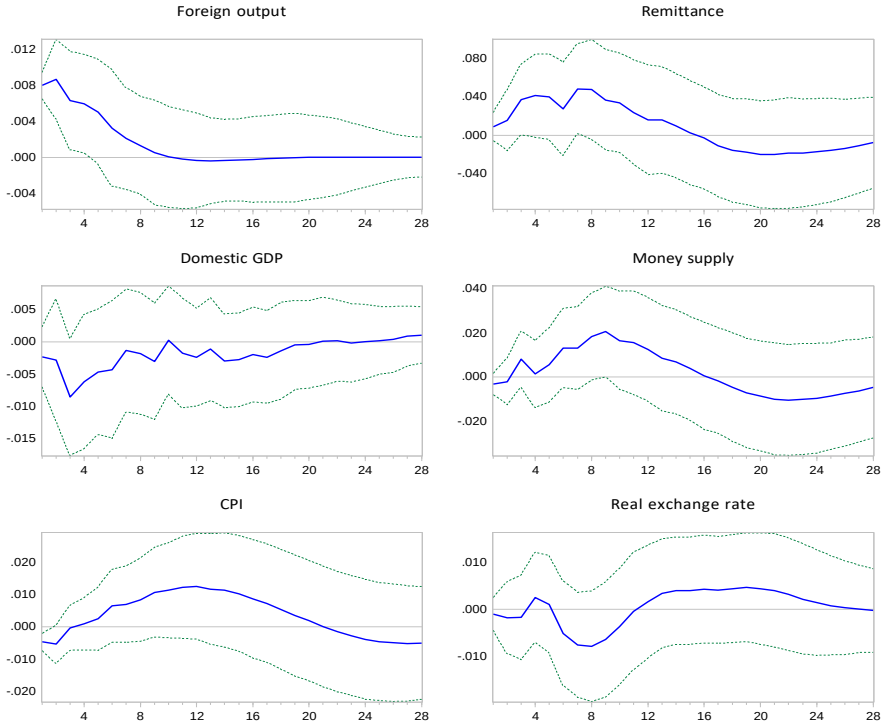

Figure 3: Impulse response functions to a foreign output shock, 2004Q3 to 2019Q4

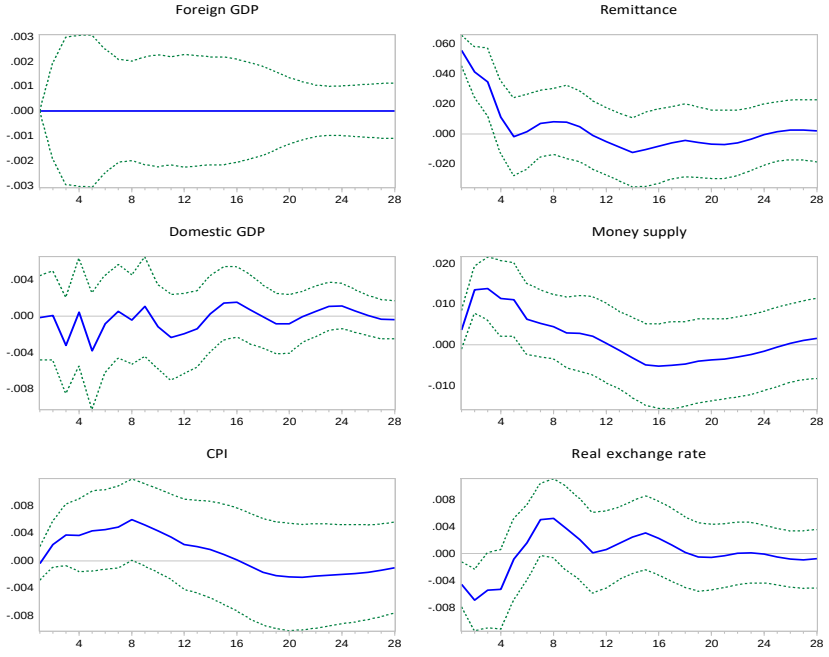

Figure 4: Impulse response functions to a remittances shock, 2004Q3 to 2019Q4

cross-country study and found that remittances benefit employment in lower-wage, lower-productivity, non-tradable industries, whereas employment in manufacturing is negatively impacted by remittances. This could lead to higher reservation wages in the home economy and negatively impact the tradable sector (Chami et al., 2018, 2008; Cosic et al., 2017). Some empirical studies have also indicated that the outflow of migrant workers could negatively impact the domestic agriculture sector because of the lack of agricultural workers and high reservation wages (Tuladhar, Sapkota & Adhikari, 2014). Finally, remittances contribute to real exchange rate appreciation, which can negatively impact the tradable and export sectors (Lartey, 2018; Portugal &

Zildzovic, 2016a). Exports declined from 15% to 7% of GDP during the 2004–2019 period in Nepal.

However, the impact of remittances on GDP is not straightforward and works through complex transmission channels. Theoretically, such a substantial external flow is expected to have a significant positive impact on GDP because external capital inflows are expected to ease credit constraints in an economy and drive consumption and investment (Clemens & McKenzie, 2018). As there is no expenditure side quarterly GDP data for Nepal, the study cannot analyze the impact of remittances on investment and consumption. However, the annual data show that consumption and investment increased considerably in Nepal during the study period. The GFCF has seen a steady increase from 20% in 2004 to 33% of GDP in 2019, an increase of 13% in GDP. Both public and private investments drove this increase. Private sector credit saw an astonishing increase in Nepal from about 27% of GDP in 2004, reaching almost 80% of GDP during the study period. Previous studies have shown that remittances contribute to investment and economic growth by easing credit constraints in countries with low financial sector development (Giuliano & Ruiz-Arranz, 2009; Yang, 2008; Adams & Cuecuecha, 2013).

Recent studies using micro-data on Nepal have also shown that remittances may increase savings and investments at the household level (NRB, 2019). The impact of remittances at the household level is well-documented in Nepal. Uematsu et al. (2016) finds that one in four households received remittances in 1995, which increased to one in two households by 2010. The average remittance amount (in real terms) received by households also increased six-fold between 1995 and 2010. They find that a rapid increase in remittance receipts occurred at all levels of consumption distribution. Additionally, Kapri & Ghimire (2020) show that remittances may have positively contributed to agricultural productivity by easing credit constraints and increasing technical know-how in remittance-dependent households in Nepal. In terms of labour supply, studies have shown that while the overall labour supply declined in Nepal due to foreign migration, female members may have increased their participation in self-employment, as international migration has largely been a male-dominated phenomenon in Nepal (Phadera, 2019). Hence, due to the confluence of these positive and negative transmission channels at the macro and micro levels and the data challenges around measuring remittances (Clemens & McKenzie, 2018), the impact of remittances on GDP was not conclusive during the study period in Nepal.

The impact of remittances on the money supply is positive and significant. A one standard deviation shock on remittances increases the money supply and peaks at 1.4% above the baseline three quarters after the shock. When remittances enter a country, they are converted to a local currency, which increases the money supply. This inflow of remittances also puts pressure on prices. Hence, the central bank is most likely to respond by reducing the money supply after 12 quarters; however, the effect is not statistically significant.

A positive remittance shock leads to a statistically significant inflationary effect in the Nepali economy (Fig. 4). The CPI peaked at 0.6% above the baseline eight quarters after the shock. This finding is consistent with several studies in the remittance and inflation literature (Chami et al., 2008; Narayan, Narayan & Mishra, 2011). While these studies have found an inflationary effect due to a remittance shock, Ball et al. (2013) differentiate the effect based on the exchange rate regime. They find that inflation increases in countries with fixed exchange rate regimes, whereas inflation declines in countries with flexible exchange rates because of positive remittance shocks. The findings from this study are consistent with those of Ball et al. (2013).

The contemporaneous effect of remittance shocks on Nepal's REER is noteworthy. REER depreciates immediately in the first quarter, and the effect is significant. However, it starts appreciating after quarter 6, and the REER appreciation is significant between quarters 7 and 8, peaking at 0.50% above the baseline. Nepal's currency suffers from appreciation after a little more than a year due to the remittance shock. Hence, this study solves the exchange rate puzzle found in earlier studies on Nepal. Panday (2014a) finds that the effect of remittances on the real exchange rate is insignificant. In contrast, the ADB's NMEM model finds a depreciating effect on the real exchange rate due to a positive remittance shock (ADB, 2011).

The results from the study concur with a recent study in Nepal using a single equation Portugal & Zildzovic (2016a). The appreciation of the exchange rate provides evidence that Nepal is likely to have suffered from the Dutch disease effect, which could be one of the transmission channels through which remittances can negatively impact GDP. Cross-country studies have shown that remittances appreciate the exchange rate, which is associated with a decline in competitiveness, lower exports, and a decline in the tradable sector (Amuedo-Dorantes & Pozo, 2004; Lartey et al., 2012).

4.1.3. Impulse responses to a money supply shock

Fig. 5 shows the responses of the macroeconomic variables to a one standard deviation shock to money supply in the model for Nepal. The impact of money supply on CPI is positive (inflationary effect) and significant but moderate. CPI peaks at 0.6% above the baseline and is significant until six quarters. Theoretical models suggest that an increase in money supply leads to higher inflation Krugman, Obstfeld & Melitz (2012). Some previous studies in Nepal have found that the money supply does not significantly impact prices in Nepal (Khatiwada, 2005). However, the finding from my study aligns with recent studies that have increasingly found that the money supply leads to an inflationary effect in Nepal, but the effect is modest (IMF, 2011, 2014). These studies have shown that inflation in Nepal is mostly determined by inflation in India due to its open border, high trade dependency, and pegged exchange rate with India. The IMF

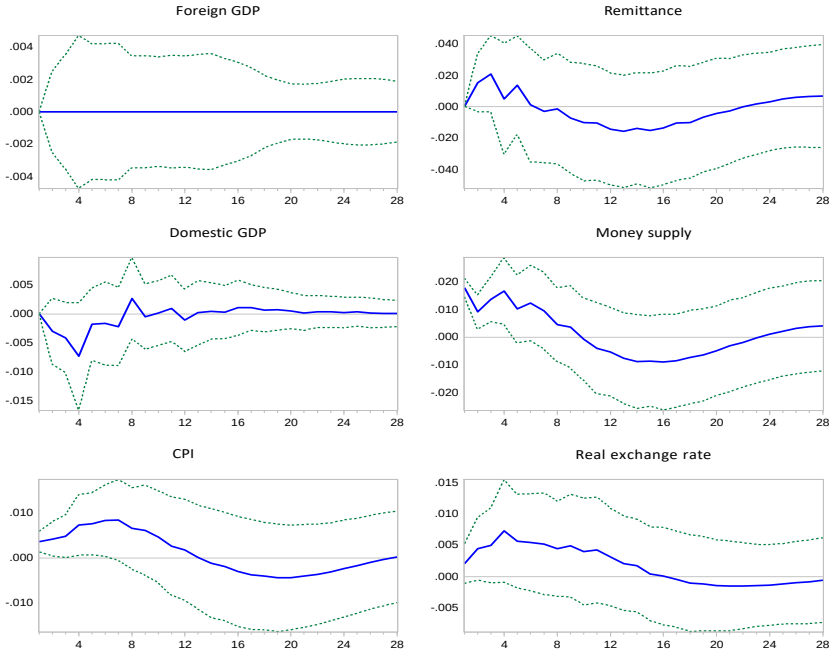

Figure 5: Impulse response functions to a money supply shock, 2004Q3 to 2019Q4

(2014) finds that a 1% increase in India's inflation leads to a 0.45% increase in Nepal's inflation, whereas a 1% increase in broad money growth corresponds to only a 0.1% increase in inflation. Overall, an increase in money supply in Nepal does not significantly impact most macroeconomic variables, except the CPI. Despite the money supply being one of the main monetary policy tools of the central bank in Nepal, its policy effect appears to be minimal in moving macroeconomic aggregates in Nepal. The money supply's impact on GDP or the real exchange rate appears insignificant. REER appreciates due to a positive money supply shock, but the effect is insignificant. This finding is interesting because an increase in money supply is generally associated with domestic currency depreciation (Dornbusch, 1976; Krugman et al., 2012).

4.1.4. Impulse responses to a price shock

Fig. 6 shows the the impulse response function of a one standard deviation shock to the CPI and its effect on the macroeconomic variables in Nepal. While the responses of the macroaggregates to the price shock appear to be consistent with theoretical and empirical studies, the effect is largely insignificant for most of the variables, except REER. A positive shock to the domestic CPI appears to increase remittance inflows to Nepal, but the effect is not significant. As prices in Nepal increase, migrants are likely to send more remittances home to support their families. This indicates that the remittances sent to Nepal may have a "welfare motive" (also known as an "altruistic" motive). A positive shock on CPI negatively impacts the money supply throughout, but the effect is insignificant. However, the price effect leads to an appreciation in the exchange rate, and the effect is significant. The appreciation of REER is immediate and peaks at 0.4% above the baseline within one quarter.

4.1.5. Impulse responses to an exchange rate shock

Fig. 7 presents the impulse response function of a one standard deviation shock to the REER and its effect on the macroeconomic variables in the Nepal model. The positive shock of REER (appreciation) has a significant negative impact on remittance inflows. The effect is relatively large, and the remittances troughs at 3.1% below the baseline three quarters after the one-day REER shock. This finding is consistent with previous studies showing that migrants tend to send more dollars back home when their home country's exchange rate depreciates (Yang, 2008) as their families receive more NPR for the same dollar value. Hence, when there is an exchange rate appreciation shock, migrants send fewer dollars home.

REER appreciation negatively impacts GDP until quarter eight, but the impact is insignificant. This result is important because the exchange rate appreciation is expected to be one of the transmission channels for the negative impact of remittances on GDP.

A positive shock on REER (appreciation) has no significant impact on the money supply. The CPI declines in response to the REER appreciation shock for the most part, but the effect is not significant. Generally, the exchange rate and inflation have an inverse relationship in heavily import-dependent countries, such as Nepal. Hence, when the real exchange rate appreciates, it is likely to alleviate some inflationary pressure and thus negatively affect the CPI.

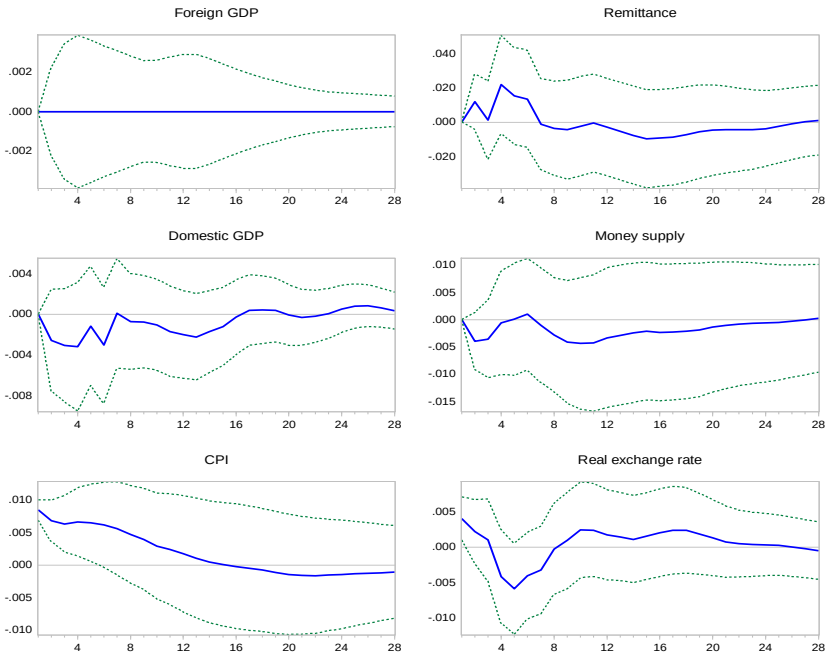

Figure 6: Impulse response functions to a shock to CPI, 2004Q3 to 2019Q4

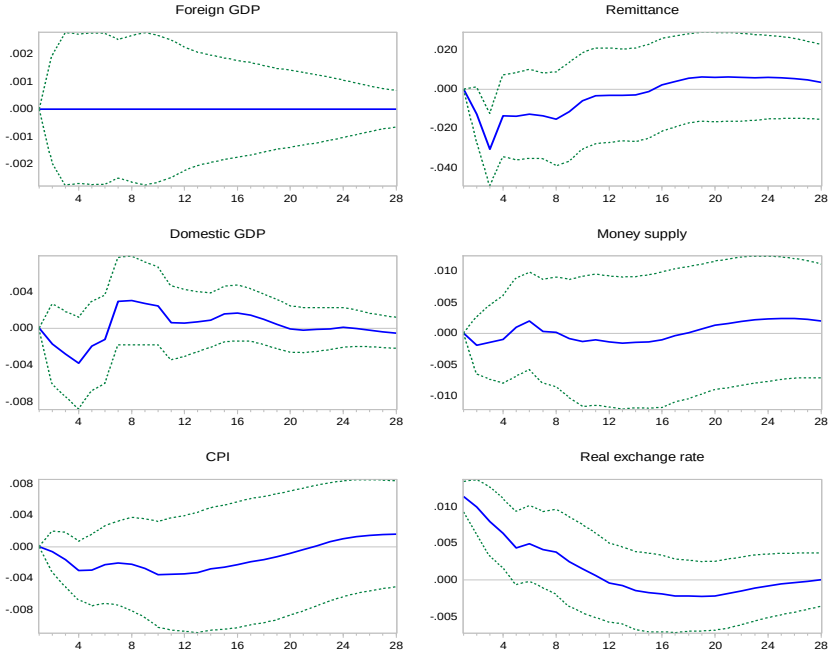

Figure 7: Impulse response functions to an exchange rate shock, 2004Q3 to 2019Q4

4.2. Forecast error variance decomposition

Forecast error variance decomposition is a valuable output of the SVAR model. The variance decomposition of variables - remittance, GDP, money supply, CPI, and REER - is reported in Fig. 8. The variance decomposition results confirm the impulse response findings.

Variance decomposition of remittances: The first chart in Fig. 8 contains the variance decomposition of the remittance inflows to Nepal, which shows that the remittance shock is largely exogenous. Even after 28 quarters, foreign GDP and remittances contributed 75% of the variation. Among the domestic variables, REER (8.5%) is the largest contributor to the variance in remittances. Hence, the IRF findings are further reinforced by the variance decomposition. Money supply (8%), CPI (5%), and domestic GDP (2.5%) contribute to the variance decomposition of remittances over the horizon of 28 quarters.

Variance decomposition of the domestic GDP: The second chart in Fig. 8 shows the variance decomposition of the domestic GDP. Over the horizon of 28 quarters, domestic

GDP contributes 46% of its own variation, followed by foreign output (24%), money supply (11%), and REER (8%). The CPI and remittance have relatively small contributions of 6% and 5%, respectively.

Variance decomposition of M2: The third chart in Fig. 8 shows the variance decomposition of the money supply. Over a horizon of 28 quarters, foreign output (47%) and remittances (16%) are the major contributors to their variance decomposition, apart from their own shocks (31%). This shows that foreign variables have an overwhelming contribution (jointly 63%) to the variance decomposition of money supply in Nepal, while the contribution of domestic variables is small (jointly 7%). CPI, REER, and domestic GDP contributions to the M2 variance decompositions are only 3%, 3%, and 1%, respectively.

Variance decomposition of CPI: Foreign output followed by remittances again has a considerable influence on Nepal's CPI and explains 49% and 8% of the variance decomposition over a horizon of 28 quarters, respectively, apart from its own contribution of 13%. Among the domestic variables, money supply (19%) has the largest contribution to the variance decomposition of CPI during the same period. This reinforces the finding from the IRF that external factors largely determine inflation in Nepal and that domestic variables, including money supply, have a modest contribution. Domestic GDP and REER explain only 6% and 4% of the variance decomposition of CPI, respectively.

Variance decomposition of REER: Foreign output, M2, and remittance have a considerable influence on REER, explaining 24%, 19%, and 14% of the variance decomposition of REER over the horizon of 28 quarters, respectively, apart from its own contribution at 29%. Over the same period, GDP (5%) and CPI (9%) contributed to the variance decomposition of the REER.

4.3. Historical decomposition

Figs. 9 and 10 contain the historical decomposition of GDP for Nepal, containing the international and domestic contributions, respectively. The horizontal axis shows the deviation of output around the trend and presents the relative share of the model shock in the determination of GDP over time. The bar charts are the actual values of GDP. The baseline is the forecast of each variable and is calculated from the parameter estimates of the SVAR model. The line chart shows the contribution of the respective shocks to GDP evolution in the model.

Between 2006Q4 and 2013Q4, Nepal's GDP was mainly below the trend or negative. GDP was then briefly above the trend between 2014Q2 and 2014Q4. However, it sharply contracted from 2015Q1 to 2018Q1 owing to the massive earthquake of 2015, followed by a trade blockade imposed on Nepal by India. As the reconstruction activities increased, the GDP exceeded the trend again from 2018Q2 to 2019Q4. The baseline projection in the model tracks the GDP moderately well, except between 2010Q1 and 2013Q4.

Fig. 9 shows that foreign GDP shock systematically influences the evolution of domestic GDP series among the international variables, while the remittances' influence is much less systematic. For example, during 2010Q1 and 2013Q4, when the domestic GDP was mainly in the negative territory, foreign output shocks were the only negative shock for output. In contrast, the remittance shocks were a positive shock for the output.

Fig. 10 shows that domestic variable shocks appear to have a weaker influence on the evolution of the domestic GDP series than the foreign output shock. For example, during 2010Q1 and 2014Q2, when domestic GDP was largely negative, none of the domestic shocks was negative for output. As seen above the foreign output shocks were negative shocks to output during the same period. Among domestic shocks, the CPI appears to influence the evolution of the domestic GDP series, which is stronger than other domestic variables.

5. Robustness check

The three robustness checks were performed. Different lag lengths were used for the benchmark model in the first exercise. The second robustness check changed the order of the variables in the VAR system. In the third exercise, the interest rate was included in the benchmark model, followed by different lag lengths for the model with the interest rate. In all the robustness check exercises, the qualitative results of the model largely hold and hence reinforce the results from the benchmark model.

The first two robustness checks were straightforward. Given the small sample size, the lag length was changed to two in the first exercise. Among the five lag length criteria results, three find four lags as the optimal lag, but the Schwarz information (SC) criterion finds one lag as optimal. As lag 1 had autocorrelation problems, lag 2 was chosen for the robustness check. The results are presented in Fig. B.3 in Appendix 3. There are minor changes in the significance levels, but the results' qualitative direction largely holds.

In the second robustness exercise, the order of variables was changed. The domestic financial variables are placed first in the system: M2, CPI, and REER followed by a real variable (GDP) at the end. The results are presented in Fig. B.4 in the Appendix. There are minor changes in the results and significance levels, but the results mostly hold.

In the third robustness check, the t-bill is added as a proxy for the interest rate (policy rate). Figs. B.5 and B.6 in the Appendix present results with lags 4 and with lags 2, respectively. The results that we found in the benchmark model largely hold, which is further elaborated in Sections 5.1 and 5.2 below. The results show that i) the response of the interest rate to other macro-variables and ii) the response of macro-variables to the interest rate are weak. This finding reinforces some of the results from the Granger causality test about the relative unimportance of the policy rate to the Nepali economy.

5.1. Impulse responses to the interest rate shock

Fig. 11 shows the impact of the t-bill rate (a proxy for monetary policy shocks) on the macroeconomic variables in

Figure 8: Forecast error variance decomposition for Nepal, 2004Q3 to 2019Q4 (in %)

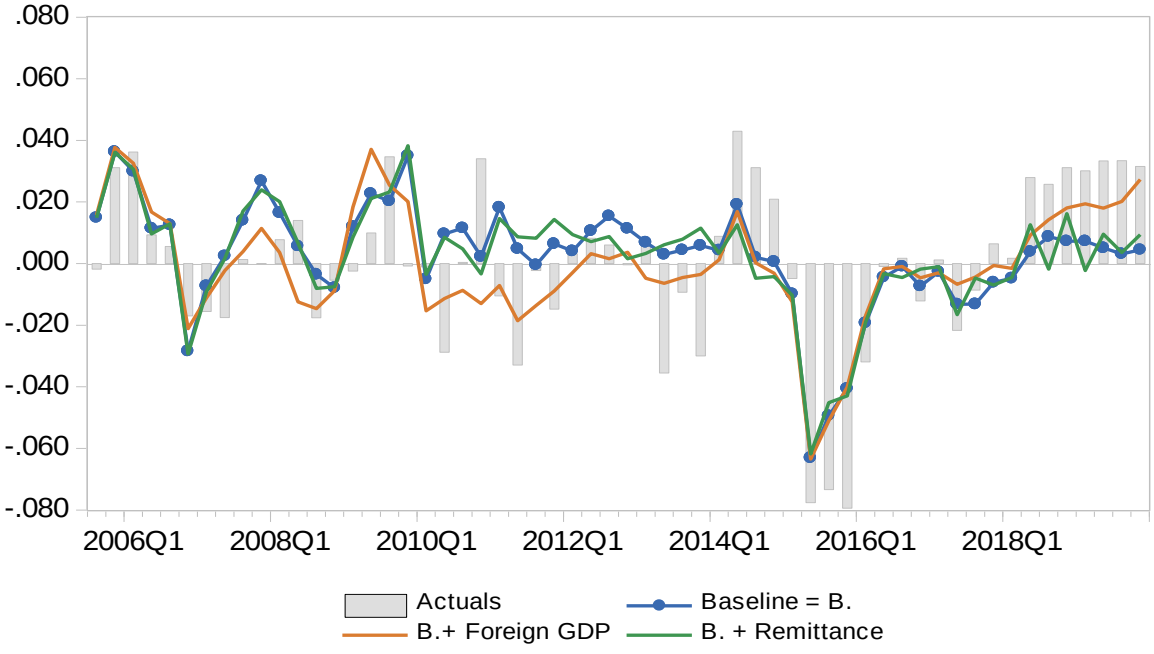

Figure 9: Historical decomposition of GDP for Nepal, 2004Q3-2019Q4: The international contributions

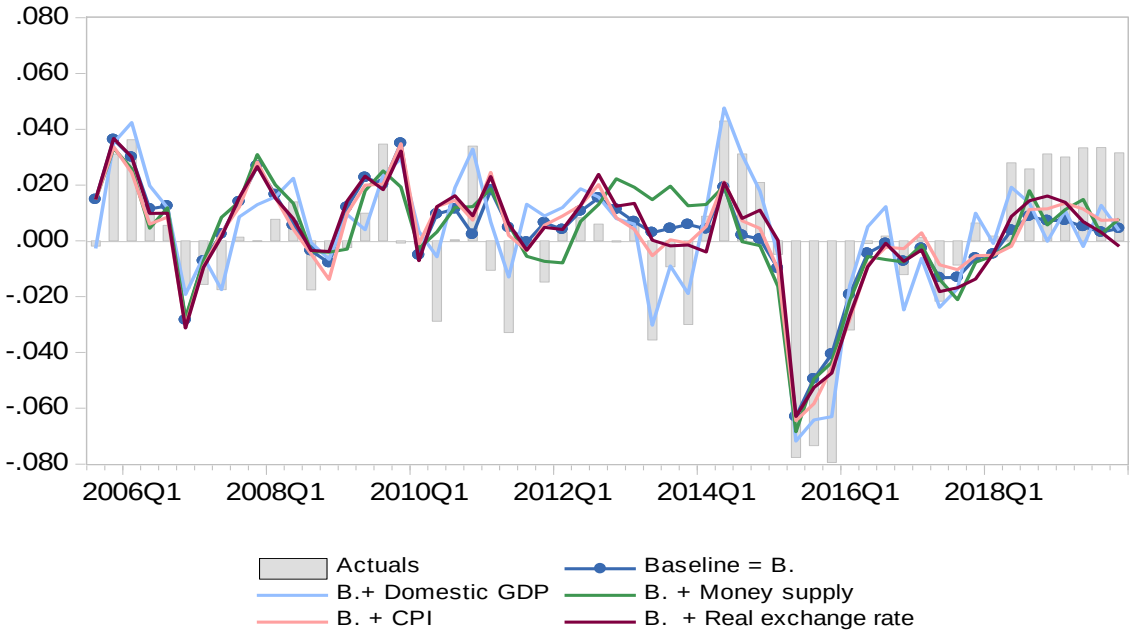

Figure 10: Historical decomposition of GDP for Nepal, 2004Q3-2019Q4: The domestic contributions

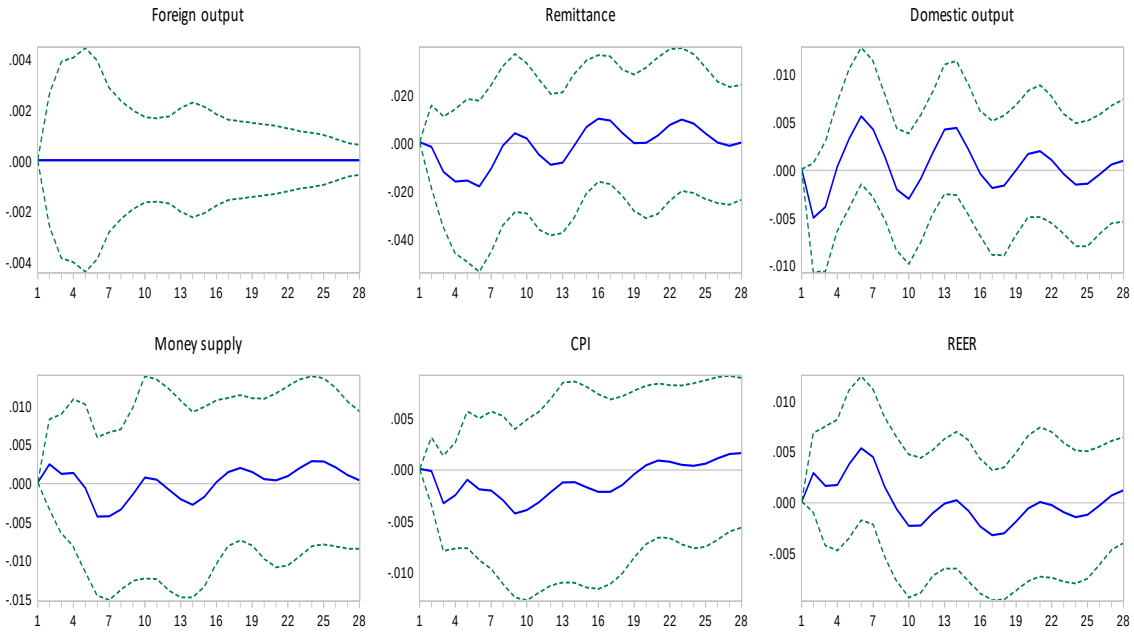

Figure 11: Impulse response functions of remittances and macro-variables to t-bill shock

the system. The results show that none of the variables in the system has a significant impact because of the interest rate shock. This result further reinforces the relative unimportance of the interest rate.

5.2. Impulse responses of t-bill to remittances and macro-variable shocks

Fig. 12 presents the impulse response function of a one standard deviation shocks to remittances and other macro-variables in the Nepal model. The results show that except for foreign output, CPI, and REER, none of the other variables significantly impacted t-bill rates. Positive foreign output leads to a decline in the t-bill rate in Nepal, and

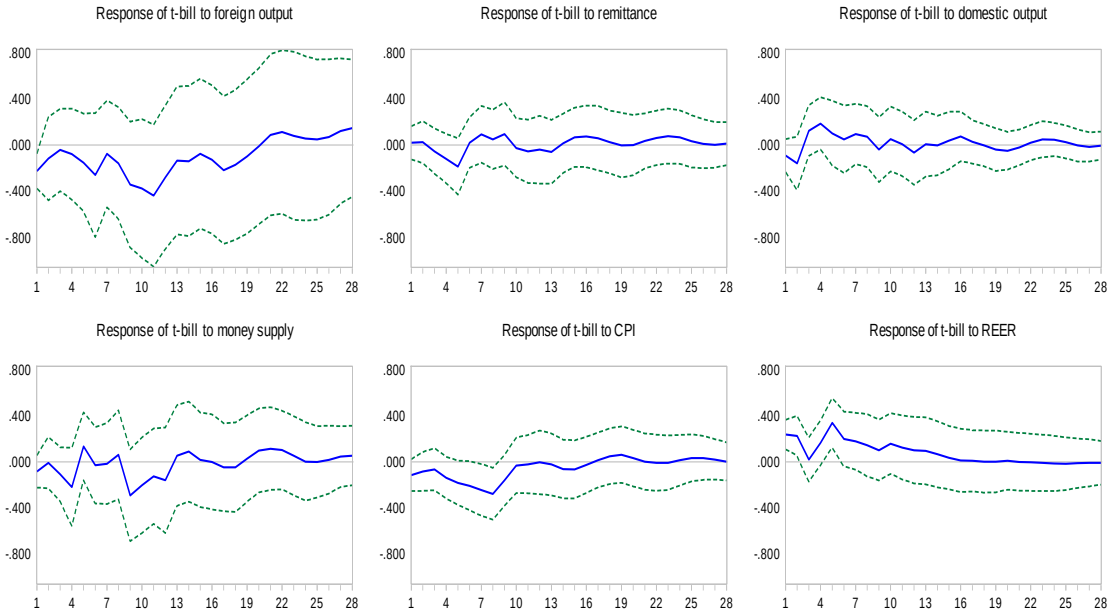

Figure 12: Impulse responses of t-bill to remittances and macro-variable shocks

this effect is significant. The remittance shock also led to a decline in the t-bill rate in Nepal, but the effect was not significant in any period. As a positive shock to foreign output also increases remittances, we can expect an increase in foreign currency inflow into the country when foreign output increases. Generally, central bank is expected to react to tighter monetary policy, that is, by raising the interest rate. However, the interest rate declined in Nepal, which is not surprising for several reasons. First, the decline in the interest rate might be due to the increase in short-term liquidity in financial markets provided by the buoyant global economy and the associated increase in remittances. The combined effect could be downward pressure on the interest rate. The central bank may have reacted to the influx of remittances by lowering the interest rate which occurred in Nepal between 2007–2011 (World Bank, 2018). Second, increasing the interest rate comes with a cost to the exchange rate. With the increase in interest rate, more remittance or private capital inflows are likely to flow, further appreciating the exchange rate and weakening export performance. Hence, monetary authorities may not be willing to immediately increase interest rates without seeing the shock's effect unfold. Third, there is growing evidence that monetary transmission is weak in many developing countries, and the authorities' response may not be swift, as expected by macro theory (Mishra & Montiel, 2013).

Fig. 12 also shows that the t-bill decreases in response to the CPI shock and that the effect is significant. The t-bill troughs at 0.29% below the baseline due to one standard deviation shock to the CPI. The policy response of the monetary authority in Nepal is opposite to the theoretical models and is generally practised by monetary authorities globally. Generally, central banks react by increasing the interest rate when there is inflationary pressure in the economy, whereas, in Nepal, the reaction seems to be the opposite. The study further reinforces previous findings that monetary policy through the interest rate channel has not been effective in Nepal, even after 20 years of starting the policy rate (Maskay & Pandit, 2010; NRB, 2005, 2018a). Instead, these results further reinforce that the interest rate channel in Nepal is extremely weak and underdeveloped, and monetary authorities may even respond in opposite directions at times. IMF (2011) specifically wrote, *"There is no evidence that monetary policy tools are actively used to manage inflation (in Nepal). Rather, there seems to be some procyclicality in the monetary conditions."*

6. Conclusion

Remittances are generally stable, counter-cyclical, and less volatile than other external flows (Chami et al., 2008; Frankel, 2011; De et al., 2019). However, the management of remittances has been a critical macroeconomic challenge for policymakers in remittance-receiving countries, especially when the inflows are substantial, such as in the case of Nepal. Macroeconomic modelling of the Nepali economy is in the infancy stage, primarily due to the unavailability of reliable data. This study uses novel quarterly GDP data to close both gaps by examining the effects of remittances and other macroeconomic variable shocks on Nepal's small open economy between 2004 and 2019 using an SVAR model. This study contributes to these two strands of literature: first, it contributes to the literature on the impact of remittances on macroeconomic variables in a remittance-dependent country. Second, as this study uses recursive SVAR with short-term restrictions, it also contributes to the literature on VAR.

This study finds that remittances influenced several macroaggregates in Nepal. The remittance shock increases

the money supply and prices and appreciates the real exchange rate. Despite the massive inflow of remittances to the Nepali economy, the impact on the real GDP is not significant during the study period. The study also finds that remittances are primarily driven by external factors, particularly the output of foreign partners. However, the study also finds that the real exchange rate significantly affects Nepal's remittance inflows. In Nepal, migrants also tend to send more remittances in response to inflation, but the effect is insignificant. The study does not find that the interest rates in Nepal influence remittance inflows. Taking these three influences together, it reinforces that the "welfare motive" (also known as the "altruistic" motive) appears to be a more dominant reason for sending remittances by the migrants than the "investment motive" during the study period.

The study finds that remittances contribute to a significant increase in the money supply. A positive shock to remittances also has an inflationary effect on the Nepali economy, which solved the price puzzle found in earlier studies in Nepal (NRB, 2018a; Panday, 2014a). The study also find that a positive shock to remittances appreciates the real exchange rate, which solved the exchange rate puzzle found in previous studies in Nepal (ADB, 2011; NRB, 2018a).

On the other macroaggregates, the study finds that money supply has a significant, albeit modest, impact on inflation. This finding reinforces a growing body of literature that finds a relationship between money supply and the inflation nexus in Nepal (Ginting, 2007; IMF, 2011). However, a positive shock to inflation leads to a decline in the money supply, but the effect is insignificant. Consistent with previous studies, this finding reinforces that the monetary authorities in Nepal use money supply as the primary tool of monetary policy. However, the effect may have been impaired because inflation in Nepal is mainly exogenous. The study also finds that most macroeconomic variables do not respond to interest rates, which poses a challenge for policymakers in Nepal.

Previous studies show that remittances play a crucial role in supporting consumption, reducing poverty, and improving health and education in Nepal. However, most literature at the macro level has indicated a negative impact on GDP and growth. The study, using quarterly data, finds that the impact on GDP is not significant. The transmission channel of remittances to the economy is complex. The annual data shows that while imports have increased and exports have declined considerably in Nepal, this period also coincided with an increase in investment (both private and public), easing of credit and liquidity constraints in the economy, and a considerable increase in domestic revenue. In the literature, these factors are associated with an increase in output and economic growth. Therefore, further evidence and data are needed to study remittance and macroeconomic relationships in Nepal. The study shows that policymakers in Nepal, however, need to be clear-eyed about the benefits and pitfalls of "too much" remittances and better manage the remittances so that some of the negative impacts, such as the impacts on inflation and the exchange rate, can be better managed. Given that Nepal's demographic divide is likely to continue until the mid-2030s, young people are likely to continue migrating outside Nepal to search for better opportunities (Cosic et al., 2017); thus, remittances will continue to be a major source of external flows for the foreseeable future.

One of the limitations of this study is the sample size due to the short timeframe of the availability of real sector quarterly data. As more quarterly data become available, future studies could incorporate more extended datasets and explore further interactions between remittances and macro-variable interactions. Additionally, the study constructs foreign output using a simple average of the trade-weighted real GDP of Nepal's top 10 trading partners. The remittance-weighted real GDP of top remittance-sending countries could be a better variable but could not be constructed due to data unavailability. These issues are parked for future research.

A. Data description and sources

Foreign GDP: The foreign output data were constructed as a simple average of the trade-weighted real GDP of Nepal's top ten trading partners. Quarterly real GDP (million USD) for partner countries were obtained from the GEM of the World Bank. Trade weights (constant average 2004–2019) were calculated from the IMF's DOTS. The data are seasonally adjusted using Census X13 and linearly detrended.

Remittances: Quarterly remittances data (nominal, million USD) were obtained from the IFS of the IMF. It was converted to NPR by the average exchange rate for that period which was also obtained from the IFS of the IMF. The data was then deflated using CPI (2001Q2 = 100). The data are seasonally adjusted using Census X13 and linearly detrended.

Domestic output (GDP): Quarterly GDP seasonally adjusted data (million NPR, 2001 prices) were obtained from the CBS, July 2020 vintage. The data are then linearly detrended.

CPI: The CPI data were obtained from the IFS/IMF. The base year was changed to 2001Q2 = 100. The data are seasonally adjusted using Census X13 and linearly de-trended.

M2: The M2 data (nominal, million NPR) were obtained from the IFS/IMF. Monthly data are converted to quarterly by taking the period end. The date is then seasonally adjusted using Census X13 and linearly de-trended

REER: The source of the REER data is the Bruegel dataset. Monthly data are converted to quarterly by taking the period end. The data are rebased to 2001Q2 = 100. The data are then seasonally adjusted using Census X13 and linearly detrended.

B. Charts and tables

Figure B.1: Plots of the variables in the SVAR model for Nepal

Table B.1
VAR stability test

Root	Modulus
$0.900640 - 0.216415i$	0.926277
$0.900640 + 0.216415i$	0.926277
$0.907871 - 0.169767i$	0.923607
$0.907871 + 0.169767i$	0.923607
$0.637840 - 0.655539i$	0.914643
$0.637840 + 0.655539i$	0.914643
$-0.498604 + 0.689051i$	0.850528
$-0.498604 - 0.689051i$	0.850528
$0.625004 - 0.543792i$	0.828456
$0.625004 + 0.543792i$	0.828456
$-0.686613 - 0.429811i$	0.810046
$-0.686613 + 0.429811i$	0.810046
$0.338998 + 0.696106i$	0.774263
$0.338998 - 0.696106i$	0.774263
$0.734323 - 0.215846i$	0.765389
$0.734323 + 0.215846i$	0.765389
-0.663135	0.663135
$-0.158538 - 0.610254i$	0.630511
$-0.158538 + 0.610254i$	0.630511
$-0.190563 + 0.575277i$	0.606018
$-0.190563 - 0.575277i$	0.606018
0.602465	0.602465
$-0.379529 - 0.403456i$	0.553912
$-0.379529 + 0.403456i$	0.553912

Note: No root lies outside the unit circle. VAR satisfies the stability condition.
Included observations: 57. Sample: 2004Q3 2019Q4.

Table B.2
VAR lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	688.1906	NA	3.77e-18	-23.09441	-22.01912	-22.67651
1	955.5489	431.5256	1.16e-21	-31.21224	-28.84660*	-30.29287
2	992.3987	51.71912	1.22e-21	-31.24206	-27.58607	-29.82122
3	1043.630	61.11830	8.54e-22	-31.7765	-26.83017	-29.85419
4	1109.417	64.6321*	4.20e-22*	-32.82163	-26.58495	-30.39785*
5	1156.276	36.17221	5.17e-22	-33.20267*	-25.67564	-30.27741

Note: * indicates lag order selected by the criterion.
Included observations: 57. Sample: 2004Q3 2019Q4.
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table B.3
Test for serial auto-correlation

Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	48.06417	36	0.0861	1.423725	(36, 81.8)	0.0957
2	35.56854	36	0.4890	0.984639	(36, 81.8)	0.5070
3	33.08893	36	0.6078	0.903919	(36, 81.8)	0.6241
4	36.05400	36	0.4661	1.000681	(36, 81.8)	0.4844
Null hypothesis: No serial correlation at lags 1 to h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	48.06417	36	0.0861	1.423725	(36, 81.8)	0.0957
2	88.18190	72	0.0945	1.279690	(72, 71.1)	0.1498
3	148.0093	108	0.0064	1.456086	(108, 41.6)	0.0854
4	295.8500	144	0.0000	2.276607	(144, 7.9)	0.1061

58 observations included in the VAR Residual Serial Correlation LM Tests.
*Edgeworth expansion corrected likelihood ratio statistic.

Table B.4
Normality test

Component	**Skewness**	**Chi-sq**	**df**	**Prob.***
1	0.359522	1.452725	1	0.2281
2	0.288541	0.949884	1	0.3297
3	-0.349836	1.378547	1	0.2403
4	0.478892	2.498620	1	0.1139
5	0.353166	1.403860	1	0.2361
6	-0.246427	0.698083	1	0.4034
Joint		8.381719	6	0.2114

Component	**Kurtosis**	**Chi-sq**	**df**	**Prob.**
1	3.838368	2.747063	1	0.0974
2	2.375702	1.176186	1	0.2781
3	3.051467	0.075883	1	0.7830
4	5.183694	10.33189	1	0.0013
5	3.077977	0.101467	1	0.7501
6	3.836656	3.658942	1	0.0558
Joint		18.09143	6	0.0060

Component	**Jarque-Bera**	**df**	**Prob.**
1	4.199788	2	0.1225
2	2.126070	2	0.3454
3	1.454430	2	0.4833
4	12.83051	2	0.0016
5	1.505327	2	0.4711
6	4.357025	2	0.1132
Joint	26.47315	12	0.0092

Table B.5
Granger causality: Benchmark model with interest rate, 4 lags

Dependent variable: REMITTANCE

Excluded	Chi-sq	df	Prob.
FOREIGN OUTPUT	18.83442	4	0.0008
DOMESTIC OUTPUT	8.804685	4	0.0662
MONEY SUPPLY	20.70971	4	0.0004
CPI	29.80712	4	0.0000
REER	32.31712	4	0.0000
T-BILL	8.849398	4	0.0650
All	177.6701	24	0.0000

Dependent variable: DOMESTIC OUTPUT

Excluded	Chi-sq	df	Prob.
FOREIGN OUTPUT	18.54541	4	0.0010
REMITTANCE	16.15413	4	0.0028
MONEY SUPPLY	15.03434	4	0.0046
CPI	13.53384	4	0.0089
REER	5.443649	4	0.2447
T-BILL	11.19013	4	0.0245
All	80.83327	24	0.0000

Dependent variable: MONEY SUPPLY

Excluded	Chi-sq	df	Prob.
FOREIGN OUTPUT	10.53035	4	0.0324
REMITTANCE	29.71988	4	0.0000
DOMESTIC OUTPUT	5.511711	4	0.2387
CPI	10.16640	4	0.0377
REER	9.045257	4	0.0600
T-BILL	**5.039530**	**4**	**0.2833**
All	108.2289	24	0.0000

Dependent variable: CPI

Excluded	Chi-sq	df	Prob.
FOREIGN OUTPUT	3.292405	4	0.5101
REMITTANCE	20.87272	4	0.0003
DOMESTIC OUTPUT	55.47854	4	0.0000
MONEY SUPPLY	23.68774	4	0.0001
REER	3.021498	4	0.5542
T-BILL	**14.42625**	**4**	**0.0061**
All	121.9988	24	0.0000

Continue

Dependent variable: REER

Excluded	Chi-sq	df	Prob.
FOREIGN OUTPUT	5.727986	4	0.2204
REMITTANCE	34.61972	4	0.0000
DOMESTIC OUTPUT	4.658765	4	0.3241
MONEY SUPPLY	27.90428	4	0.0000
CPI	23.82097	4	0.0001
T-BILL	12.33404	4	0.0150
All	134.8417	24	0.0000

Dependent variable: T-BILL

Excluded	Chi-sq	df	Prob.
FOREIGN OUTPUT	20.15608	4	0.0005
REMITTANCE	13.85530	4	0.0078
DOMESTIC OUTPUT	15.48639	4	0.0038
MONEY SUPPLY	23.59223	4	0.0001
CPI	43.87529	4	0.0000
REER	41.66536	4	0.0000
All	131.7305	24	0.0000

Table B.6
LR Ratio test: Restricted model (t-bill not included) vs unrestricted model (t-bill included)

Likelihood ratio tests of whether to include interest rate in the model		
Hypothesis	**Statistic**	p-value
H0: No interest rate	1.59	0.995

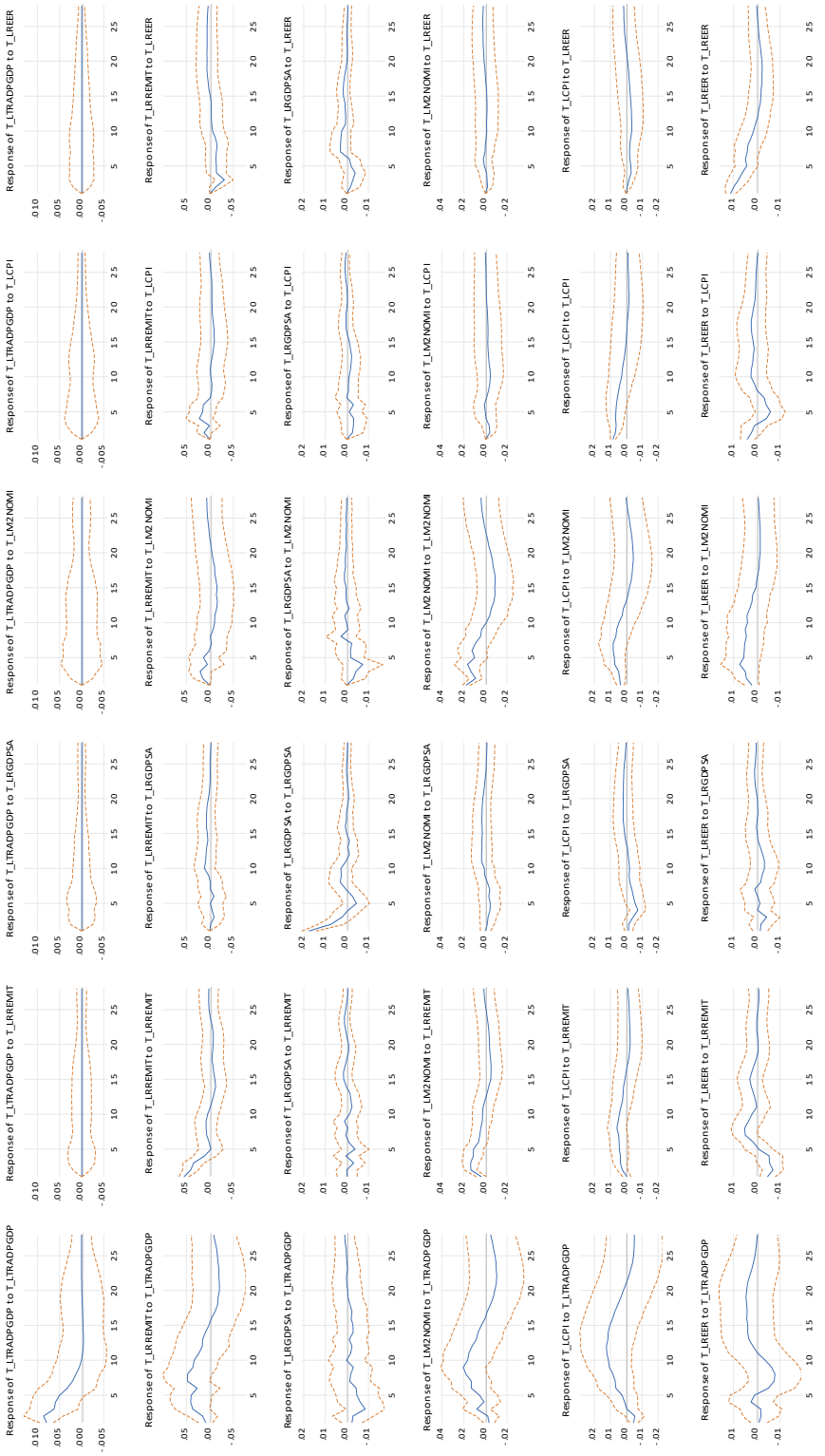

Figure B.2: Impulse responses: Benchmark model with 4 lags

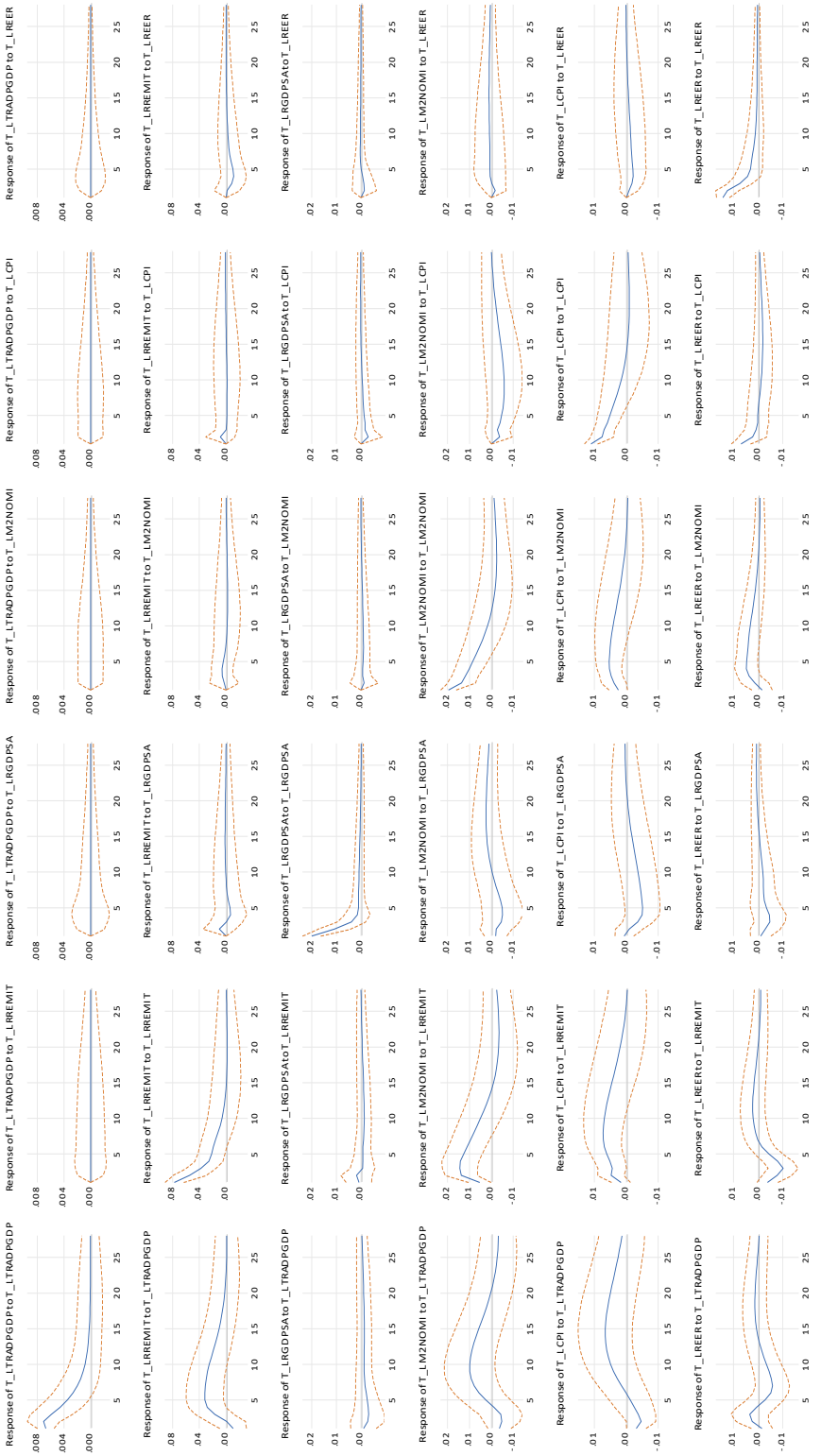

Figure B.3: Impulse responses: Robustness check, benchmark model with 2 lags

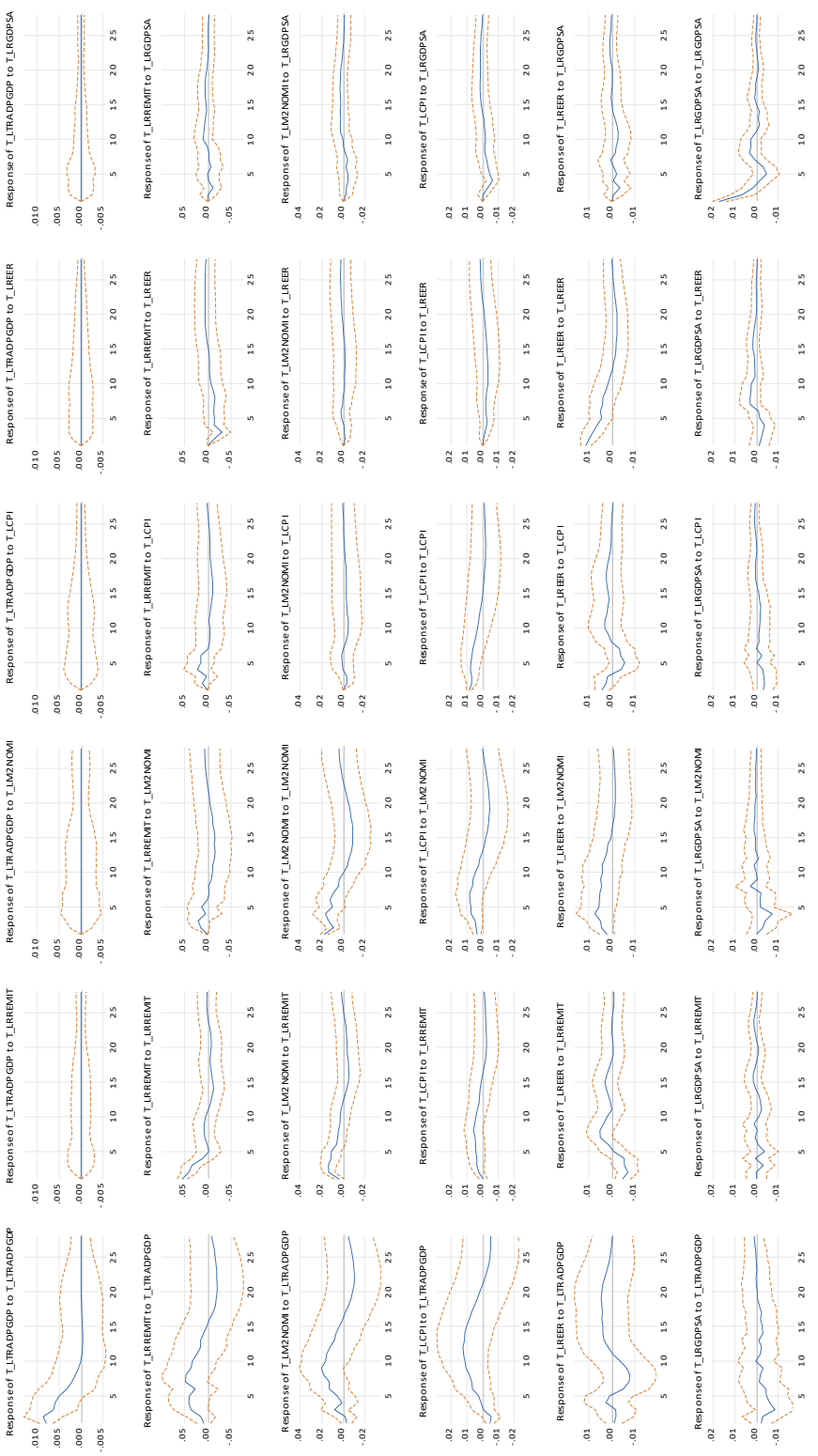

Figure B.4: Impulse responses: Robustness check, variables order change in the benchmark model, 4 lags

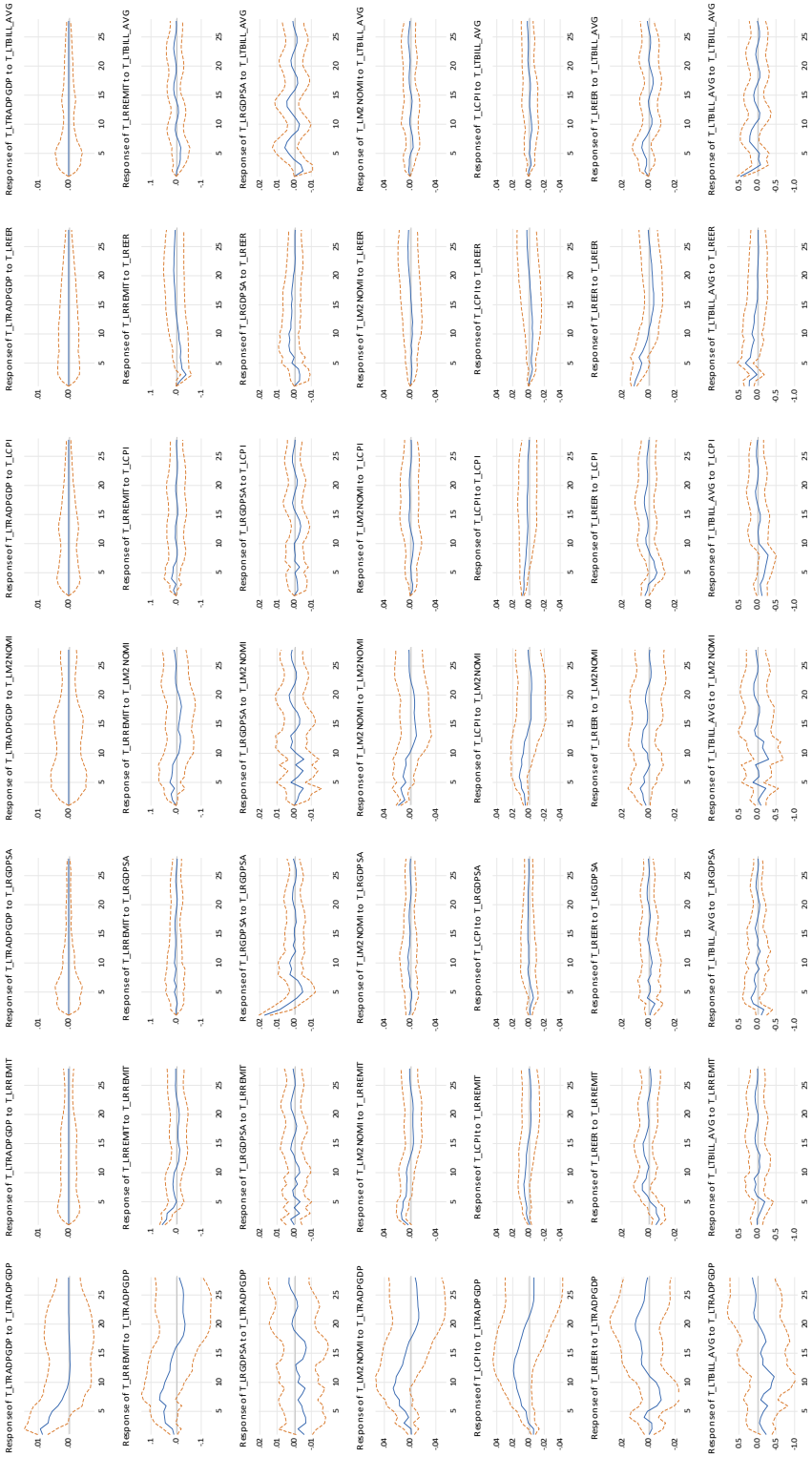

Figure B.5: Impulse responses: Robustness check, interest rate in the main model, 4 lags

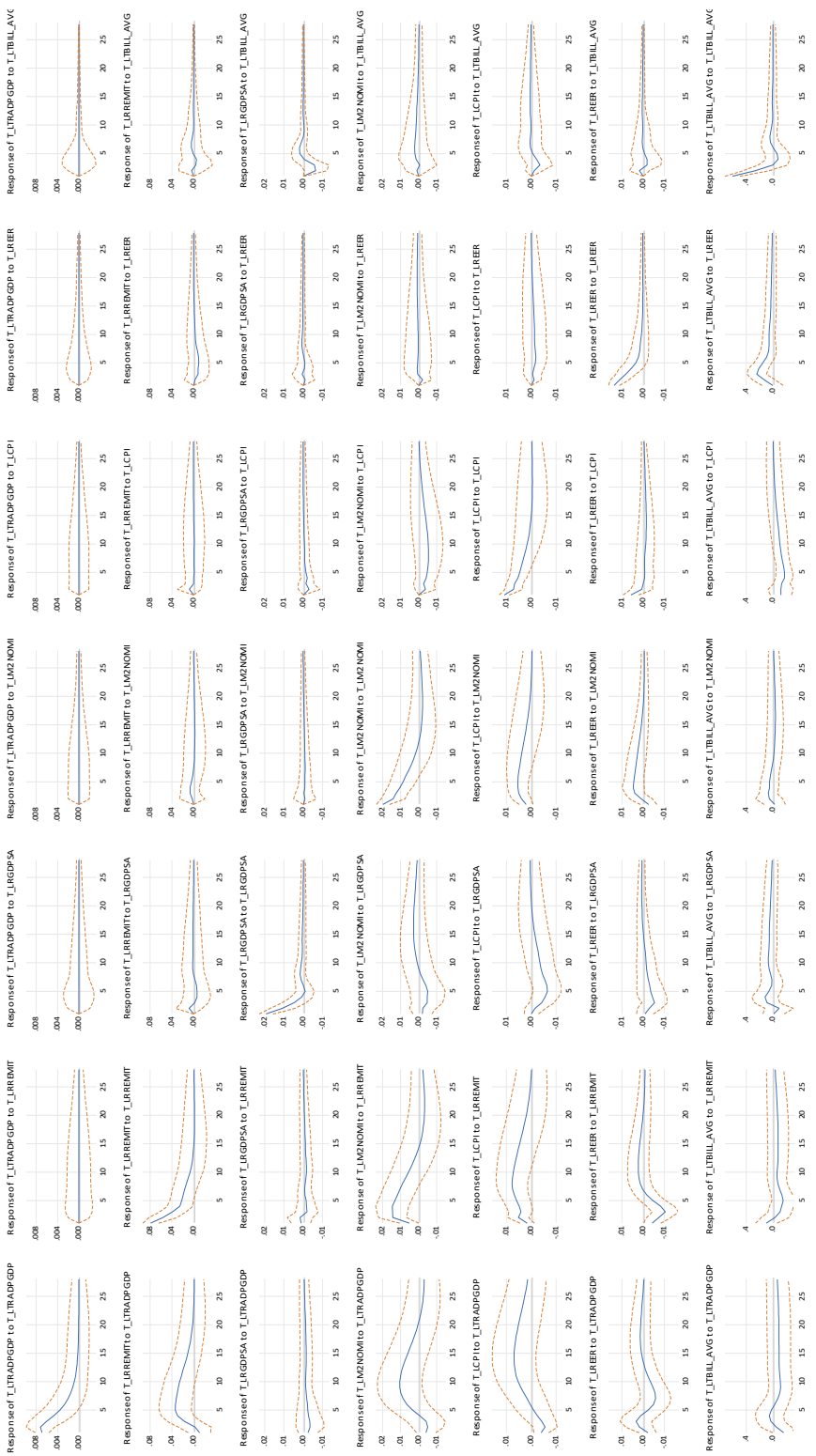

Figure B.6: Impulse responses: Robustness check, interest rate in the main model with 2 lags

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