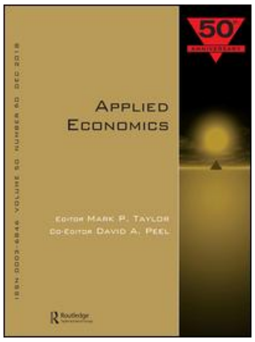

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Assessing the price and output effects of monetary policy in Vietnam: evidence from a VAR analysis

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ABSTRACT
Using monthly data, we perform a vector-autoregressive analysis to measure the effects of monetary policy on the Vietnamese economy. We concentrate our attention on the period following the introduction of the Law on Central Bank in January 1998 (which brought the national monetary policy and its objectives in line with international practices). Contrary to previous studies on Vietnam, we find evidence suggesting that monetary policy (through the manipulation of interest rates) is an effective policy tool in stabilizing prices. However, credit growth tends to induce inflationary pressures. In addition, we find that an expansion of broad money supply leads to an increase in industrial production.

KEYWORDS
Monetary policy; Vietnam; price level; VAR model

JEL CLASSIFICATION
E58; E52

I. Introduction

The literature on the effectiveness of monetary policy in developed countries largely points to significant impact on the real economy at least in the short-run (Bernanke and Gertler 1995). In the context of developing countries, however, the impact is less clear, possibly due to less developed financial structures (see Laurens 2005; Mishra, Montiel, and Spilimbergo 2012; Mishra and Montiel 2013). Empirical studies suggest that the effect of monetary policy is very heterogeneous (in terms of the effect sign, the magnitude, and the occurrence of anomalous/'puzzle' effects) and possibly affected by publication bias. This observed heterogeneity renders one-size-fits-all policy solutions inappropriate and, hence, necessitates that policy makers take into account country-specific circumstances when evaluating the conduct of their monetary policy (especially in countries like Vietnam with limited empirical research to provide guidance). For the case of Vietnam, a comprehensive analysis of the output and price effects of monetary policy becomes especially necessary because of the transformation of the Vietnamese economy and the changing role of the Central Bank since the adoption of the Law (No.01/1997/QH10) on the Central Bank in 1998. The findings and quality of the existing studies on Vietnam are unfortunately limited and hence do not offer sufficient guidance for evidence-based policy.

To our knowledge, the existing literature on the effect of monetary policy in the context of Vietnam is rather sparse (and the few published studies are based on limited samples that span less than 10 years). Some studies report a positive causality between the increase in broad money and/or exchange-rate deprecation and inflation (Goujon 2006; Hung and Pfau 2009; Bhattacharya 2014). Vo and Nguyen (2017) show that the effect of monetary policy occurs primarily through the cost channel (i.e. firms' costs depend directly on the nominal rate of interest). Anwar and Nguyen (2018) indicate that the monetary policy in Vietnam is susceptible to foreign shocks, such as the world oil price or the Federal funds rate. However, the effect of monetary policy on prices and output still remains largely under-researched.

We aim to contribute to the existing literature by providing a vector auto-regressive (VAR) analysis covering the period from January 1998 (when the new Law on Central Bank was adopted) to November 2017. We focus on the effect of the interest rate (the most important and extensively used instrument of monetary policy in Vietnam)

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on aggregate prices and output. First, we discuss the properties of our dataset (seasonality, structural breaks, and stationarity). Second, we shift our attention to the methodological aspects of our analysis and argue that a Cholesky decomposition VAR model is more appropriate for Vietnam than a structural VAR framework. Then, we perform Granger causality tests and carry out impulse response and variance decomposition analyses to uncover the impact of monetary policy on the aggregate price level and output.

The remainder of this paper is organized into five sections. Section 2 summarizes the literature. Section 3 introduces the policy framework and environment in Vietnam. Section 4 proposes the methodology and data analysis. Section 5 discusses the impulse responses and variance decomposition analyses. Section 6 concludes.

II. Literature review

There are only a few published studies on the empirical effect of monetary policy in Vietnam, and these studies mainly focus on transmission channels (Hung and Pfau 2009; Vo and Nguyen 2017; Anwar and Nguyen 2018). Some examine the determinants of inflation (Bhattacharya 2014; Nguyen, Cavoli, and Wilson 2012) and the role of exchange rate regimes in achieving price stability (Goujon 2006; Phuc and Duc-Tho 2009; Phuc et al. 2014).

In terms of the transmission channels, Hung and Pfau (2009) employed Granger causality tests, impulse response functions and variance decomposition analyses using quarterly data from 1996Q2 to 2005Q4. The authors argued that money aggregates (such as the growth rate of broad money – M2) were the best proxy for the monetary policy stance. They set up a core VAR model with three variables (industrial production, price level and money supply). As a next step, the authors extended the core model with three different variables representing the three different channels (i.e. the interest rate, bank lending and exchange-rate channels). In all cases, the authors did not find any significant effect of monetary policy on industrial production and prices for all three channels. Granger causality tests and variance decomposition analyses showed that broad money (M2) had a positive correlation with output, but no relationship with the changes in price level. This study, however, has some limitations. First, the small number of endogenous variables (only 4) of the extended models is unable to capture the full information used by the Central Bank when designing and conducting its monetary policy. For example, the extended model of the exchange-rate channel failed to include an interest rate variable (which is an important tool used by the Vietnamese Central Bank). Similarly, the extended model of the interest-rate channel ignored the exchange-rate variable (that has been influencing the fluctuation of price levels, Bhattacharya 2014; Goujon 2006; Phuc and Duc-Tho 2009). Second, the study covers the period from 1996 to 2005. However, the model did not take into account possible distortions in 1997 due to the Asian crisis or any structural changes in 1998 when the Law on Central Bank was enforced.

Applying a similar approach as Hung and Pfau (2009), Vo and Nguyen (2017) constructed a VAR model with three variables (industrial production, price level and interest rate). They investigated the impact of monetary policy through the interest rate, exchange-rate and asset price channels using monthly data from January 2003 to December 2012. In the case of the latter two channels, monetary policy appeared to be rather ineffective – in other words, the authors did not find any evidence of a significant effect of monetary policy on industrial production and price levels, operating through the exchange-rate and asset prices. Nevertheless, they found that CPI responds positively (i.e. contrary to intuition) to an increase in interest rates. The authors concluded that there is a monetary policy impact via the cost channel (i.e. an unconventional, or 'price puzzle', response of the price level). This type of response may be explained by the sequence of variables in their Cholesky recursive VARs, which ordered industrial production and price level before interest rate. Furthermore, the robustness of outcomes was not assessed against alternative orderings.

Using a structural VAR model with quarterly data from 1995Q1 to 2004Q4, Anwar and Nguyen (2018) investigated the dynamic responses of output and price levels to shocks from monetary policy (interest rate, money supply and exchange-rate) and to external shocks (the world oil price and the US Federal Fund rates). The study finds no evidence of a significant effect of monetary policy on these outcome variables, but indicates that monetary policy in Vietnam is susceptible to external shocks. However, this structural VAR employed too many prior (over-identified) assumptions that restrict the contemporaneous interaction among variables.

Turning to the determinants of inflation, Bhattacharya (2014) recently used quarterly data from 2004Q1 to 2012Q4 to estimate a VAR model with five variables (price level, output, credit, exchange rate, and interest rate). The author found several factors that influence inflation. In the short-term, nominal exchange rate depreciation has a statistically negative impact on inflation. In the long term, inflation responds positively to an increase in the growth rate of credit. Following an increase in interest rates, the evidence from accumulated impulse responses indicates that output responds negatively in the first five quarters (and the 'price puzzle' responses occur in the first two quarters). Phuc et al. (2014) distinguished between tradable and non-tradable goods for a price-taking economy to investigate the determinants of Vietnamese inflation. They show that inflation in the 1990s was caused by excessive money supply and the devaluation of the local currency against the US dollar.

Apart from the above peer-reviewed studies, several working papers (for example, Van Hai and Trang 2015; Phan 2014) and two PhD theses (Nguyen, 2014a; Pham Anh 2016) have recently employed (S) VAR models to evaluate the impacts of monetary policy in Vietnam. However, the variable selection (model identification) was loosely aligned with the actual implementation of monetary policy in Vietnam (the International Monetary Fund (IMF) and the Bank for International Settlements (BIS) carried out analysis on the mechanisms of implemented monetary policy in Vietnam, see (Camen 2006; IMF 2003, 2006). These studies are largely pieces of exploratory research on very short time periods.

The monetary policy environment in Vietnam

This section turns attention to the monetary policy environment in Vietnam in recent ^years. The first turning point of central banking policy in Vietnam was the shift from a mono-bank system to a two-tier banking system that includes a Central Bank (the State Bank of Vietnam) and four state-owned commercial banks in 1988 (Camen 2006). As a result, the functions of the Central Bank and commercial banks became separated. This process was part of the financial reform that took place in the late 1980s, which gradually transformed Vietnam from a centrally planned economy to a more market-based economy.

The second turning point was 1998 when the Law on the Central Bank in Vietnam was enforced (which brought the national monetary policy and its objectives in line with international practices). The law was slightly amended in 2010, but the main content remained the same. According to the Law, the ultimate goal of monetary policy is price stability (and in addition, monetary policy also supports economic growth). Intermediate targets are set in relation to growth in broad money (M2) and total credits. These quantitative indicators are often selected by countries at early stages of financial market development (Laurens 2005). Table 1 summarizes the targeted and actual growth rate of M2 and total credits from 2000 to 2016 (2000 is the first year for which data on targets are available).

To achieve these targets, a combination of rule-based and market-based instruments have been adopted in Vietnam. However, rule-based instruments (especially the use of interest rates and exchange rates) are more commonly used. Table 2 summarizes the key features of policy instruments.

Although price stability is the ultimate goal, the conduct of monetary policy in Vietnam is also used as a stimulus to support growth. According to the annual reports and directives of the Central Bank of Vietnam, a tighter monetary policy (in the form of a smaller pace of increase in M2) was applied only a few times between 1998 and 2017 (for instance in 2011 to reduce the inflationary pressure from oil prices).

The undergoing financial reform has also resulted in many financial innovations, liberalization, economic openness, and rapid development of the financial markets and the banking system.

Table 1. Targeted and actual growth rate of M2 and total credit.

	Broad money (M2) growth (annual, %)			Total credit growth (annual, %)		
	Target	*Actual*	*Mismatch (% target)*	*Target*	*Actual*	*Mismatch (% target)*
2000	38	38.96	3%	28–30	38.14	27%
2001	23	25.53	11%	20–25	21.44	0%
2002	22–23	17.7	−19%	20–21	22.2	6%
2003	25	24.94	0%	25	28.41	14%
2004	22	30.4	38%	25	41.6	66%
2005	22	29.6	35%	25	31.1	24%
2006	23–25	33.6	36%	18–20	25.4	27%
2007	20–23	46.1	107%	17–21	53.9	157%
2008	32	20.3	−37%	30	25.4	−15%
2009	18–20	29	47%	21–23	37.5	63%
2010	25	33.3	33%	25	31.2	25%
2011	15–16	12.4	−17%	20	14.4	−28%
2012	14–16	17	13%	15–17	8.85	−41%
2013	15	19	27%	12	12.5	4%
2014	17	17.69	4%	12–14	12.62	0%
2015	16–18	16.23	0%	13–15	17.29	15%
2016	16–18	18.25	1%	18–20	18.38	0%
Average	24.3	25.3	4%	23.1	25.9	12%

Note: in case the target is a range (for example in 2002), the average value of target is used to calculate the mismatch. Sources: author calculations based on targets and actual growth rates of M2 and total credit from various resources: (1997–1999: IMF (2002:p31); 2000–2010: RS-02 (2012:p98); and 2011–2016: Directives of State Bank of Vietnam).

Table 2. Main features of policy instruments.

Instruments	Features
Required reserve ratios	Discretionary measure, it encourages a relatively higher ratio for foreign currency deposits to fight dollarization(*)
Re-financing	Supplies instant liquidity for credit institutions and provides funds for state-controlled commercial banks
Open market operations	Newly established in 2000, still small in scale, few types of financial options available in the market.
Interest rate	Various types of policy interest rates: base rate (policy interest rate), re-financing rate, discount and rediscount rate. Discretionary ceilings (or band from the base rate) adopted for commercial banks' lending and deposit rates (and extensively used in high inflation periods, such as from May 2008 to Feb 2010 and from 2011 to 2016).
Exchange rate	Flexible exchange-rate regime. There are set bands for exchange rates applied by commercial banks(**)

Note: (*): despite being a partially dollarized economy, the extent of dollarization in Vietnam has become smaller in recent years. Foreign currency amounted to 42% of total liquidity in 2000 (Goujon 2006) *and fell to about 20% in 2010. (**): see* Nguyen, Cavoli, and Wilson (2012) *for a review on the Vietnamese exchange-rate regimes.*

The score of the financial development index (by the World Economic Forum, which captures the extent of financial market and institutional development) has been increasing over time for Vietnam, but is still lower than in neighboring countries and in comparision to the average level of emerging economies (IMF 2017).[1] In addition, the financial sector is largely bank-centric. In 2016, the total assets of the banking sector were equivalent to 194% of GDP and accounted for 96% of the total assets of the financial sector (and the capitalization of the stock market amounted to 33% of GDP, although the corporate bond market still remains under-developed, see (IMF 2017). The movement of the two main target variables of monetary policy (price stability and growth) and its main policy instruments (policy interest rates) are depicted in Figure 1 (for the period of our analysis).

The movements of the three main macroeconomic variables illustrate the business cycle of the Vietnamese economy and the conduct of Vietnamese monetary policy. The main instruments (policy interest rates) and inflation rates co-move, whereas GDP growth moves opposite to inflation and interest rates. GDP slowdown occurs during the period that inflation rates are high (for example during the periods from 2008Q1 to 2009Q3 and from 2010Q4 to 2012Q3). The GDP growth shows an upward trend during period of low and stable interest rates (for example during the periods from 1999Q3 to2007Q3, and from 2014Q1 to 2017Q4). However, Figure 1 is only a visual inspection of the movement and in need of further econometric investigation in the following sections.

III. Methodology and data analysis

According to Walsh (2017, 18), 'much of the understanding of the empirical effects of monetary policy on real economic activity has come from the use of vector auto-regression (VAR) frameworks pioneered by Sims (1972, 1980)'. However, the specification of VAR models (such as variable selection, lag length used, and in particular the identification assumptions) could influence the outcomes of a VAR model (Stock and Watson 2001). Therefore, a VAR model should be best designed in a way that reflects the actual implementation of monetary policy and the context of the country investigated (Walsh 2017). We first discuss our variable selection and then proceed to explain the identification of our VAR model for Vietnam.

[1]The financial reform index of Vietnam is still at relatively low levels, but has been on the rise. It was 1.75 in 1990, 5.75 in 1999, and 9.5 in 2005 (the scale is from 1 to 20) (Abiad, Detragiache, and Tressel 2010). See also Sviryzenka (2016) for further information on the calculation of financial development indices.

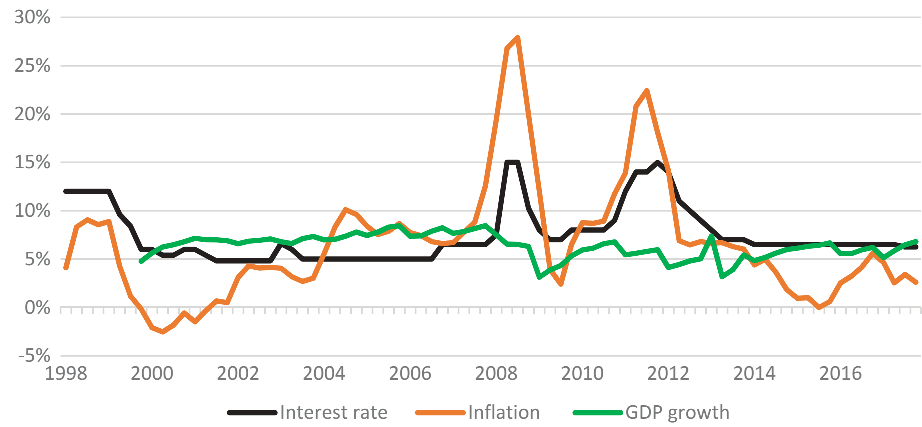

Figure 1. The movements of policy interest rates, inflation rate, and GDP growth from 1998Q1 to 2017Q4.
Source: data on the policy interest rate and inflation rate as reported in Table 3; data on GDP growth from CEIC, accessed on Feb 15th, 2018.

Variable selection

We follow the common practice in the literature (for example Sims 1992; Elbourne and de Haan 2009) of modeling a VAR model in accordance with the monetary policy feedback rule (the Taylor rule). In other words, a VAR model should include variables that capture the information used by the Central Bank when defining monetary targets and corresponding instruments. In addition, the Vietnamese economy is becoming increasingly more open to trade (Nguyen, 2014b; Athukorala and Tien 2012) and, consequently, monetary policy is also more susceptible to external shocks (Anwar and Nguyen 2018). We, therefore, include six endogenous variables (to capture the transmission mechanisms of monetary policy, see *domestic block* below) and two exogenous variables (see *foreign block* below). Our VAR specification is largely based on the model by Kim and Roubini (2000) for open economies and Raghavan, Silvapulle, and Athanasopoulos (2012) for Malaysia (but adapted to the specificities of the Vietnamese economy).

Domestic block variables

Industrial production index (IPI) and *consumer price index (CPI)*: to investigate the impact of monetary policy on the economy, we choose the IPI and CPI indices as the primary target variables of monetary policy. Given that the ultimate goal of monetary policy is price stability, we use the CPI

Table 3. Variables and data sources.

Variable	Initial	Unit	Source and notes
Domestic block			
Industrial production index	IPI	Index	2005 = 100; not seasonally adjusted. Data from the General Statistic Office of Vietnam (GSO), including data on gross value of industrial production in constant prices (from 1/1998 to 6/2011) and data on index of industrial production (from 7/2011 to 11/2017), retrieved from CEIC (Euromoney Institutional Investor Company- www.ceicdata.com). Assessed on 15 February 2018
Consumer price index	CPI	Index	2010 = 100; not seasonally adjusted. CPI data from the General Statistics Office (GSO) of Vietnam, retrieved from CEIC. Assessed on 15 February 2018
Broad money	M2	%	Broad money includes money in circulation and deposits at credit institutions in both domestic and foreign currencies (money plus Quasi money). Data is from IMF- IFS (Monetary survey), not seasonally adjusted. Assessed on 15 February 2018
Central Bank policy rate	Inte	%	Central bank policy rate (% per year) announced by the state bank of Vietnam. Data is from IMF-IFS and non- seasonally adjusted. Assessed on 15 February 2018
Total domestic credit	Cred	Billion VND	Total domestic credits in national currency from IMF-IFS (Monetary survey), not seasonally adjusted. Assessed on 15 February 2018.
Nominal exchange rate	EXC	%	Nominal average exchange rate, data is retrieved from CEIC and not seasonally adjusted. Assessed on 15 February 2018
Foreign block			
World oil price	OIL	U.S dollars per barrel	Global price of Brent Crude from IMF-IFS, not seasonally adjusted, retrieved from FRED; https://fred.stlouisfed.org/series/POILBREUSDM, assessed on 15 February 2018.
Chinese lending rate	Chirate	% per year	Data from IMF-IFS, not seasonally adjusted, assessed on 15 February 2018.

index as a key variable to evaluate the impact of monetary policy. Several authors (Hung and Pfau 2009; Vo and Nguyen 2017) chose industrial production as a proxy for the aggregate output. This is because data on industrial production are available on a monthly basis (which is not the case for GDP). Pham Anh (2016) inferred monthly GDP data by combining quarterly GDP data with the growth rate of monthly industrial production. However, this combination is not plausible for the case of Vietnam, because Vietnamese industrial production accounts for less than 40% of GDP.

Broad money (M2): as discussed in Section 3, broad money is considered by law an intermediate target of the Vietnamese monetary policy. Most studies on the effect of monetary policy in Vietnam include M2 in their models, e.g. see Anwar and Nguyen (2018), Bhattacharya (2014) and Hung and Pfau (2009).

Interest rates (Inte): interest rates enter our VAR model as a policy variable. A single short-term interest can be a valid proxy for the overall monetary policy stance, assuming that other interest rates co-move in the same direction (Walsh 2017). We selected the policy basic rates to proxy for monetary policy. First, this interest rate instrument has been extensively used by the Vietnamese central bank. Second, other interest rates (such as the bank deposit rates and bank lending rates) have exhibited similar trends with the policy basis rate (Figure 2).

Total credit (Cred): total credit is considered an additional intermediate target of monetary policy. Moreover, we include this variable because of the importance of the banking sector in Vietnam (see Section 3). The variation of total credit, hence, reflects the reaction of financial markets to policy signals. Within a bank-based financial system (as the one in Vietnam), we expect the credit channel to be an important one.

Exchange rates (EXC): owing to the Law on Central Bank, the exchange rate is explicitly considered an instrument of monetary policy (Table 2). Furthermore, in a transitional economy (as it is the case for Vietnam), foreign direct investment and international trade play an important role in stimulating economic growth (Athukorala and Tien 2012). Therefore, exchange rate variability is a concern for the authorities. The studies by Goujon (2006) and Phuc and Duc-Tho (2009), for example, confirm the role of depreciation (of the Vietnamese currency) in explaining inflationary pressures.

Foreign block: the world oil price (OIL) and the Chinese lending rate (Chirate)

As Vietnam is becoming an increasingly open economy, domestic prices and the output growth rate are also becoming more vulnerable to external shocks (Anwar and Nguyen 2018). It has been common practice to include the world oil price and the U.S. Federal Fund rates as exogenous variables in VAR models for Vietnam (see Anwar and Nguyen 2018; Hung and Pfau 2009; Vo and Nguyen 2017). The inclusion of the world oil price (as an exogenous variable) is necessary, because crude oil is an important good in the Vietnamese export basket. However, the inclusion of the U.S. Federal Fund rate would be less meaningful. Instead, we chose the Chinese lending rate (as an exogenous variable), because China is a neighboring country and, more importantly,

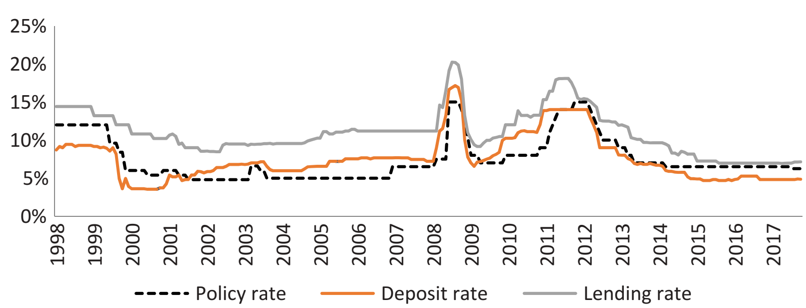

Figure 2. Movement of policy interest rates, bank lending rates and deposit rates.
Source: data from IMF-IFS, accessed on Feb 15th, 2018

the biggest trading partner of Vietnam. Table 2 summarizes the data sources of all variables, which are all of monthly frequency.

Data properties

Next, we analyze the properties of the data in order to detect seasonality, structural breaks and unit roots. The time span covers January 1998 to November 2017. During this period, there was no shift in the exchange-rate regime of Vietnam (Ilzetzki, Reinhart, and Rogoff 2017). To smooth the data, we transformed all variables (except from the interest rates; i.e. the policy basis rate and Chinese lending rates) into logarithmic forms.

Seasonality

To test for seasonality, we first plotted the data. The industrial production index explicitly shows seasonal patterns. Broad money, credit and exchange rates partly show seasonal patterns (while no seasonal patterns are present for the policy rate, the world oil price and the Chinese lending rate). Second, we detected seasonality by regressing each variable on seasonal dummy variables and a yearly time trend (see Equation (1)).

$$Y_t = c_0 + \; qYear_t + \sum\nolimits_1^{11} m_i D_{it} + \varepsilon_t, \qquad (1)$$

where Y_t is the value of any variable Y at time t; c_0 is the constant (corresponding to the mean value observed for month 12), q is the coefficient of the linear (yearly) time trend; m_i is the coefficient of each seasonal dummy variable D_{it} for the first 11 months of the year $(i = 1,2,3,,,11)$ and ε_t is the error term. The coefficients of the seasonal dummy variables are statistically significant in the case of industrial production, broad money, total credit, and the exchange rate. Third, we created seasonally-adjusted values by using the X-12 ARIMA/TRAMO procedures (Franses, Paap, and Fok 2005).[2] An alternative solution to deal with seasonality is to use a complete set of monthly dummy variables in the VAR models. The estimated impulse response functions when using seasonal dummy variable are similar to the ones with seasonally-adjusted data. The plotted time series graphs before and after seasonal adjustment are presented in Appendix 1 and the summary statistics of all variables are reported in Table 4.

Structural breaks

Structural breaks indicate unexpected shifts in time series that can lead to unreliable estimates. We tested for structural breaks in industrial production and price level (given our primary interest in the responses of output and price level to the shock from monetary policy). We first estimated with OLS the dependence of industrial production and price levels on all other included variables. We then applied a test for unknown break dates. The results suggested a structural break in November 2014 for industrial production and a structural break in October 2003 for prices (when the data are expressed in first differences, no structural break was identified, see Appendix 2). The structural break in October 2003 in price levels is similar to the Quandt-Andrews test for structural breaks in CPI conducted by Bhattacharya (2014). In the analysis that follows, we included two dummy variables to control for these structural breaks in our VAR models in levels. However, note that the impulse response functions corresponding to the VAR models with and without structural breaks are very similar.

Unit root tests

We used the Augmented Dickey Fuller statistic (ADF) to test for the stationarity of all variables. Table 5 presents the results. Broad money, total

Table 4. Summary statistics of all variables.

Variable	Obs	Mean	Std.Dev	Min	Max
Domestic block					
IPI	239	4.472	0.701	3.379	6.052
CPI	239	4.396	0.449	3.804	5.054
M2	239	13.80	1.39	11.15	15.86
Inte	239	7.49	2.84	4.8	15
Cred	239	13.694	1.449	11.087	15.780
EXC	239	9.760	0.168	9.415	10.019
Foreign block					
OIL	239	3.895	0.589	2.429	4.897
Chirate	239	5.78	0.83	4.35	8.64

Note: Except for interest rates, all other variables are in logarithmic form. IPI, CPI, M2, Cred, and EXC are seasonally adjusted.

[2]X-12 ARIMA, TRAMO are popular procedures to deseasonalize and recommended by IMF. We use X-12 ARIMA to create seasonally-adjusted values for industrial production, the consumer price index and the exchange rate. We use the TRAMO procedure for money supply and total credit, because TRAMO is best suited when there are missing observation in time series.

Table 5. ADF test for stationarity or unit root tests.

Variables	ADF (t-statistic) Data (at level)	Data (first difference)
Domestic block		
Industrial production (IPI), log, seasonal adjusted	−1.128	−32.922***
Consumer price index (CPI), log, seasonally adjusted	0.778	−6.554***
Broad money (M2), log, seasonally adjusted	−4.404***	−11.103***
Central bank policy rate-end of period (%)/annually (CPI)	−2.196	−13.041***
Total domestic credit, log, seasonally adjusted	−3.099**	−15.041***
Nominal exchange rate, average (EXC), log, seasonally adjusted	−0.507	−17.075***
Foreign block		
World oil price (OIL), log	−1.875	−11.659***
Chinese lending rate, percentage	−3.051**	−12.265***

*Note: *, ** and *** denote statistical significance at 10%, 5% and 1%.*

credit, and the Chinese lending rates are stationary at level; the five other time series are stationary at first difference.

VAR identification for Vietnam

A structural form VAR is useful to isolate the purely exogenous shocks from policy and to measure the impact of these shocks on variables included in a VAR model (Sims 1986). A structural form VAR is written as follows:

$$A_0 Y_t = \alpha_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + u_t, \tag{2}$$

where Y_t is a (m x 1) vector of endogenous variable at time t; α_0 is a (m x 1) vector of constants; A_i $(i = 1,2,\ldots,p)$ is a (m x m) vector of structural parameters and u_t is a (m x 1) vector of structural shocks. The parameters of a structural form VAR in Equation (1) cannot be estimated directly. Multiplying (Equation (2)) by the inverse of matrix A_0 yields a reduced-form VAR (Equation (3)), which can be estimated directly by ordinary least squares.

$$Y_t = g_0 + G_1 Y_{t-1} + G_2 Y_{t-2} + \ldots + G_p Y_{t-p} + e_t, \tag{3}$$

where Y_t (a vector of endogenous variables) depends on the lag of itself and the lag of other endogenous variables, and the forecast error vector e_t; $e_t = A_0^{-1} * u_t$ is a linear combination of the structural shocks u_t. The next step is to recover the structural parameters of (Equation (2)) from the estimated parameters of (Equation (3)). This process is called identification (Sims 1986). Due to the number of unknown elements of a structural VAR being larger than the number of known elements from an estimated reduced-form VAR, the usual approach is to impose restrictions on matrix A_0 (i.e. the matrix of the contemporaneous relationships among endogenous variables of the structural model) guided by economic intuition. If a VAR has m endogenous variables, one needs to impose at least $m(m\text{-}1)/2$ restrictions (Gujarati 2009). One popular way of imposing restrictions on matrix A_0 is the Cholesky decomposition, where A_0 is assumed to be a lower triangular matrix. In this identification, the variable ordered first is assumed to have contemporaneous effects on all variables following it, while the variable ordered last is assumed to have effect on other variables ordered before it with a lag. An alternative identification is the structural decomposition (SVAR), in which the matrix A_0 could have any structure, as long as it imposes sufficient restrictions (Kim and Roubini 2000).

We prefer the Cholesky decomposition (recursive identification) rather than the structural decomposition (SVAR). The Cholesky decomposition imposes fewer restrictions (the number of restrictions is equal to m (m-1)/2, m being the number of variables in a VAR model. A SVAR approach, instead, can impose more than $m(m\text{-}1)/2$ restrictions (over-identified SVAR).

In our VAR model, the recursive identification (Cholesky decomposition) of endogenous variables is expressed in Equation (4):

$$\begin{bmatrix} u_{IPI} \\ u_{CPI} \\ u_{M2} \\ u_{Inte} \\ u_{Cred} \\ u_{EXC} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a^0_{21} & 1 & 0 & 0 & 0 & 0 \\ a^0_{31} & 0 & 1 & 0 & 0 & 0 \\ a^0_{41} & a^0_{42} & a^0_{43} & 1 & 0 & 0 \\ a^0_{51} & a^0_{52} & a^0_{53} & a^0_{54} & 1 & 0 \\ a^0_{61} & a^0_{61} & a^0_{63} & a^0_{64} & a^0_{65} & 1 \end{bmatrix} \times \begin{bmatrix} e_{IPI} \\ e_{CPI} \\ e_{M2} \\ e_{Inte} \\ e_{Cred} \\ e_{EXC} \end{bmatrix}, \tag{4}$$

where u_{IPI}, u_{CPI}, u_{M2}, u_{Inte}, u_{Cred} and u_{EXC} are shocks in industrial production, prices, monetary base, credit and exchange rate respectively. The reduced-form forecast errors are e_{IPI}, e_{CPI},

e_{M2}, e_{Inte}, e_{Cred}, e_{EXC} respectively. Output and the price level are ordered first to be consistent with the nominal rigidity theory, which suggests persistence in output and inertia in prices after a monetary policy shock (Christiano, Eichenbaum, and Evans 2005). Subsequently, the policy variables become adjusted (following information on the primary target variables, namely industrial production and prices): first the broad money base, followed by the interest rate levels and credit. The exchange rate is the last policy variable that adjusts according to the earlier values of the other variables in the VAR system (see also Kim and Roubini 2000; Elbourne and de Haan 2009; Raghavan, Silvapulle, and Athanasopoulos 2012 for a discussion on similar orderings).

This ordering is also supported by Granger causality tests. By carrying out pairwise Granger causality tests for a VAR model in levels with two lags, we found that economic target variables *(IPI, CPI)* Granger-cause policy variables (*M2, Inte, EXC). M2* Granger-causes *Inte* and *EXC* at the 10% significance level and *Cred* at the 1% significance level. *Inte* Granger-causes *Cred* at 1% significant level. *EXC* is Granger-caused by almost all variables (*IPI, CPI, M2, Cred*).

The endogenous variable ordering (*IPI, CPI, M2, Inte, Cred, EXC)* of our VAR model for Vietnam is similar to the one adopted by several other papers with a focus on Asian developing countries; for example, see Raghavan, Silvapulle, and Athanasopoulos (2012) for Malaysia, Disyatat and Vongsinsirikul (2003) for Thailand, Fung (2002) for Indonesia, Malaysia, Philippine, Taiwan and Thailand, and Hung and Pfau (2009) for Vietnam. In these studies, economic target variables (output, price levels) are ordered before policy variables (money supply, interest rates, exchange-rates).

IV. Impulse response functions and variance decomposition

We now proceed to identify the lag length of our VAR system, estimate the impulse response functions and then analyse the variance decomposition. As discussed in Table 3, three time series are stationary at level (I(0)) and five time series are integrated of order one (I(1)). Sims, Stock, and Watson (1990), among others, argue in favor of estimating VAR models in levels (as this makes the interpretation of impulse response functions more straightforward (i.e. compared to a VAR model estimated in first differences). It is also common practice in the monetary policy literature to estimate a VAR in levels, even if the model contains some unit root series (see Sims 1992; Kim and Roubini 2000; Elbourne and de Haan 2009; Borys, Horváth, and Franta 2009 for open economies; Aleem, 2010 for India; Raghavan, Silvapulle, and Athanasopoulos 2012 for Malaysia; Anwar and Nguyen 2018; Vo and Nguyen 2017 for Vietnam). What really matters for the robustness of a VAR estimation is the stability of the VAR system as a whole. According to Lütkepohl (2005), the overall stationarity condition of a VAR model is more important than the stationarity of all single series. Our VAR models fulfil this requirement (Appendix 3.1 presents the post-estimation of our VAR stability with all eigenvalues lying inside the unit circle). In addition, our VAR model in levels shows no evidence of serial correlation (the results of the Lagrange Multiplier (LM) test for autocorrelation are reported in Appendix 3.2).

Table 6 indicates the suggested lag length based on different criteria: most selection criteria (FPE, AIC, HQIC, SBIC) support the inclusion of two lags (with the exception of the likelihood-ratio (LR) test that is in favor of

Table 6. Lag length selection criteria.

Lag	LL	LR	FPE	AIC	HQIC	SBIC
0	759.263	0	7.7e-11	−6.25977	−6.08059	−5.81543
1	3036.51	4554.5	3.4e-19	−25.498	−25.1038	−24.5204
2	3136.45	199.88	2.0e-19*	−26.0468*	−25.4376*	−24.536*
3	3169.97	67.035*	2.0e-19	−26.0255	−25.2013	−23.9815
4	3191.9	43.856	2.3e-19	−25.9047	−24.8655	−23.3275
5	3209.92	36.04	2.7e-19	−25.7504	−24.4961	−22.64
6	3232.83	45.825	3.0e-19	−25.638	−24.1688	−21.9944

*Note: * indicates the optimal number of lags according to different criteria.*

three lags). We opt for two lags for our VAR estimations (as this in accordance with the vast majority of the selection criteria), but we will also experiment with three lags as an additional robustness check.

Impulse response functions

In this subsection, we compute impulse response functions (IRFs) to trace out the dynamic response (over a period of 30 months) of endogenous variables to exogenous shocks emanating from other variables. IRFs predict the sign, the magnitude, and statistical significance of the responses to shocks from policy variables (Stock and Watson 2001). Figure 3 depicts the impulse response functions of output and price levels to a shock (measured by a one standard deviation increase) in policy variables (policy interest rate, exchange rate, broad money, credit). We report the 95% confidence intervals for all graphs (see grey-shaded area). Table 7 presents detailed numerical results for two IRFs: namely, the expected output and price responses (in percentage changes) to an initial one standard deviation shock in the interest rate.

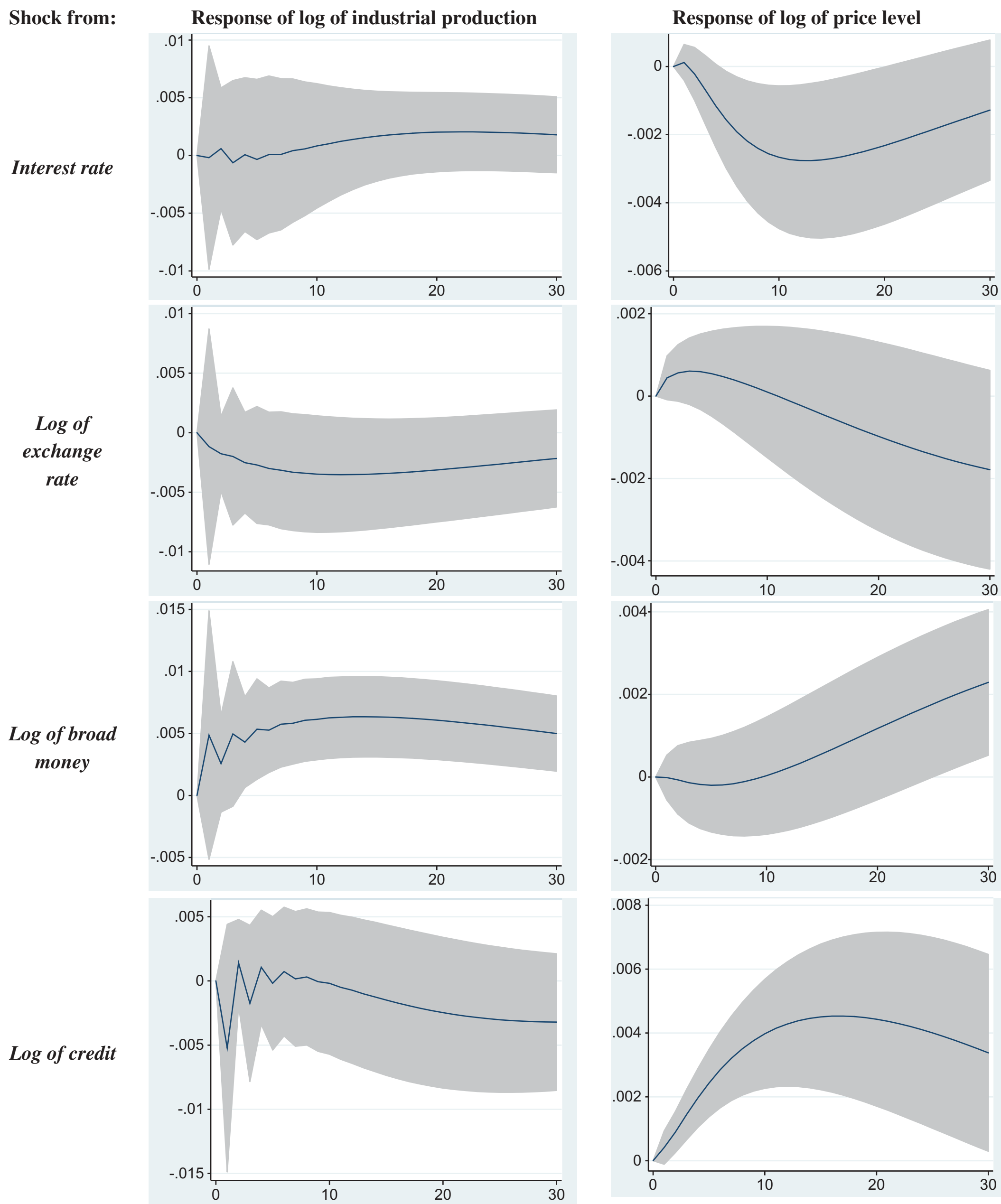

Figure 3. Impulse responses of industrial production and prices to shocks in policy variab.

Table 7. Percentage changes in prices and industrial production due to a one standard deviation shock in interest rates.

Months	3	6	12	18	24	30	Bottom effect/months
CPI	−0.67	−0.19	−0.27	−0.25	−0.19	−0.12	−0.28/13
	(−0.17;0.06)	(−0.35;-0.03)	(−0.50;-0.05)	(−0.49;-0.02)	(−0.41;-0.03)	(−0.33;-0.08)	(−0.51;-0.05)
IP	−0.06	0.01	0.13	0.19	0.20	0.18	−0.06/3
	(−0.78;0.65)	(−0.67;0.69)	(−0.34;0.59)	(−0.16;0.55)	(−0.13;0.54)	(−0.15;0.51)	(−0.77;0.65)

Note: upper and lower 95% confidence intervals in parenthesis.

According to the IRFs, initially, an increase in the interest rate causes prices to decline. The negative effect becomes statistically significant (at the 5% level) four months after the interest rate shock takes place. This negative effect remains statistically significant until 20 months after the initial shock. The maximum drop in prices is about 0.28% (Table 7) at about 13 months. This empirical evidence shows that a tighter monetary policy is indeed effective in controlling price levels in Vietnam. On the contrary, the effect of an increase in interest rate on industrial production is not statistically significant. Similarly, an increase in the exchange rate does not bear statistically significant effects on either industrial production or prices.

Second, the effect of broad money on industrial production becomes statistically significant after three months from the initial shock (the industrial production index increases by about 0.5%). The effect gains its peak at about 12 months, and then gradually fades away. The price level also responds positively to an increase in broad money, although the effect is not statistically significant (at least for the first 26 months, after which the size of the effect is quite small – less than 0.2%).

Third, an increase in credit increases the price level. The effect is statistically significant and peaks (0.45% rise) at about 17 months after the shock. The significant positive response of prices indicates the positive expansionary side-effects of a credit rise. The IRFs also indicate a negative response of industrial production (however, the estimated effects are not statistically significant).

Variance decomposition

In the previous section, we discussed the effects of several exogenous shocks arising from changes in policy variables. In this section, we proceed to decompose the fluctuations of the response variables (price level, industrial production) that arise from these aforementioned shocks in the VAR system. Following Morsink and Bayoumi (2001), we calculated the variance decomposition of the price level and output for a forecast horizon of 36 months (Table 8). The second column provides the forecast error of the variable and the remaining columns show the percentage of the variance attributed to each shock (each row adds up to 100%).

The results indicate that changes in credit and interest rates account for a substantial share of the fluctuation in prices. Credit accounts for 15.46%, 28.30% and 31.29% of the total variance of prices after one, two and three years respectively. The corresponding figures for the interest rate shocks are 6.67%, 9.98% and 9.21% respectively. Meanwhile, the fluctuation of industrial production is mainly explained by its own past shocks. Broad money has the second most important influence and accounts for 2.89, 6.53% and 8.60% of the total variance of industrial production after one, two and three years respectively.

Robustness analysis

As discussed earlier, the IRFs can be sensitive to lag length and structural identification (i.e. the adopted sequence of endogenous variables in the recursive Cholesky decomposition). Therefore, it is important to check the robustness of the IRF patterns using different lag lengths and different endogenous variable orderings. As indicated in Table 5 (lag length selection) and Appendix 3.1 (VAR stability and autocorrelation tests), one may also opt for three lags (based on the LR selection criterion). The IRFs of our VAR model with three lags are reported in Appendix 4. The patterns of IFRs are similar to the ones with two lags.

Regarding the Cholesky orderings, we estimated a number of alternative VAR models using different variable sequences. Generally, the IRFs are quite similar to the ones appearing in Figure 3. The IRFs indicating the effects of the interest rate and credit on the price index, as well as the effects

Table 8. Variance decomposition (%).

Period (months)	Forecast error	Output	Price level	Broad money	Interest rate	Credit	Exchange rate
Variance decomposition for price level							
1	0.00	0.60	99.40	0.00	0.00	0.00	0.00
6	0.02	0.17	92.51	0.04	1.68	5.00	0.60
12	0.03	0.38	77.02	0.03	6.76	15.46	0.35
18	0.04	0.61	66.11	0.22	9.32	23.38	0.36
24	0.04	0.62	59.28	0.99	9.98	28.30	0.84
30	0.04	0.54	54.62	2.53	9.76	30.76	1.79
36	0.04	0.63	50.98	4.81	9.21	31.29	3.08
Variance decomposition for industrial production							
1	0.08	100.	0.00	0.00	0.00	0.00	0.00
6	0.10	98.38	0.03	1.04	0.01	0.34	0.23
12	0.11	95.79	0.14	2.89	0.03	0.32	0.82
18	0.11	92.87	0.26	4.88	0.16	0.41	1.42
24	0.11	90.23	0.32	6.53	0.36	0.72	1.85
30	0.11	88.12	0.33	7.75	0.54	1.17	2.09
36	0.12	86.59	0.33	8.60	0.65	1.62	2.22

of broad money on industrial production, are the most robust. Appendix 5 reports the IRFs of our VAR model using the following variable ordering (policy variables → economic variables: *Inte, EXC, Cred, M2, CPI, IPI*) which is opposite to the one adopted in the main analysis (Section 4.1: economic variables → policy variables) . Even in this case, the patterns of IFRs are still similar to IRFs reported in Figure 3. The sensitivity analysis, hence, supports our earlier findings.

According to Pesaran and Shin (1998), generalized VARs (GVARs) and their corresponding IRFs are invariant to the variable ordering of a VAR model;. However, generalized IRFs are based on extreme assumptions (that conflict each other), leading to unreliable economic inferences (Kim 2013). Due to this reason, we opted for the standard approach (orthogonalized IRFs) as discussed in the main analysis. Here we estimate generalized IRFs as a robustness check. The patterns of generalized IRFs using 2 lags are reported in Figure 4. The generalized impulse responses exhibit a clear pattern of a significant fall of the price level in response to a one-standard deviation shock in policy interest rate. The maximum decrease is about 0.32% at 14 months after the shock. Following a one standard deviation shock in money supply, industrial production increases significantly. Following a one standard deviation shock in total credit, price level increases significantly. These impulse responses obtained by the generalized VAR approach are similar to the ones obtained by orthogonalized approach (Figure 3). The sensitivity analyses, hence, supports our earlier findings.

V. Conclusions

Our study examined the effects of monetary policy on the real economy in Vietnam since the enforcement of the Law on the Central Bank in January 1998. First, we found that a tighter monetary policy (measured as an increase in interest rates) is effective in stabilizing prices. After an increase in the interest rate, the consumer price index drops (with a maximum decline of 0.28%). To our knowledge, our empirical analysis is the first to uncover such an effect of monetary policy on prices in the case of Vietnam. Other studies on Vietnam did not find statistically-significant negative effects (Anwar and Nguyen 2018; Bhattacharya 2014; Hung and Pfau 2009) or indicated the existence of a ‘price puzzle’ (Vo and Nguyen 2017). Second, we also found a significant effect of an expansionary monetary policy (measured as an increase in broad money) on industrial production. Three months after an increase in broad money, the industrial production index responds positively (by 0.5%) – this finding is in line with Hung and Pfau (2009). Last, our study also provides support to the inflationary pressures arising from credit expansion in Vietnam. Right after an increase in credit, the consumer price index responds positively. The effect is statistically significant and of a long duration. Our findings contribute to the understanding of the conduct of

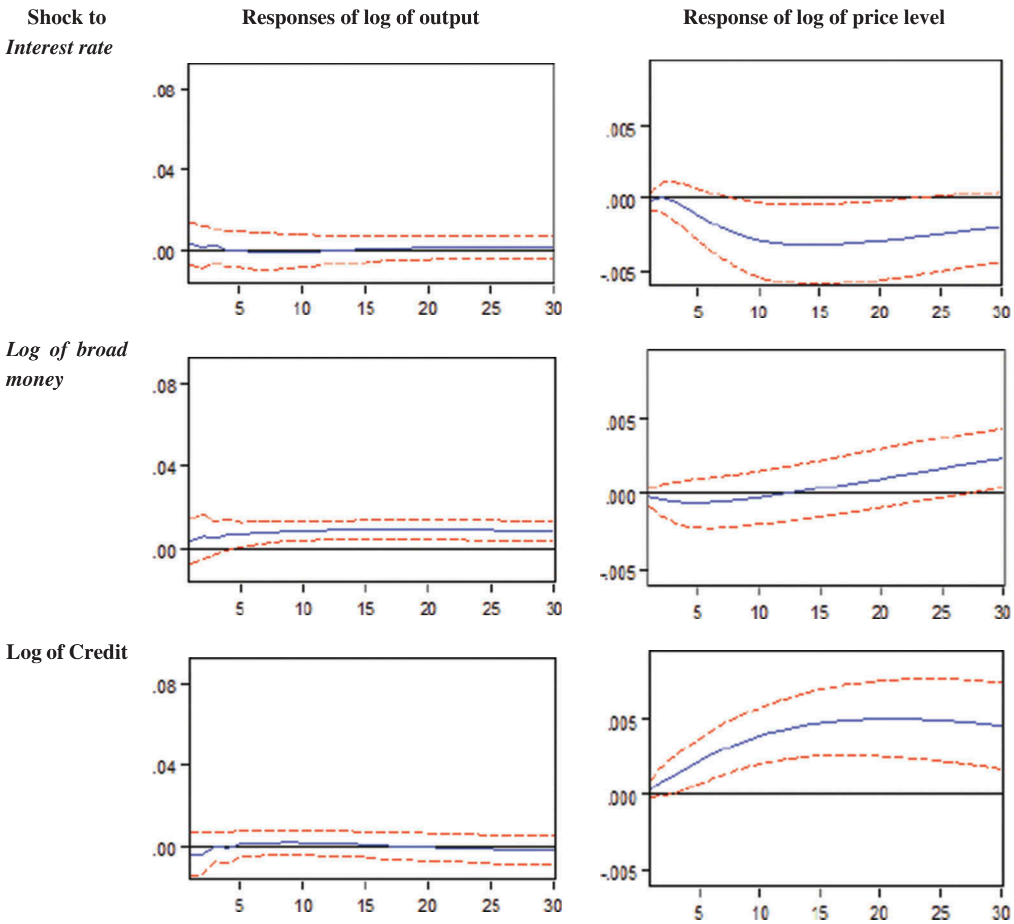

Figure 4. Generalized IRFs using 2 lags.

Note: Estimated using Eview 10; the solid lines are the generalized impulse responses, the dashed lines are the 95% confidence intervals.

monetary policy during different stages of the business cycle in Vietnam. Our results indicate that interest rates are an effective instrument of monetary policy for confronting inflation during periods of economic expansion.

Our analysis has important policy implications; the results suggest that price stability and sustained growth can be simultaneously pursued in the context of Vietnam (in line with the Law on Central Bank). However, we also find that an expansionary credit policy (currently favored by policy makers) is likely to create inflationary pressure (and, hence, work against the price-stabilizing effect of other monetary instruments).

Disclosure statement

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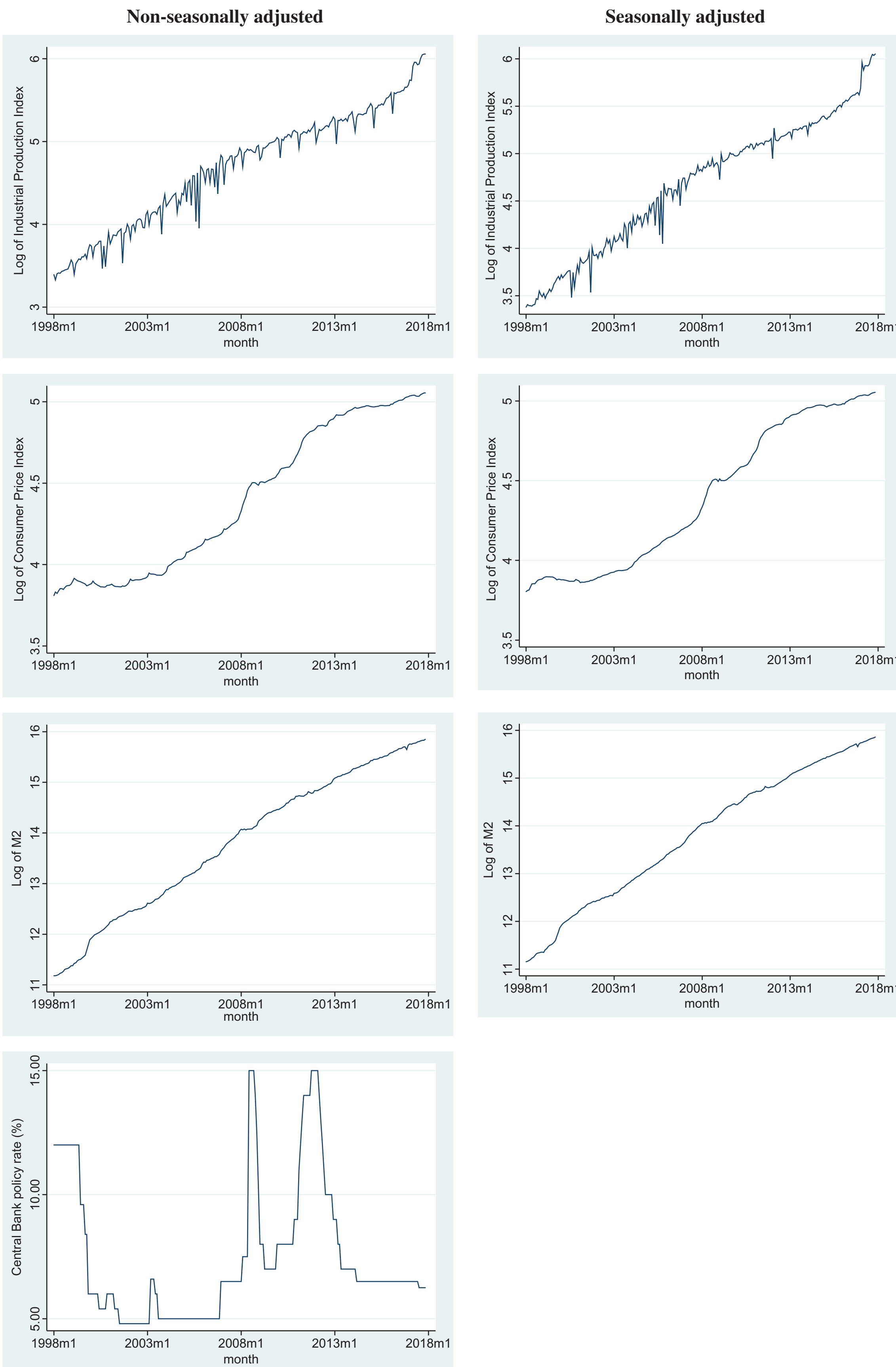
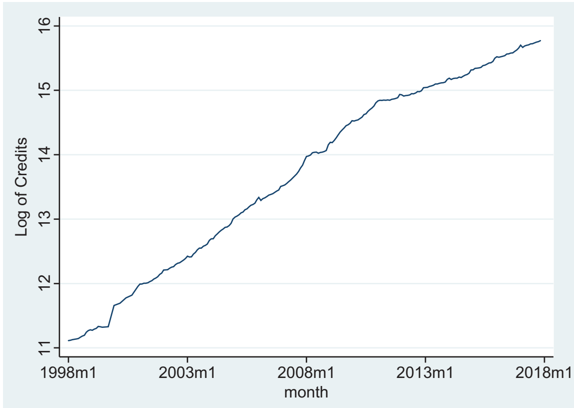
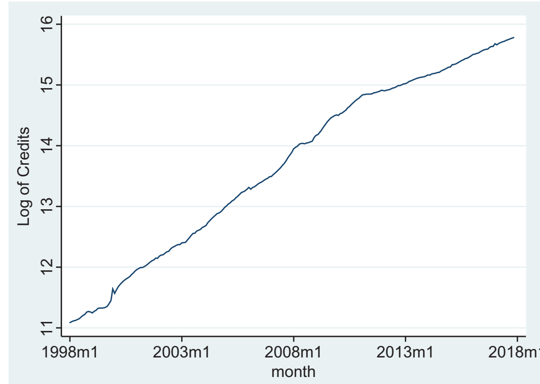
Appendix 1: Non-seasonally vs. seasonally adjusted data




Log of Credits
11
12
13
14
15
16
1998m1
2003m1
2008m1
2013m1
2018m1
month


Log of Credits
11
12
13
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15
16
1998m1
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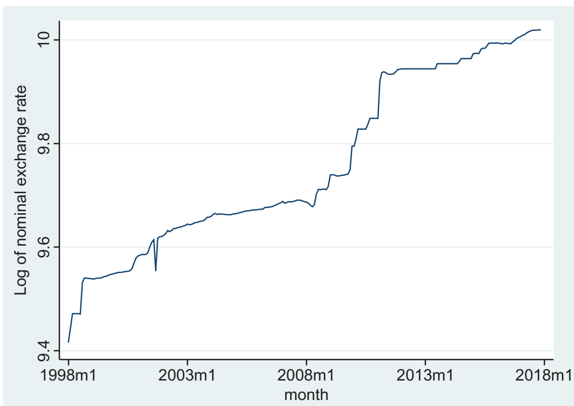
2008m1
2013m1
2018m1
month


Log of nominal exchange rate
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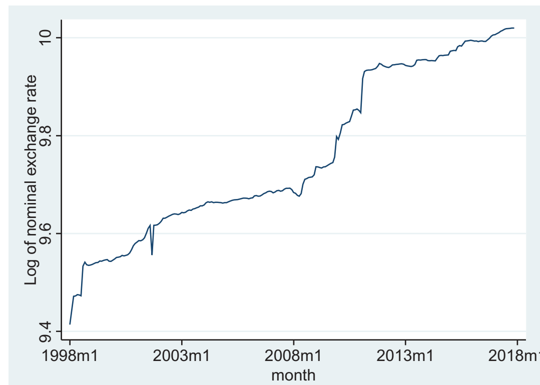
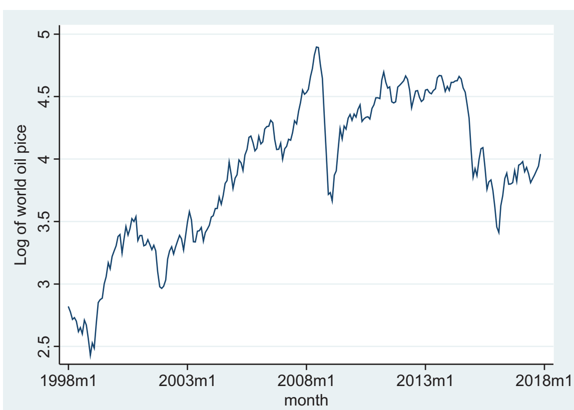
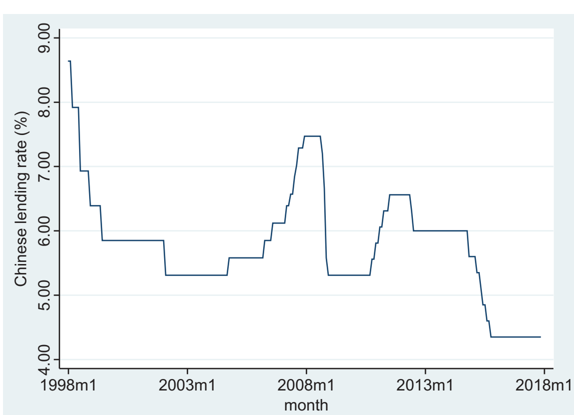
9.6
9.8
10
1998m1
2003m1
2008m1
2013m1
2018m1
month


Log of nominal exchange rate
9.4
9.6
9.8
10
1998m1
2003m1
2008m1
2013m1
2018m1
month

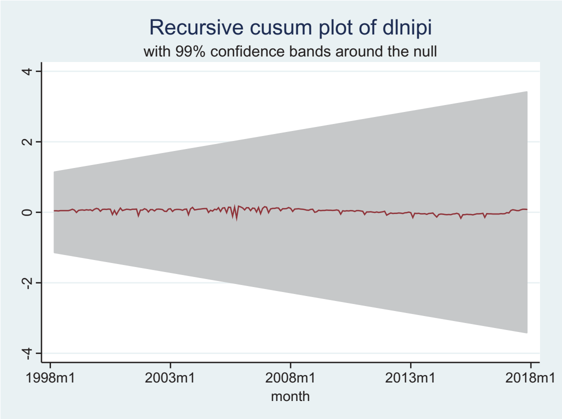

Log of world oil pice
2.5
3
3.5
4
4.5
5
1998m1
2003m1
2008m1
2013m1
2018m1
month

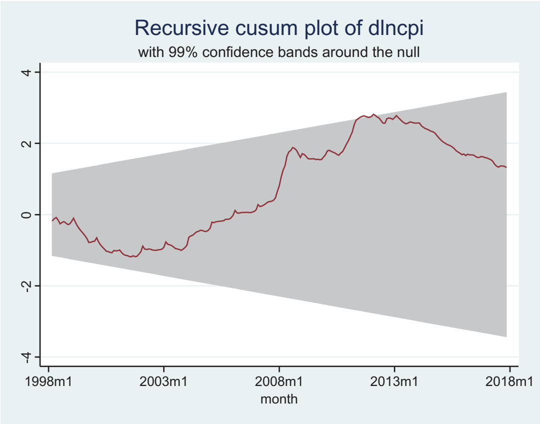

Chinese lending rate (%)
4.00
5.00
6.00
7.00
8.00
9.00
1998m1
2003m1
2008m1
2013m1
2018m1
month

Appendix 2: Test for structural breaks (data in first differences)

Lag 2		Lag 3	
Eigenvalue	Modulus	Eigenvalue	Modulus
0.9918	0.9918	0.9916	0.9916
0.9697 + 0.0479i	0.9711	0.9502 + 0.0393i	0.9510
0.9697–0.0479i	0.9711	0.9502–0.0393i	0.9510
0.9351	0.9351	0.9421 + 0.0120i	0.9422
0.8031 + 0.0369i	0.8039	0.9421–0.0120i	0.9422
0.8031–0.0369i	0.8039	0.7885	0.7885
−0.5832	0.5832	0.7108	0.7108
0.5009	0.5009	−0.4451 + 0.4413i	0.6268
−0.3087	0.3087	−0.4451–0.4413i	0.6268
0.1612	0.1612	−0.4379	0.4379
−0.0827 + 0.0505i	0.0969	0.4330	0.4330
−0.0827–0.0505i	0.0969	0.0045 + 0.2827i	0.2827
		0.0045–0.2827i	0.2827
		−0.1376 + 0.2449	0.2809
		−0.1376–0.2449	0.2809
		−0.1834 + 0.0606i	0.1931
		−0.1834–0.0606i	0.1931
		0.0241	0.0241

Appendix 3.1: Test for the stability of the VAR system



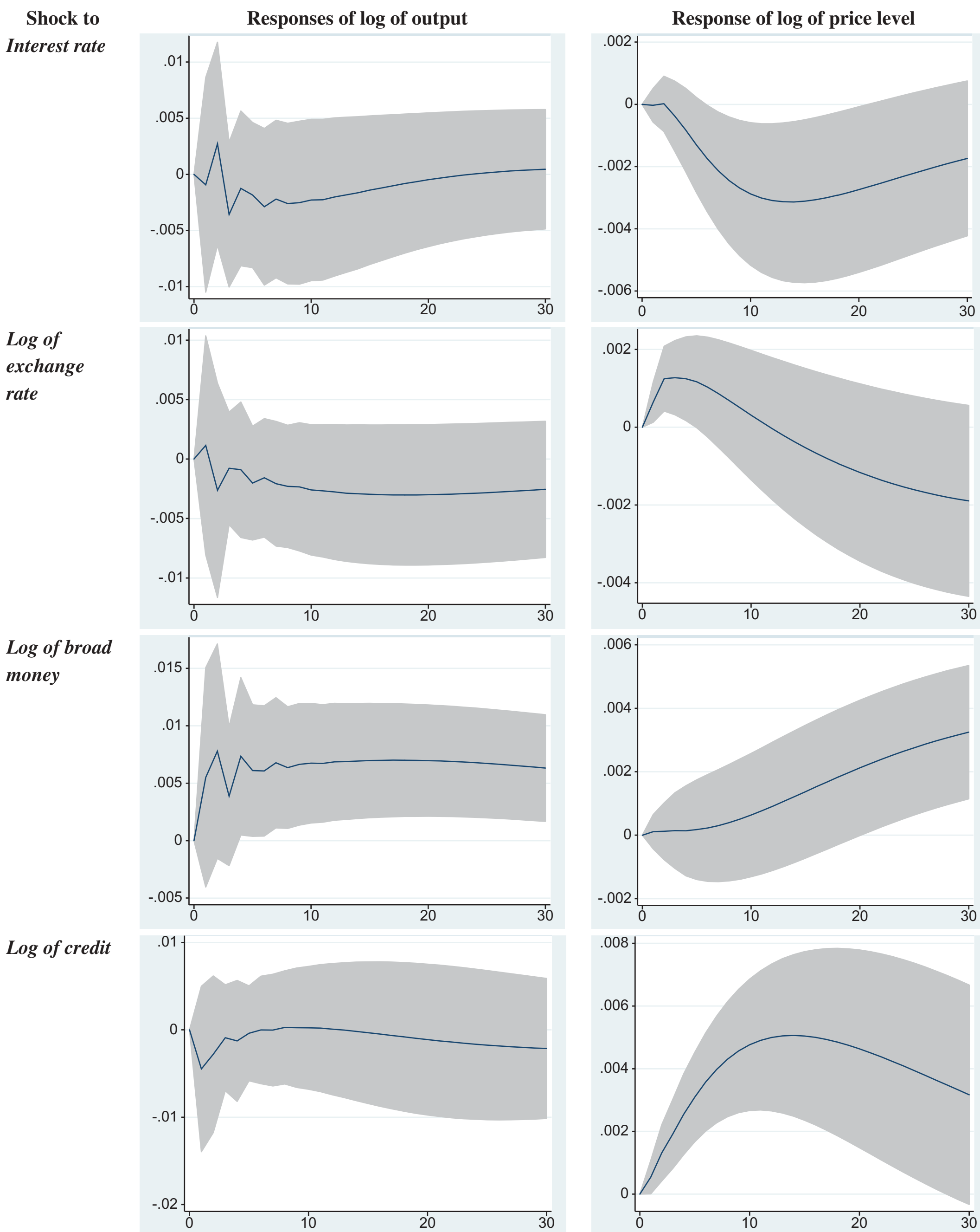


Appendix 3.2: Lagrange Multiplier test for autocorrelation

Lag	chi2	Prob > chi2
1	70.5977	0.00050
2	40.9399	0.26262
3	46.6817	0.10951
4	23.3243	0.94909
5	38.7783	0.34549
6	40.9750	0.26138

Note: Null hypothesis (H_0): no autocorrelation at lag order

Appendix 4: IRFs of the VAR model using 3 lags



Appendix 5: IRFs using alternative variable ordering