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WHAT DRIVES PERSISTENTLY HIGH INFLATIONARY PRESSURES IN VIETNAM? SOME EVIDENCE FROM THE NEW KEYNESIAN CURVE FRAMEWORK

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ABSTRACT

In this study, we revisit the inflation process in Vietnam through the New Keynesian Phillips Curve (NKPC) model. We use monthly and quarterly data frequencies to track the forces driving inflationary pressures up to a quarter. Interest rate, an important determinant of inflation, is often found to give theoretically inconsistent result. Hence, we examine different interest rates, including, the central bank policy rate, lending interest rate and one-month interbank interest rates. Further, there is no unified approach to measuring the output gap – an important variable of the model - in the literature which may affect the results. Therefore, in this study, output gap is measured using two different approaches, namely, the linear trend model and the Hodrick-Prescott (HP) filter to see whether different measurement approaches matter for the signs and significance of this variable. Our key findings show that while the effects of interest rate vary by its type, measurement of output gap does not matter for the determination of inflation in Vietnam. What matters is whether the inflation model is quarterly or monthly. We explain the main determinants of inflation and provide some policy implications in the paper.

Keywords: Inflation; Interest rate; Exchange rate; Output gap.
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I. INTRODUCTION

Since the introduction of its Doi Moi (also known as Renovation) policy, the Vietnamese economy has registered a remarkable growth rate (Narayan and Nguyen, 2016). However, probably owing to both external (the Asian Financial Crisis-AFC in 1997, the Global Financial Crisis-GFC in 2008, the energy crisis in 2000s) and internal (the consequences of the Vietnam War, economic mismanagement) factors, the Vietnamese economy also suffered from several periods of double-digit inflation rate from late 1988 to early 1990, in the late 2007 to early 2009 and then from late 2010 to early 2012 (see Figure 1).

Figure 1.
Inflation in Vietnam

This figure displays the inflation in Vietnam.

Source: World Bank's World Development Indicators (WDI)

As inflation has always been a major cause of concern in Vietnam[1], this study investigates the inflation process under the New Keynesian Philips Curve (NKPC). Our contributions to the extant literature on inflation determination are as follows. First, we model inflation using different types of interest rate. While there are several similar studies, they only use interest rates at one or two maturity level (see Table 1 for a summary of the literature). Moreover, as an important determinant of inflation, interest rate is often found to give theoretically inconsistent result

[1] At the end of each year, the Vietnamese government has to submit an annual draft plan of macroeconomic objectives of inflation and economic growth to be reached next year to the Vietnamese National Assembly for approval. A low inflation is also the focus of the Vietnamese government as affirmed by Dizioli and Schmittmann (2015). Bhattacharya (2014) also confirms that the Vietnamese economy suffered from high and volatile inflation since 2007. Nguyen and Nguyen (2010) argue that the bitter experiences with hyper-inflation in the 1980s and early 1990s as well as double-digit inflation in 2008 cause inflation inertia to be serious.

(Podkaminer, 1998; Rabanal, 2003; Oomes and Ohnsorge, 2005; Ravenna and Walsh, 2006; Gaiotti and Secchi, 2006; Chowdhury *et al*., 2006; Tillman, 2009; Henzel *et al*., 2009; Kaufmann and Scharler, 2009; Ali and Anwar, 2013; Florio, 2018; Vo and Nguyen, 2017). Hence, we examine different interest rates, including, the central bank policy rate, the lending interest rate and the one-month interbank interest rates. Our findings show that interest rate type matters. Specifically, we find that while interest rates of all maturities have the same positive impact on inflation, their significance varies. At the quarterly models, the central bank policy rate, the lending rate and one-month interbank interest rates are significant. However, at the monthly models, only the lending interest rate is significant, suggesting that other types of interest rate have a delayed effect on inflation.

Second, we follow Lee (1995) and use two data frequencies, namely monthly and quarterly, in this paper to test for any instability of the inflation determination across frequencies. Lee (1995) is the only study on inflation that uses multiple data frequencies (annual and quarterly), and finds that the US Phillips curve is unstable across both time and frequency as annual and quarterly results are varied.[2] Our findings show that inflation determination in the monthly and quarterly frequencies differ significantly. Specifically, we find that in the monthly models, the lending interest rate, the government budget deficit, the output gap (two different measures), leads and lags of inflation matter for the inflation determination in Vietnam and in the quarterly models, the central bank policy rate, the lending interest rate and the one-month interbank interest rates, leads and lags of inflation matter. Third, we notice that output gap, an important determinant of inflation is measured in several ways in the literature. It is unclear whether the relationship between inflation and output gap depends on the measure used. Hence, we take two approaches widely used in the literature to measure output gap, and examine the inflation models with each of two output gap measures. We show that output gap developed using the linear trend model and the HP filter produce consistent results – in all cases, we find that output gap has a negative and significant effect in the monthly models. Their effect on inflation is found to be insignificant in the quarterly models.

This paper is organized in the following manner. Section II summarizes the extant literature as well as specifies the empirical model while Section III explains the data and provides the preliminary analysis of the data. Section IV discusses the main empirical results, while Section V concludes the study.

II. EMPIRICAL LITERATURE REVIEW AND MODEL SPECIFICATION

The empirical literature on inflation is voluminous and diverse in terms of the countries investigated, the methods and variables selected. We summarize the empirical studies in Table 1 below.

[2] The importance of data frequency has been confirmed in the finance literature (see Narayan *et al*., 2013; Narayan and Sharma, 2015; Narayan and Rehman, 2017, 2019). However, apart from Lee (1995), no attempt has been made to examine inflation model at different frequencies.

Table 1.
Summary of Empirical Studies on Inflation

This table provides a summary of the empirical studies on inflation. Here, VECM is Vector Error Correction Model; GDP is Gross Domestic Product; OLS is Ordinary Least Squares; HP is Hodrick-Prescott; BP is band-pass; GMM is Generalized Methods of Moments; VAR - Vector Autoregressive; SVAR - Structural Vector Autoregressive; 2SLS -Two-stage Least Squares; NEER - nominal effective exchange rate; REER - real effective exchange rate; VNIBOR - Vietnam's interbank offered interest rate; 3M LIBOR - Three-month London's Interbank Interest Rate; EIA - Energy International Agency; VN-index - Vietnam's stock market index of the Ho Chi Minh stock exchange; T-bills - Treasury-bills rate; and CPI - consumer price index.

Study	Country (Period)	Method	Variables	Results
Moser (1995)	Nigeria 1960-1993	VECM	Inflation: money supply, real GDP, nominal exchange rate, foreign prices, expected inflation, expected foreign interest rate, rainfall	Long-run (LR): Money supply, exchange rate: positive, significant; real income: negative, significant; Short-run (SR): Money supply, exchange rate, expected inflation: positive, significant;
Lee (1995)	US 1891-1992 (annual data) 1955Q1-1992Q4	OLS, HP filter frequency, BP filter frequency	Inflation (CPI and core): lags of inflation, money supply growth output growth or unemployment	Unemployment: negative, significant at both annual and quarterly data; Output growth: positive, significant at annual and quarterly data; Money supply growth: positive, significant at quarterly data,
Gali and Gertler (1999)	US 1960Q1:1997Q4	GMM	Inflation: leads and lags of inflation, real marginal costs or output gap	Real marginal costs, leads and lags: positive, significant; Output gap: negative, significant
Chowdhury *et al.*, (2006)	G7 countries 1980Q1-1997Q4	GMM	Inflation: 3-month T-bill; real unit labour cost (ratio of total compensation to GDP)	Leads and lags of inflation: positive, significant; Real marginal costs: positive, significance varied; Interest rate: positive, significance varied;
Tillmann (2008)	US, UK, Euro 1960Q1-2004Q4	VAR	Inflation (GDP deflator): three-month T-bill; lending rate real marginal costs (labour share of income);	Real marginal costs: positive, significant; Interest rates: positive, significant.
Abbas and Sgro (2011)	Australia	GMM, 2SLS, OLS	Inflation (GDP deflator): three-month and 10-year interest rates, output gap (quadratic linear trend)/marginal cost, wage share	Lead and lag: positive, significant; Output gap: mixed signs, insignificant;
Bleaney and Francisco (2018)	120 countries 1990-2012	Pooled OLS, Fixed effects	Lag of inflation, expected inflation, output gap (deviation of the log of real GDP from HP trend), GDP growth, fiscal balance, policy commitment (dummy variable for the adoption of inflation targeting and hard peg currency), lags of changes in commodity prices, REER	Lags of inflation: positive, significant in all; Leads of inflation: all positive, significance mixed; GDP growth, output gap, oil price, exchange rate, fiscal balance: mixed signs and significance; Rice price: positive, significant; Exchange rate: mixed signs and significance

Table 1.
Summary of Empirical Studies on Inflation (Continued)

Study	Country (Period)	Method	Variables	Results
Behera *et al.* (2018)	21 states in India 2007-2016	GMM	Inflation (CPI): lags of inflation, exchange rate, output gap (HP filter), oil price	Output gap, exchange rate, oil price, first-order lag of inflation: positive and significant;; Second-order lag of inflation: negative and significant
Bhattacharya (2014)	Vietnam 2004Q1 - 2012Q3	VAR	Inflation (CPI): central bank policy rate, exchange rate growth, real GDP growth, credit growth,	Exchange rate: positive, significant; Interest rate: positive, significant;
Nguyen and Nguyen (2010)	Vietnam 2000M1 - 2010M3	VECM	Industrial Production, credit, interest rate, Money supply (M2), exchange rate, producer price index, budget deficits, trading value of the stock market, import price index, oil price (Brent EIA), rice price	Lags of inflation: positive, significant; exchange rate: positive, significant; Interest rate and money growth: negative, insignificant.
Vo and Nguyen (2017)	Vietnam 2003M1 - 2012M12	VAR	Industrial production, VNIBOR, lending rate , CPI, NEER, VN-index; Oil price, US industrial production, US 3M LIBOR	Exchange rate: negative, insignificant; Interest rate: positive, significant; stock market index: negative, insignificant;
Anwar and Nguyen (2018)	Vietnam 1995Q1 - 2010Q4	SVAR	Inflation (CPI), T-Bills, Real GDP, Exchange rate, Money supply	Exchange rate: negative, insignificant; Interest rate: negative, insignificant; Money supply: negative, insignificant

The determinants of inflation make up a popular subject and an enormous volume in the literature of macroeconomics. While underlying theories (such as the quantity theory of money) motivating the relationship between inflation and its determinants are well-established and provide a proper explanation for inflation determination, these theories only cover a simple and reduced-form model of inflation process while the NKPC framework can supply an in-depth understanding of the inflation process (Keen Meng, 2016).[3]

Following Gali and Gertler (1999), Chowdhury *et al*. (2006), Tillmann (2009), and Lanne and Luoto (2014), Behera *et al*. (2018) and Narayan *et al*. (2019), the hybrid open-economy version of the NKPC for Vietnam is specified as follows:

$$\pi_t = \alpha_0 + \alpha_1 e_t + \alpha_2 i_t + \alpha_3 m_t + \alpha_4 gbd_t + \alpha_5 gap_t + \sum_{i=1}^{t} \alpha_{6i} (\pi_{t-i}) + \sum_{i=1}^{t} \alpha_{7i} (\pi_{t+i}) + \alpha_8 ipi_t + \alpha_9 oil_t + \alpha_{10} rice_t + \varepsilon_t \quad (1)$$

where π_t is inflation rate measured as year-on-year growth of CPI, π_{t-i} is lag(s) of inflation, π_{t+i} is lead(s) of inflation, e_t is exchange rate (number of VND per 1 USD), i_t is the interest rate (one of the following: central bank policy rate, lending interest rate, one-month interbank interest rates) m_t is money supply proxied by broad money *M*2, gbd_t is the ratio of government budget deficit over GDP, gap_t is the output gap (derived from the HP filter, linear trend model or quadratic trend model), ipi_t is import price index, oil_t is the Brent oil price (USD per barrel), $rice_t$ is the rice price (USD per metric ton), ε_t is the error term and Δ is the first-difference operator. While the interest rate has an expected negative sign, the exchange rate, money supply, government budget deficit, output gap, import price index, oil price and rice price are expected to have positive signs.

While all other variables are relatively easily accessible (see Table 2 below), the variable, output gap, deserves some attention here. Defined as the difference between actual output and potential output, output gap usually occupies an essential role in the NKPC framework[4]. However, there is a variety of ways to derive this variable. Some scholars prefer the use of a linear trend model (Abbas and Sgro, 2011; Abbas *et al*., 2016; Bleaney and Francisco, 2018; Florio, 2018) or quadratic trend model (Abbas and Srgo, 2011; Lanne and Luoto, 2014) to derive the potential output and then compute the output gap. Others (Hahn, 2003; Ramakrishnan and Vamvakidis, 2002; Batini *et al*., 2005; Paul, 2009) make use of the HP filter to extract potential GDP and then calculate the output gap as the difference between actual and potential GDP. In order to see whether the impact of the output gap is dependent on how it is derived, this study employs two measures to calculate the output gap (HP filter and linear trend models).

[3] For a detailed discussion of the quantity theory of money and its extensions, see Mankiw (2016) and Nghiem (2020).

[4] Both Giordani (2004) and Florio (2018) argue that the output gap should be used instead of real GDP in an inflation model because the omission of the output gap is likely to lead to the price puzzle.

Table 2.
Variable Definitions and Sources for Inflation Model

This table provides a list of variables definitions, measurements and sources. Note: IMF IFS stands for International Monetary Fund (IMF) International Financial Statistics (IFS); GSO: General Statistics Office; EIA: Energy International Agency; GDP: Gross Domestic Product; VND: Vietnam Dong; USD: US Dollar; Vietnam's Interbank Offered Rate (VNIBOR).

Variable	Definition/Constructions	Source
Inflation π	Inflation, measured by year-on-year growth of CPI, seasonally adjusted using Eviews' Census X-12, in decimals	IMF IFS
gap (HP filter)	Output gap derived using the HP filter from (log of) real GDP, seasonally adjusted using Census X12, in USD terms	Vietnam's GSO, author's calculations
gap (linear trend)	Output gap derived from the linear trend model of (log of) real GDP, in USD terms.	Vietnam's GSO, author's calculations
IR_1M (*i*)	Average one-month interbank interest rate in Vietnam (VNIBOR), in decimals	Reuters DataStream
e	Average interbank exchange rate, measured as number of VND per 1 USD.	Reuters Eikon
Policy rate (*i*)	SBV's policy interest rate, in decimals	IMF IFS
Lending rate (*i*)	Average lending interest rate of four major commercial banks	IMF IFS
m	Vietnam's money supply, seasonally adjusted using Census X12 in EViews. Monthly missing values in Vietnam's money supply (12/255) observations missing) are linearly interpolated using EViews 9	IMF IFS
ipi	Import price index, seasonally adjusted using Census X12 in Eviews (2010=100). Monthly data interpolated from quarterly series	Vietnam's GSO
oil	Brent oil price in USD, seasonally adjusted using Census X12 in Eviews.	EIA
rice	Rice price in USD per tonne, seasonally adjusted using Census X12 in Eviews	Indexmundi, US Department of Agriculture; World Bank

III. DATA AND PRELIMINARY ANALYSIS

Data are sourced from IMF's International Financial Statistics, Vietnam's General Statistics Office (GSO), Thomson Reuters Datastream, Energy International Agency and Indexmundi. Tables 3 and 4 present the descriptive statistics as well as results of the ADF and PP unit root tests of the variables used in the estimation at the quarterly and monthly frequencies, respectively.

According to the results, most variables are non-stationary at their level forms while becoming stationary at their first-difference forms. There are some cases where the ADF test and PP test give conflicting results (namely, the output gap derived from the HP filter, the central bank policy rate; the output gap derived from the HP filter,). However, to avoid the problem of spurious regression, all variables will enter the model in their first-difference forms[5] [6].

IV. EMPIRICAL RESULTS

A. Empirical Results

Empirical estimations of the augmented NKPC are presented in Tables 5 to 7. The optimal number of lead(s) and lag(s) is chosen using SIC.

[5] We also measure the output gap using the quadratic linear trend model. However, results using this approach are very similar to those when the output gap derived from the HP filter and linear trend model. These results are available upon request.

[6] Under the NKPC framework, the unemployment rate is also used instead of the output gap. However, results of the PP unit root test indicate that this variable is I(2) across both quarterly and monthly frequencies. Therefore, it is not used in the model.

Table 3.
Descriptive Statistics for Inflation Model

This table provides descriptive statistics of the variables used in the model (defined in Table 2 in the main text) at the quarterly and monthly frequencies. Output gap (*gap*) is measured by two different methods: using the HP filter, using a linear trend model (linear), IR_ON, IR_1W, IR_1M, IR_2M, IR_3M, IR_6M, IR_1Y denote the interbank interest rates in Vietnam of the following maturities: one-month, Policy rate is the SBV's policy interest rate, Lending Rate is the lending interest rate. π is the inflation rate, *e* is the exchange rate, *ipi* is the import price index, oil is the Brent crude oil price, rice is the price of rice, *gbd* is the ratio of government budget deficit over GDP, *m* is money supply, SD is standard deviation, N is the number of observations.

	Output Gap (*gap*)		Other Variables									
	HP Filter	Linear	Policy rate	IR_1M	Lending Rate	π	*e*	*ipi*	*gbd*	*m*	*oil*	rice
Panel A: Quarterly Frequency												
Mean	0.0000	0.0000	0.0822	0.0740	0.1165	0.0664	16,949.3400	85.5930	−0.0249	87,800,000,000.00	55.7951	363.0538
Median	0.0017	0.0036	0.0650	0.0694	0.1108	0.0562	15,958.0700	85.9172	−0.0275	48,100,000,000.00	49.3734	330.8034
Maximum	0.0829	0.1361	0.1890	0.1823	0.2100	0.2775	22,701.3300	127.7606	0.0120	310,000,000,000.00	119.8189	838.0692
Minimum	−0.1531	−0.1916	0.0480	0.0216	0.0696	−0.0233	11,009.4700	59.5800	−0.0507	4,390,000,000.00	10.9058	165.4581
SD	0.0394	0.0593	0.0366	0.0309	0.0336	0.0609	3,368.9790	17.4452	0.0169	89,300,000,000.00	34.0878	142.2533
N	85	85	85	74	85	81	85	85	85	85	85	85
Panel B: Monthly Frequency												
Mean	0.0000	0.0000	0.0823	0.0735	0.1165	0.0664	16,949.3400	85.5957	-0.0249	86,000,000,000.00	55.8043	363.0154
Median	0.0008	0.0067	0.0650	0.0688	0.1114	0.0560	15,975.8300	85.7928	-0.0263	47,700,000,000.00	47.8213	329.8400
Maximum	0.0670	0.1382	0.1890	0.1894	0.2100	0.2838	22,788.0900	128.4227	0.0137	307,000,000,000.00	125.5190	888.0117
Minimum	-0.1532	-0.2166	0.0480	0.0167	0.0696	-0.0270	11,008.2900	59.5869	-0.0518	4,170,000,000.00	10.1425	165.1430
SD	0.0302	0.0599	0.0369	0.0312	0.0339	0.0612	3,357.4510	17.3917	0.0169	87,200,000,000.00	34.1450	142.6134
N	255	255	255	220	254	243	255	255	255	255	255	255

Table 4.
Unit Root Test Results for Inflation Model

This table provides the ADF and PP unit root test results (based on a model with constant and trend) of variables used in Equation (1) at quarterly and monthly frequencies. The optimal number of lags in ADF test is selected using SIC; the bandwidth selection for PP test is based on Newey-West bandwidth. Output gap (*gap*) is measured by three different methods: using the HP filter, using a linear trend model (linear) and a quadratic trend model (quadratic), IR_1M, denote the one-month interbank interest rates in Vietnam of the following maturities, Policy rate is the SBV's policy interest rate; *p*-values are in parentheses; **, *** denote significant at 5% and 1% levels, respectively.

	Output Gap (*gap*)		Other Variables									
	HP Filter	**Linear**	**Policy rate**	**Lending Rate**	**IR_1M**	π	*e*	*ipi*	*gbd*	*m*	*oil*	*rice*
Panel A: Quarterly Frequency, Level Form												
ADF test	−2.7818	−1.6869	−3.5188	-2.6767	−2.4823***	−1.3591	-2.7396	-2.0436	−1.7128	-1.0843	-2.1550	-1.9292
(*p*-value)	(0.2081)	(0.7485)	(0.0440)	(0.2489)	(0.3358)	(0.8644)	(0.2240)	(0.5689)	(0.7367)	(0.9251)	(0.5078)	(0.6304)
PP test	−4.3203***	−2.5935	−2.8990	-2.7413	−2.8619	−2.5007	2.1901	-1.4966	−2.0764	-0.8714	-1.6274	-1.8413
(*p*-value)	(0.0048)	(0.2844)	(0.1682)	(0.2233)	(0.1809)	(0.3271)	(0.4886)	(0.8232)	(0.5510)	(0.9539)	(0.7738)	(0.6757)
Panel B: Quarterly Frequency, First-difference Form												
ADF test	-12.2519***	-11.4838***	-6.4007***	-7.2407***	-7.1058***	-3.1767**	-5.0093***	-5.3524***	-6.1691***	-5.9095***	-6.2174***	-7.2637***
(*p*-value)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0256)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
PP test	-12.2519***	-11.3814***	-6.7600***	-6.4074***	-5.9983***	-3.7859***	-5.1479***	-5.3342***	-4.0685***	-5.8881***	-6.2208***	-7.2193***
(*p*-value)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0045)	(0.0000)	(0.0000)	(0.0018)	(0.0000)	(0.0000)	(0.0000)
Panel C: Monthly Frequency, Level Form												
ADF test	−2.7818	−1.6869	−3.5188	-2.6767	−2.4823***	−1.3591	-2.7396	-2.0436	−1.7128	-1.0843	-2.1550	-1.9292
(*p*-value)	(0.2081)	(0.7485)	(0.0440)	(0.2489)	(0.3358)	(0.8644)	(0.2240)	(0.5689)	(0.7367)	(0.9251)	(0.5078)	(0.6304)
PP test	−4.3203***	−2.5935	−2.8990	-2.7413	−2.8619	−2.5007	2.1901	-1.4966	−2.0764	-0.8714	-1.6274	-1.8413
(*p*-value)	(0.0048)	(0.2844)	(0.1682)	(0.2233)	(0.1809)	(0.3271)	(0.4886)	(0.8232)	(0.5510)	(0.9539)	(0.7738)	(0.6757)
Panel D: Monthly Frequency, First-difference Form												
ADF test	-12.2519***	-11.4838***	-6.4007***	-7.2407***	-7.1058***	-3.1767**	-5.0093***	-5.3524***	-6.1691***	-5.9095***	-6.2174***	-7.2637***
(*p*-value)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0256)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
PP test	-12.2519***	-11.3814***	-6.7600***	-6.4074***	-5.9983***	-3.7859***	-5.1479***	-5.3342***	-4.0685***	-5.8881***	-6.2208***	-7.2193***
(*p*-value)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0045)	(0.0000)	(0.0000)	(0.0018)	(0.0000)	(0.0000)	(0.0000)

Table 5.
Determinants of Inflation - Interest Rates is the Central Bank Policy Rate

This table presents empirical analysis of inflation in Vietnam using equation (1) at quarterly and monthly frequencies where interest rate is the central bank policy rate. The first column contains list of variables which are defined as follows: the dependent variable π_t is Vietnam's inflation rate (year-on-year growth of CPI); c is the constant, e_t is exchange rate (in log), i_t is the central bank policy interest rate, m_t is money supply (in log), gbd_t is the ratio of government budget deficit over GDP, gap_t is the output gap (measured by HP filter or linear trend model), π_{t-i} is lag i^{th} of inflation, π_{t+i} is lead i^{th} of inflation, ipi_t is import price index (in log), oil_t is the Brent oil price (USD per barrel, in log), $rice_t$ is the rice price (USD per metric ton, in log), Δ is the first-difference operator. The p-values are in parentheses. Rn^2 is the test of joint-significance of all variables in the model, N is the number of observations, **, *** denote significant at 5% and 1% levels respectively. The last four columns (which are divided into two groups: quarterly frequency and monthly frequency) present results when the output gap is computed using HP filter or linear trend model. The optimal number of lead(s) and lag(s) is chosen using SIC.

	Quarterly Frequency		**Monthly Frequency**	
	Output gap using HP filter	**Output gap using Linear Trend**	**Output gap using HP filter**	**Output gap using Linear Trend**
c	0.0037	0.0038	-0.0001	0.0001
	(0.3172)	(0.2990)	(0.9029)	(0.8275)
Δe_t	-0.1677	-0.1817	-0.1287**	-0.1131
	(0.2994)	(0.2642)	(0.0257)	(0.0538)
Δi_t	0.5030**	0.4988**	0.0316	0.0367
	(0.0118)	(0.0120)	(0.5913)	(0.5343)
Δm_t	-0.0328	-0.0331	0.0052	-0.0015
	(0.5274)	(0.5210)	(0.8260)	(0.9506)
Δgbd_t	0.9349**	0.9416**	0.5806**	0.4977
	(0.0489)	(0.0477)	(0.0237)	(0.0546)
Δgap_t	-0.0846	-0.0885	-0.1015***	-0.0950***
	(0.1387)	(0.1136)	(0.0001)	(0.0003)
$\Delta\pi_{t-1}$	0.3619***	0.3595***	0.3788***	0.4059***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\Delta\pi_{t+1}$	0.2528***	0.2473**	0.3533***	0.3663***
	(0.0089)	(0.0103)	(0.0000)	(0.0000)
$\Delta\pi_{t-2}$			-0.0996**	-0.1263**
			(0.0450)	(0.0114)
$\Delta\pi_{t+2}$			-0.0269	-0.0096
			(0.5986)	(0.8520)
$\Delta\pi_{t-3}$			0.1219***	0.1240***
			(0.0067)	(0.0060)
$\Delta\pi_{t+3}$			0.0694	0.0315
			(0.1363)	(0.5009)
Δipi_t	0.0668	0.0691	0.0227	0.0219
	(0.2821)	(0.2632)	(0.4953)	(0.5110)
Δoil_t	0.0033	0.0036	-0.0012	-0.0024
	(0.7977)	(0.7763)	(0.7793)	(0.5579)
$\Delta rice_t$	0.0283	0.0291	0.0117	0.0291***
	(0.1171)	(0.1046)	(0.1069)	(0.0001)
Adj R^2	0.4852	0.4773	0.3414	0.3413
Rn^2	214.5489***	215.0155***	599.4179***	648.4779***
(prob)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
N	78	78	234	234

Table 6.
Determinants of Inflation - Interest Rate is the Lending Rate

This table presents empirical analysis of inflation in Vietnam using equation (1) at quarterly and monthly frequencies where interest rate is the lending interest rate. The first column contains list of variables which are defined as follows: the dependent variable π_t is Vietnam's inflation rate (year-on-year growth of CPI); c is the constant, e_t is exchange rate (in log), i_t is the central bank policy interest rate, m_t is money supply (in log), gbd_t is the ratio of government budget deficit over GDP, gap_t is the output gap (measured by HP filter or linear trend model), π_{t-i} is lag i^{th} of inflation, π_{t+i} is lead i^{th} of inflation, ipi_t is import price index (in log), oil_t is the Brent oil price (USD per barrel, in log), $rice_t$ is the rice price (USD per metric ton, in log), Δ is the first-difference operator. The p-values are in parentheses. Rn^2 is the test of joint-significance of all variables in the model, N is the number of observations, **, *** denote significant at 5% and 1% levels respectively. The last four columns (which are divided into two groups: quarterly frequency and monthly frequency) present results when the output gap is computed using HP filter or linear trend model. The optimal number of lead(s) and lag(s) is chosen using SIC.

	Quarterly Frequency		Monthly Frequency	
	Output gap using HP filter	**Output gap using Linear Trend**	**Output gap using HP filter**	**Output gap using Linear Trend**
c	0.0058	0.0059	0.0002	0.0002
	(0.0813)	(0.0740)	(0.7351)	(0.7654)
Δe_t	-0.1673	-0.1826	-0.1503***	-0.0898
	(0.2729)	(0.2307)	(0.0071)	(0.1202)
Δi_t	0.4745***	0.4749***	0.1044	0.1270**
	(0.0049)	(0.0043)	(0.0926)	(0.0433)
Δm_t	-0.0649	-0.0644	0.0008	-0.0005
	(0.1517)	(0.1491)	(0.9732)	(0.9840)
Δgbd_t	0.4675	0.4679	0.7331***	0.5882**
	(0.2931)	(0.2892)	(0.0019)	(0.0179)
Δgap_t	-0.0721	-0.0763	-0.0880***	-0.0822***
	(0.1769)	(0.1413)	(0.0003)	(0.0008)
$\Delta\pi_{t-1}$	0.3398***	0.3366***	0.3596***	0.4125***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\Delta\pi_{t+1}$	0.2313**	0.2259**	0.3311***	0.3172***
	(0.0114)	(0.0125)	(0.0000)	(0.0000)
$\Delta\pi_{t-2}$				-0.0676
				(0.1240)
$\Delta\pi_{t+2}$				0.0108
				(0.8197)
Δipi_t	0.1088	0.1096**	0.0532	0.0436
	(0.0533)	(0.0485)	(0.0951)	(0.1856)
Δoil_t	-0.0063	-0.0060	-0.0035	-0.0035
	(0.6292)	(0.6398)	(0.4105)	(0.4090)
$\Delta rice_t$	0.0258	0.0269	0.0118	0.0196***
	(0.1231)	(0.1028)	(0.0960)	(0.0058)
Adj R^2	0.4334	0.4264	0.3532	0.3408
Rn^2	213.4581***	217.2886***	574.4409***	573.3105***
(prob)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
N	78	78	238	236

Table 7.
Determinants of Inflation - Interest Rate is the One-month Interbank Rate

This table presents empirical analysis of inflation in Vietnam using equation (1) at quarterly frequency where interest rate is the one-month interbank interest rate. The first column contains list of variables which are defined as follows: the dependent variable π_t is Vietnam's inflation rate (year-on-year growth of CPI); c is the constant, e_t is exchange rate (in log), i_t is the central bank policy interest rate, m_t is money supply (in log), gbd_t is the ratio of government budget deficit over GDP, gap_t is the output gap (measured by HP filter or linear trend model), π_{t-i} is lag i^{th} of inflation, π_{t+i} is lead i^{th} of inflation, ipi_t is import price index (in log), oil_t is the Brent oil price (USD per barrel, in log), $rice_t$ is the rice price (USD per metric ton, in log), Δ is the first-difference operator. The p-values are in parentheses. Rn^2 is the test of joint-significance of all variables in the model, N is the number of observations, **, *** denote significant at 5% and 1% levels respectively. The last four columns (which are divided into two groups: quarterly frequency and monthly frequency) present results when the output gap is computed using HP filter or linear trend model. The optimal number of lead(s) and lag(s) is chosen using SIC.

	Quarterly Frequency		**Monthly Frequency**	
	Output gap using HP filter	**Output gap using Linear Trend**	**Output gap using HP filter**	**Output gap using Linear Trend**
c	0.0014	0.0014	0.0000	0.0000
	(0.6589)	(0.6458)	(0.9849)	(0.9500)
Δe_t	-0.1113	-0.1204	-0.2061***	-0.2123***
	(0.5041)	(0.4697)	(0.0028)	(0.0024)
Δi_t	0.5158***	0.5141***	0.0473	0.0466
	(0.0000)	(0.0000)	(0.3388)	(0.3481)
Δm_t	-0.0035	-0.0031	0.0015	0.0011
	(0.9361)	(0.9431)	(0.9495)	(0.9639)
Δgbd_t	0.4346	0.4616	0.6333**	0.6193**
	(0.3010)	(0.2740)	(0.0209)	(0.0255)
Δgap_t	-0.0621	-0.0654	-0.0988***	-0.0907***
	(0.2105)	(0.1801)	(0.0003)	(0.0009)
$\Delta\pi_{t-1}$	0.4148***	0.4148***	0.3009***	0.3010***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\Delta\pi_{t+1}$	0.2813***	0.2777***	0.3588***	0.3577***
	(0.0007)	(0.0008)	(0.0000)	(0.0000)
$\Delta\pi_{t-2}$			-0.0303	-0.0313
			(0.5565)	(0.5469)
$\Delta\pi_{t+2}$			0.0048	0.0070
			(0.9272)	(0.8948)
$\Delta\pi_{t-3}$			0.1438***	0.1441***
			(0.0022)	(0.0023)
$\Delta\pi_{t+3}$			0.0503	0.0464
			(0.3026)	(0.3449)
Δipi_t	0.0199	0.0207	0.0345	0.0357
	(0.7078)	(0.6960)	(0.3131)	(0.2993)
Δoil_t	0.0000	0.0002	-0.0034	-0.0032
	(0.9996)	(0.9868)	(0.4170)	(0.4399)
$\Delta rice_t$	0.0194	0.0197	0.0046	0.0048
	(0.2043)	(0.1966)	(0.5128)	(0.4957)
Adj R^2	0.5016	0.5010	0.3699	0.3689
Rn^2	290.7887***	293.4137***	635.0096***	622.1622***
(prob)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
N	72	72	216	216

B. Discussion of Results

First, results in Tables 5 to 7 show that both the lead(s) and lag(s) of inflation are significant with quite consistent effects across both frequencies, implying that economic agents in Vietnam are both forward- and backward-looking. The significance of lead(s) and lag(s) of inflation also indicates that inflation is probably highly persistent in Vietnam, signaling that it could be difficult for the SBV to contain inflation.

Second, in contrast to the (highly) significant role of both lead(s) and lag(s) of inflation, the import price index, oil price and rice price are all insignificant across both frequencies.

The next variable grabbing special attention is the interest rate. In this study, there are several types of interest rates used: namely, the central bank policy rate, the lending interest rate and the one-month interbank interest rates.[7] The results are quite consistent across maturities: at the quarterly frequency, almost all types of interest rates are significant. However, all of these rates have positive impact on inflation – which is inconsistent with theory. Although this result is in contrast to conventional theories, it is not uncommon in the literature and can be attributed to several reasons.

The first reason is that higher interest rates could be considered as a reference point for higher inflation expectations. McKinnon (1993) argues that when interest rates become higher, agents are likely to use the current high interest rates as a signal for higher expected inflation. Furthermore, Narayan *et al*. (2019) state that when agents are backward-looking, they tend to use past inflation to form inflation expectations. As a result, if a country already suffered high inflation and employed higher interest rates to contain inflation in the past, raising the present interest rates may be seen as the signal that inflation is likely to rise and therefore, fueling inflation rather than containing it.

Podkaminer (1998) puts forward that when interest rates rise, it will become more costly for firms to maintain their inventories, thus making the so-called excess market supply disappear which in turn, grant retailers a quasi-monopoly power to charge consumers with higher prices even when there is excessive production capacity. Another reason, according to Elliott (1962) and Ratchford (1973), is that higher interest rates may cause housing prices and durable prices to rise (direct effects) as well as make producers scale back their production or charge higher prices (indirect effects), thus pushing up inflation.

From a different perspective, Linnemann (2005) opines that under the presence of distorted income taxes, higher interest rates may have contradictory effects on prices. On the one hand, in the conventional demand channel, higher nominal interest rates may lead to higher real interest rates (due to sticky prices) which in turn, bring down consumption and lower prices. On the other hand, higher interest rates also imply greater debt burdens in the future. Heavier debt burden and repayments, through the effects of intertemporal substitutions, may lead to lowered labor supply and higher wages and prices.

[7] As a robustness check, models using other remaining types of interest rates including: the deposit rate, the overnight, one-week, two-month, three-month, six-month, one-year interbank interest rates are also estimated. Generally, the results are the same, further strengthening the unexpected effects of interest rates on inflation, regardless of the types of interest rates used. These results will be available upon request.

Also related to debt, Ali and Anwar (2013) propose another explanation for the positive effect of interest rate on inflation: the higher the level of public debt in a country is, the more likely that country will engage in debt monetization which in turn, may destroy monetary policy credibility and bring about undesirable consequences.

Last, but not least, for economies in transition (such as Vietnam), higher interest rates may fuel inflation rather than contain it. In these economies, monetary authorities usually decide and adjust their policy interest rates based on inflation dynamics, so interest rates have to "chase" inflation and higher interest rates are associated with higher inflation (Rother, 2000; Pelipas, 2006).

In the literature, the positive effects of higher interest rates on inflation are also known as the cost-channel of monetary policy. This channel has been confirmed by various authors (see Table 1 in Section III).

Regarding the case of Vietnam, the existence of the cost-channel has been confirmed in previous empirical studies. While Pham (2016) and Tran (2018) both document the positive impact of central bank policy rate on inflation, Vo and Nguyen (2017) record this impact using overnight interbank interest rate. Therefore, the positive effect of interest rates on inflation in this study further corroborate findings of previous studies and strengthen the existence of the cost-channel of monetary policy in Vietnam.

However, when it comes to monthly frequency, the interest rate variable becomes insignificant, regardless of the type of interest rates used. In other words, the cost-channel of monetary policy in Vietnam is present at the quarterly frequency while it becomes negligible at the monthly level.

Similar to the interest rate, the exchange rate also has unexpected effects on inflation in Vietnam. Theoretically, the exchange rate variable should have positive sign as exchange rate devaluations/depreciations may put upward pressures on inflation. However, for Vietnam, this variable has a negative sign (insignificant at quarterly and significant at monthly levels), indicating that an appreciation of the exchange rate (rather than a depreciation) will cause inflation to rise.

At first glance, this effect may appear counter-intuitive. However, this phenomenon is not uncommon in the literature. Adu and Marbuah (2011) document this effect for Ghana while Nguyen (2015) as well as Anwar and Nguyen (2018) both confirm the upward pressures of exchange rate appreciation on prices and inflation. Similarly, Kandil and Morsy (2009) also find this effect for Oman and reason that the positive effects of exchange rate appreciation on inflation can be attributed to the so-called wealth effect: exchange rate appreciation also leads to higher purchasing power of domestic savings which in turn, causes people to spend more and therefore increases inflation. In terms of data frequency, this variable is insignificant across both frequencies.

The next variable is money supply. Theoretically, this variable should have positive sign as higher money supply will lead to higher inflation. However, in this study, money supply is insignificant across both frequencies and it has negative sign in the majority of cases at the quarterly frequency and has mixed signs (both positive and negative) at the monthly level. Although this effect is in contrast with theory, it is not uncommon in the literature. Anwar and Nguyen (2018) also find that the price level initially decreases before it increases in response to higher money supply in Vietnam (the impact is also insignificant).

In addition to findings by Anwar and Nguyen (2018), we propose another explanation for the inconsistent effect of money supply on inflation: the (in) appropriateness of the measurement of money supply. Given the ever-higher level of financial innovation and liberalization, the current measurement of money supply as simple sum of monetary aggregates may no longer be appropriate. Empirical studies point out that the so-called Divisia monetary index (Divisia index) computed as a weighted average of the monetary components (where the weights sum to unity and are assigned to each component based on their features) – has superior performance in modelling the relationship with other macroeconomic variables (inflation, output, exchange rate). Therefore, the unexpected effect of money supply on inflation in Vietnam also draws the attention of relevant authorities to the computation of the Divisia index. In fact, the superiority of the Divisia index over their simple sum counterpart is confirmed by numerous researchers (Rotemberg *et al*.,1995; Schunk, 2001; Darrat *et al*., 2005; Dahalan *et al*., 2005; Drake and Fleissig, 2008; Binner *et al*., 2009; Serletis and Rahman, 2013; Florackis *et al*., 2014; Belongia and Ireland, 2015, 2019). The last reason, proposed by Su *et al*. (2016), states that when the central bank adopts a discretionary approach to monetary policy with a view to achieving both price stability and economic growth, it has to applies various monetary policy tools to regulate the supply of credit and money. Therefore price movement and money supply may move in opposite directions rather than the same direction as directed by the quantity theory of money.

Another important determinant of inflation, namely, the government budget deficit, is significant and has theoretically correct sign of positive across both frequencies. This finding is in consistent with findings by Dhakal *et al*. (1994); Jalil *et al*. (2014) and Adu and Marbuah (2011). At the quarterly frequency, this variable is insignificant while it becomes highly significant at the month level, probably suggesting that its effect is delayed similar to the case of the exchange rate mentioned above.

Output gap is insignificant at the quarterly and significant at the monthly levels, further confirming the delayed effects of variables and strengthening the hypothesis that the frequency of data does matter for the significance of variables. However, this variable has a consistent negative sign across both frequencies, no matter how it is derived (whether using the linear trend model or the HP filter). While the negative sign might seem counter-intuitive at first, this effect is not uncommon in the literature and can be attributed to several factors.

The first reason, according to Nugent and Glezakos (1982), is due to country-level differences. They argue that less developed countries, especially those whose the agriculture sector is important, are likely to have an upward-sloping traditional Phillips curve, implying that employment can have positive impact on inflation. Nugent and Glezakos (1982) state that this phenomenon is a mirror reflecting the stark differences in institutional quality between developed and least developed countries.

Another explanation for the negative sign of the output gap is proposed by Gali and Gertler (1999) as well as Abbas *et al.* (2016) for different specifications of the NKPC. They posit that the marginal costs constitute a better proxy for economic activities than the output gap does. Their empirical evidence also lends

support to the use of marginal costs rather than the output gap in an NKPC model

In the empirical literature, the inconsistent and negative sign of the output gap has also been recorded for various countries. For example, Ramakrishnan and Vamvakidis (2002) (using quarterly data from 1980Q1-2000Q4) or Wimanda *et al*. (2011) (using monthly data from 1980M1 to 2008M12) all document the negative impact of the output gap on inflation in Indonesia. Similarly, Fedderke and Schaling (2005) record this effect for South Africa (using annual data from 1960 to 1999). On the other hand, Batini *et al*. (2005) confirm the inconclusiveness of the output gap on inflation for quarterly UK data from 1972Q3 to 1999Q2.

In a rare study making use of multiple data frequencies, Lee (1995) employs both US annual and quarterly data and conclude that the Phillips curve is unstable both across frequencies and across groups of countries.

In summary, results in this study reinforce the belief that the effects of variables are subject to frequency of data. Specifically, a variable may change from being significant to insignificant when it comes from quarterly to monthly frequency (and vice-versa). This finding implies that researchers and policymakers must be careful when making inferences about the impact of a variable as it could be influenced by data frequency.

Going into greater details, the analysis of the inflation process in Vietnam shows that significant determinants of inflation in Vietnam are the interest rates, output gap and the government budget deficit. While their significance alters between two frequencies of data, only the government budget deficit has the theoretically expected (positive) impact on inflation. Other remaining variables, namely, the interest rates (positive sign, no matter what type of interest rates used), the exchange rate (negative sign) and the output gap (negative sign, no matter how it is computed), all have unexpected effects on inflation, throwing into question the effectiveness of traditional measures of curbing inflation. The signs and significance of variables are summarized in Table 8.

V. CONCLUSION

Inspired by the overlooked role of data frequency in empirical macroeconomic research in general and for the Vietnamese economy in particular, this study revisited the inflation process in Vietnam using a NKPC approach from 1996M1 to 2017M3 (using both quarterly and monthly data). The main contributions of this paper include the confirmation of the role of data frequency in determining the impact of variables; the unexpected effects of interest rates (positive), exchange rate (negative) and output gap (negative) on inflation; the measurement of money supply.

Findings of this paper carry important implications for Vietnamese policymakers and researchers. First and foremost, the overall results lend strong support to the hypothesis that data frequency does influence the impact of independent variables in empirical research, meaning that a variable can change from being significant to insignificant when we come from one frequency to another. This implies that future studies regarding inflation in Vietnam (and also other countries) should be carried out at different frequencies before any conclusion about the effects of a variable can be made. Further, the paper also documented several interesting

Table 8.
Summary of Results

This table provides a summary of the signs and significance of variables in the model for Vietnam's inflation at both quarterly and monthly frequencies: (+) means the variable has positive impact; (-) means the variable has negative impact, +/- means the variable has mixed signs, **(*) means significant at 5% level or better at 1% level. The first column contains independent variables used in the model, the second column denote frequency of data (Q: quarterly; M: monthly) and the remaining columns correspond to the type of interest rates used in the model: Policy rate is the central bank policy rate, IR_ON is the overnight interbank interest rate, IR_1W is one-week interbank interest rate; IR1M is one-month; IR_2M is two-month, IR_3M is three-month, IR_6M is six-month; IR_1Y is one-year.

Variable	Frequency	Policy Rate	Lending Rate	1M Interbank Interest Rate
				IR_1M
Exchange rate (*e*)	Q	–	-	–
	M	–	-	– , ***
Interest rate (*i*)	Q	+, **(*)	+, ***	+, ***
	M	+	+, **	+
Money supply (*m*)	Q	–	-	–
	M	–	-	+
Government budget deficit (*gbd*)	Q	+, **	+	+
	M	+	+, **(*)	+, **
Output gap (*gap*) (HP filter)	Q	–	-	–
	M	-, ***	-, ***	-, ***
Output gap (*gap*) (linear trend)	Q	–	-	–
	M	-, ***	-, ***	-, ***
Output gap (quadratic trend)	Q	-	-	-
	M	-, ***	-, ***	-, ***
Lag 1 of inflation π_{t-i}	Q	+, **(*)	+, **(*)	+, **(*)
	M	+, **(*)	+, **(*)	+, **(*)
Lead 1 of inflation π_{t+i}	Q	+, **(*)	+, **(*)	+, **(*)
	M	+, **(*)	+, **(*)	+, **(*)
Import price index (*ipi*)	Q	+	+	+
	M	+	+	+
Oil price (*oil*)	Q	+	-	+
	M	-	-	-
Rice price (*rice*)	Q	+	-	+
	M	+, **	+, **	+

results regarding the impact of interest rates, exchange rate and output gap on inflation.

With regards to the impact of monetary policy variables on inflation, both interest rates (no matter what type of interest rate is used) and exchange rate have effects inconsistent with conventional thinking, signaling that traditional tools of containing inflation may prove counter-productive. Specifically, all types of interest rates have positive impact on inflation (although they are significant at the quarterly frequency only), meaning that higher interest rates are likely to fuel inflation rather than containing it – which goes against conventional thinking and the intended purpose of raising interest rates. This result could be attributed to several reasons such as the presence of the cost-channel of monetary policy in Vietnam, the prolonged high levels of public debt and the deeply-engrained inflation expectations in Vietnam's economic agents. Therefore, the SBV is strongly advised to implement strong measures to dampen these inflation expectations and enhance its credibility. A good choice is adopting inflation targeting - which is also a recommendation of the IMF (2017).

The exchange rate – an important monetary policy tool in Vietnam – also exerts unexpected impact on inflation. Contrary to findings of other studies, a depreciation/devaluation of the domestic currency (the Vietnam Dong) will have dampening effect on inflation and an appreciation is likely to cause inflation to hike which can be explained by the so-called wealth effect and/or uncovered interest parity. This result indicates that the effects of exchange rate on inflation are still controversial and should be investigated further.

The ratio of government budget deficit over GDP is positive across both frequencies and highly significant at the monthly level, pointing out the need for the Vietnamese government to keep its budget deficits at sustainable level as well as calling for the coordination of both monetary and fiscal policies in Vietnam (as this variable is managed by the Ministry of Finance and the Vietnamese government rather than the SBV).

The output gap, whether generated from a linear trend model or the HP filter, always exerts negative impact on inflation (inconsistent with traditional theories) which may also reflect that the current methods of computing the output gap are inappropriate and calls for further examinations of computing the output gap. Finally, the negative impact of money supply also calls into question the appropriateness of the current measurement of money supply.

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