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Welfare consequences of inconsistent monetary policy implementation in Vietnam

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ABSTRACT

We develop a New Keynesian model featuring Calvo price setting and Calvo wage setting to quantify the welfare consequences of shifting trend inflation in Vietnam. To capture the characteristics of the Vietnamese economy, we use the Simulated Method of Moment and calibrate parameters jointly to match the important selected moments of Vietnamese data. The results show a severe consequence of a constant positive trend inflation and an exogenous shock to trend inflation, especially when a central bank sets a high level of inflation target. Among staggered price and wage contracts, the latter play a vital role in transmitting the adverse impacts of constant and shifting trend inflation into the economy. Based on our analyses, raising inflation targets would seem to be a bad policy prescription in Vietnam.

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Shifting trend inflation; welfare consequences; second and third-order approximation; staggered price and wage contracts; Vietnam

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1. Introduction

Vietnam has experienced periods of unstable inflation in the past. In recent years, bad signals in the world market, such as an upsurge in the prices of commodity and petroleum, have raised concerns regarding potential substantial rises in future inflation in Vietnam. In addition, the implementation of Vietnamese monetary policies aiming to control these issues seems to be inconsistent and ineffective, which has partly contributed to a more substantial rise in inflation. All are expected to bring about serious consequences.

To model the substantial rise in inflation, many authors, such as Kozicki and Tinsley (2001), Ireland (2007), Cogley, Primiceri, and Sargent (2009) and Nakata (2014) have employed a highly persistent trend inflation process to depict slow changes in implicit inflation targets¹ set by a central bank. This adoption implies a lack of commitment to a fixed inflation target or a tendency of the central bank to let inflation rise. By using this idea, authors show the necessity for studies on shifting trend inflation², for example, the study illustrating the implications for the term

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Table 1. Monetary policy targets and performance in the period 2000-2015.

		2000	2001	2002	2003	2004	2005	2006	2007
Inflation	Target	6	< 5	3-4	< 5	< 5	< 6.5	< 8	< 8
	Perform	-1.7	-0.4	3.8	3.2	7.8	8.3	7.4	8.3
Output	Target	5.5-6	7.5-8	7-7.3	7-7.5	7.5-8	8.5	8	8.2-8.5
	Perform	6.8	6.89	7.08	7.34	7.79	8.44	8.23	8.46
		2008	2009	2010	2011	2012	2013	2014	2015
Inflation	Target	<10	< 15	7-8	<7	<10	8	7	5
	Perform	23.1	7.1	8.9	18.7	9.1	6.59	4.09	0.63
Output	Target	8.5-9	5	6.5					
	Perform	6.31	5.32	6.78					

Source: Author's computation from the data of State Bank of Vietnam (SBV), and Annual Report of SBV.

structure of interest rate by Kozicki and Tinsley (2001), that on the consequences for output and inflation by Ireland (2007), the research on implications for the predictability of inflation by Cogley et al. (2009), and the study on welfare consequences by Nakata (2014). However, the literature has mostly considered one form of rigidities - the sticky-price model with shifting trend inflation. Just recently, authors have considered other forms of rigidities to quantify welfare costs. In particular, Ascari, Phaneuf, and Sims (2018) incorporated staggered wages into the medium-scale model to quantify the welfare costs of constant trend inflation. They argue that constant trend inflation magnifies the inefficient utilization of labor, then produces more sizable welfare costs. Ha, Thanh, and Thang (2019) also emphasizes the important role of staggered wage contracts in transmitting the effects of trend inflation. However, the welfare consequences of shifting trend inflation, a salient property of developing countries, have not been fully exploited.

The present study fills the gap in the literature by exploiting the welfare costs of exogenous variation in trend inflation in Vietnam. In this paper, trend inflation is interpreted as a central bank's target inflation rate and we model it as a highly persistent AR(1) process. The focus is paid on the Vietnamese economy for the following reasons. First, the idea of shifting trend inflation is suitable for Vietnam because of its inconsistent and ineffective policy implementations during the 1996–2015 period. Table 1 reports changes in monetary policy targets as well as the difficulties in achieving them. Second, the actual data in Vietnam also indicate a time-varying and highly persistent property of trend inflation, especially during the financial crisis. Figure 1 clearly shows shifts in mean values or trend inflation (the red line) over time. To quantify the welfare consequences of shifting trend inflation, we first use a benchmark model -a standard New Keynesian model with Calvo price setting- to compare the welfare between an economy with zero and positive variance of shocks to trend inflation. Subsequently, additional analyses are conducted by considering a different price setting behavior to point out the welfare cost differences stemming from inefficient allocations of resources and physical adjustment costs; a higher-order approximation to check the accuracy of the second-order approximation; a robust check for parameters, and a model with both staggered price and wage contracts.

We model the characteristics of the Vietnamese economy by using the Simulated Method of Moment (SMM) for the quarterly data in Vietnam during the 1996Q1-2015Q4 period and make a robust check by calibrating the parameters jointly to match the important moments of the Vietnamese year data during the 2005–2016

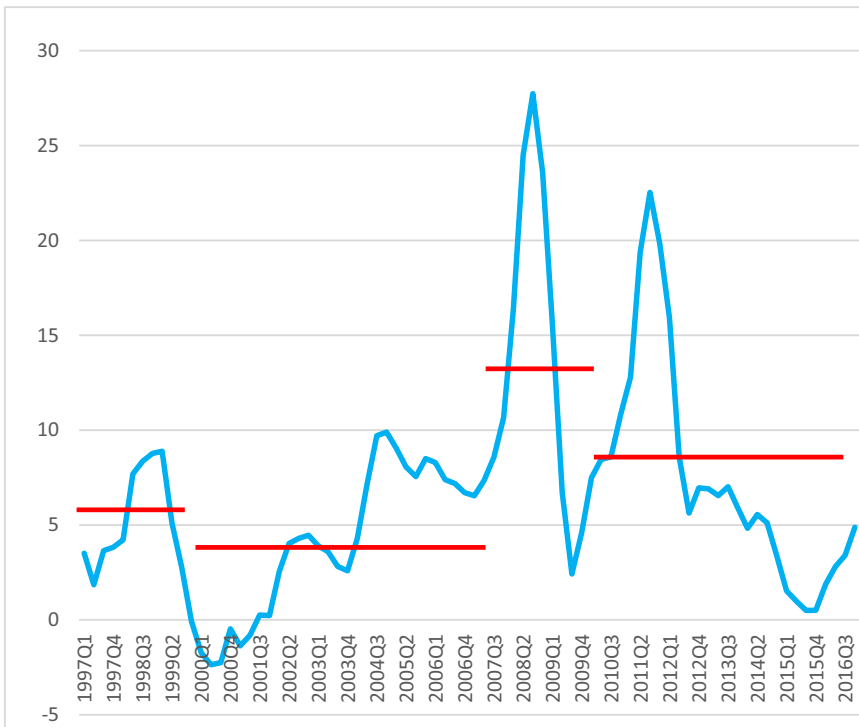


Figure 1. Vietnam CPI inflation: 1996Q1-2015Q4 (annualized quarter-to-quarter percent changes).
Source: GSO. The red lines are the average of inflation in different periods.

period. The inconsistency of the time period stems from the unavailability of quarterly data for consumption and labor supply in Vietnam—these yearly data have only been available since 2005. Selected moments, closely related to dynamic behavior of consumption and labor supply, are important for welfare cost computations, which are the main exercise of the paper.

With these considerations, we show that the consequences of constant and shifting trend inflation are severe, especially when a central bank sets a high inflation target level. The evidence is more obvious if we adopt the model with staggered price and wage contracts. Among two channels, the staggered wage contracts play a crucial role in transmitting the impacts of constant and shifting trend inflation into the economy. Our conclusion in the case of developing country is aligned with Ascari et al. (2018), who conducted a similar exercise in the U.S. In the present study, we provide additional evidence for the role of staggered wage contracts in the welfare consequences of shifting trend inflation. The welfare consequences in Vietnam are more severe than those in developed countries due to parameter value differences.

The rest of this paper is organized as follows. We outline the literature review in [Section 2](#) and the extended model is discussed in [Section 3](#). [Section 4](#) explains how to compute welfare and welfare costs. Estimated parameters are presented in [Section 5](#) while [Section 6](#) and [Section 7](#) show the main results and results of further analyses. Some conclusions are provided in [Section 8](#).

2. Literature review

A log-linearization around the zero inflation steady state is the popular approach in the existing literature³. The approach is convenient because it can produce a simple and tractable model but wash out some implications of the microfoundations⁴ and can lead to misleading conclusions. Realizing the limitations, Ascari (2004) and Bakhshia, Khanb, Burriel-Llombartc, and Rudolf (2007) make substantial changes in the short-term and long-term properties of model based on the Calvo staggered price model with trend inflation. In particular, Ascari (2004) studies the impulse response of output to the money-growth shock with various levels of trend inflation to analyse the effects of trend inflation on output persistence, while the effects of non-zero inflation on the slope of the NKPC are investigated by Bakhshia et al. (2007). The early contribution of Ascari (2004) and Bakhshia et al. (2007) are building blocks in the literature for the latter researchers to exploit diverse implications of non-zero and then shifting trend inflation.

Regarding welfare analysis, this paper is related to two strands of the literature. First, it is related to the literature on non-zero trend inflation. The plurality of models has so far adopted the sticky-price model with positive trend inflation, such as Ascari,(2004), Amano, Ambler, and Rebei (2007), Ascari and Ropele (2009), and Coibion and Gorodnichenko (2011). These papers show that a less-than-4-percent trend inflation rate has a minor impact on the economy. In particular, Ascari (2004) finds that an additional steady-state output loss of 0.5 percent is created when increasing trend inflation from 2 to 4 percent, while the compensation-equivalent welfare loss is less than one percent, as found in Amano, Moran, Murchison, and Rennison (2009). By contrast, Ascari et al. (2018) study a medium-scale model with staggered prices and staggered wages to show significant welfare costs of constant trend inflation. They also emphasize the role of staggered wage contracts on these costs.

The other strand is related to the model with shifting trend inflation. By employing the second perturbation approximation method suggested by Kim, Kim, Sims, and Schaumburg (2008), Nakata (2014) attempts to quantify the welfare consequences of shifting trend inflation. In his model, he argues that the negative impacts of exogenous variations in trend inflation are transmitted into the economy solely by the staggered price contracts. With this consideration, he shows the trivial welfare costs of shifting trend inflation. In this study, we follow an approach similar to that used in Nakata (2014) to measure the welfare consequences of shifting trend inflation. However, we incorporate an additional channel that trend inflation distorts the relative allocation of labors across households through a staggered wage contract, as discussed by Erceg, Henderson, and Levin (2000), thus causing changes in welfare. By matching the important moments of Vietnam, we argue the welfare consequences of inconsistent policy implementation for the case of developing countries.

Previously, many authors argue that raising inflation targets would seem to be a bad policy prescription. On the policy front, the significant welfare costs of trend inflation present a warning against policy proposals requiring central banks to raise their inflation targets. This policy implication is aligned with those of Ascari and

Sbordone (2014) and Ascari et al. (2018). However, these results might conflict with the fact that central banks target a positive level of inflation, around 2 percent per year. The discussion against targeting a zero or a low rate of inflation is the Zero Lower Bound (ZLB, henceforth) constraint. In particular, Summers (1991) discusses that with a very low average inflation rate, the central banks might encounter limitations of conducting an effective stabilization policy since this policy requires non-negative real interest rates and nominal rates. The need for a negative real rate of interest when there exists the zero lower bound would be accommodated by an inflation target ranged from 1 to 3 percent as argued by Summers (1991) and Fischer (1996). Krugman (1998) raises a similar point when he argues that an inflation target of 4 percent for several years in Japan is necessary to generate the negative real rates and curb deflation.

In recent years, economists have emphasized on the likelihood and consequences of hitting the ZLB, for example, Reifschneider and Williams (2000), Schmitt-Grohe and Uribe (2011), and Coibion, Gorodnichenko, and Wieland (2012). They argue that raising the inflation targets could reduce the costs related to the ZLB as well as the probability of hitting the ZLB. Moreover, the literature has so far advocated a higher inflation target, which is realized by a temporary increase in expected inflation instead of a permanent increase in the long-run inflation objective. To generate the expectation of higher inflation, the key is the commitment to a history-dependent policy as argued by Eggertsson and Woodford (2003), Coibion et al. (2012), and Ascari and Sbordone (2014). The commitment to the future policy can decrease the current real interest rate and provide economic stimulus. Without the commitment to a history-dependent policy, it would be more likely to emphasize the costs of positive trend inflation.

3. Model

The model is populated by four classes of agents: the household indexed by $j \in [0, 1]$; the final-goods producing firms; a continuum of intermediate-goods producing firms indexed by $i \in [0, 1]$; and the government.

3.1. The household

In the benchmark model, households maximize their expected discounted present value of future period utility with respect to a given budget constraint. Their period utility function can be separated into two components: consumption (C_t) and working hours (H_t) as given

$$\sum_{t=0}^{\infty} \beta^t \left(\ln(C_t - \gamma C_{t-1}) - \frac{\omega}{1+v} H_t^{1+v} \right), \quad (1)$$

where β and γ denotes the discount factor and the habit formation parameter, which are restricted as $0 < \beta < 1, 0 \leq \gamma < 1$. v is the inverse Frisch elasticity of labor supply. The flow budget constraint is represented as

$$P_t C_t + \frac{B_t}{R_t} = B_{t-1} - P_t T_t + W_t H_t + D_t. \quad (2)$$

Equation (2) shows the different sources of households' income. Households earn $W_t h_t(i)$ by providing $h_t(i)$ units of labor to each intermediate-goods producing firm $i \in [0, 1]$ at the beginning of each period. They also receive a nominal profit, D_t , because they own the intermediate goods, and receive the lump-sum government transfer, T_t . They then decide to use their income in different ways. During each period t , households purchase consumption goods, C_t , from the final-goods producing firms at the nominal price, P_t . They also purchase the one-period bond, B_t , from the intermediate-goods producers at the price $1/R_t$ as a saving. Therefore, households choose labor supply, h_t , bond holding, B_t , and consumption, C_t , to maximize the life-time utility, subject to the budget constraints.

3.2. The Final-Goods producing firm

Final-goods producing firms maximize profits by using constant-return-to-scale technology. In order to manufacture Y_t units of final products, they employ $Y_t(i)$ units of intermediate goods sold at a nominal price $P_t(i)$ as follows

$$\left[\int_0^1 Y_t(i)^{\frac{\theta_p-1}{\theta_p}} di \right]^{\frac{\theta_p}{\theta_p-1}} = Y_t, \quad (3)$$

where θ_p is the price elasticity of demand for intermediate goods. The profit maximization problem of the final-goods producing firms is given as

$$P_t \left[\int_0^1 Y_t(i)^{\frac{\theta_p-1}{\theta_p}} di \right]^{\frac{\theta_p}{\theta_p-1}} - \int_0^1 P_t(i) Y_t(i) di. \quad (4)$$

The first-order condition for the final-goods producing firms problem is given as

$$Y_t(i) = \left[\frac{P_t(i)}{P_t} \right]^{-\theta_p} Y_t. \quad (5)$$

Since the competitive final-goods firms have zero profit in the equilibrium, the final good price, therefore, can be rewritten as

$$P_t = \left[\int_0^1 P_t(i)^{1-\theta_p} di \right]^{\frac{1}{1-\theta_p}}. \quad (6)$$

3.3. The Intermediate-Goods producing firm

A continuum of intermediate-goods producing firms, indexed by $i \in [0, 1]$, hire $h_t(i)$ units of labor from households to produce Y_t units of intermediate goods (i)

during the period t . They employ constant-returns-to-scale technology, which can be written as:

$$Z_t h_t(i) = Y_t(i). \tag{7}$$

The logarithm of aggregate technology shock, Z_t , follows a stationary stochastic process:

$$\ln(Z_t) = \rho_Z \ln(Z_{t-1}) + \epsilon_{Z_t}, \tag{8}$$

where ϵ_{Z_t} is the serially uncorrelated innovation, which has a normal distribution with mean zero and standard deviation σ_Z . We assume that the intermediate-goods producers set nominal prices as in a staggered Calvo price fashion. According to Calvo (1983), a fixed fraction, η_p , of firms, which cannot re-optimize their nominal prices, still set their prices according to the indexation rule. The way those firms reset their prices is given as:

$$P_t(i) = (\pi_{t-1}^{\mu_p} \bar{\pi}_t^{1-\mu_p})^{\chi_p} P_{t-1}(i), \tag{9}$$

where χ_p and μ_p are a degree of price indexation and the relative weight on lagged inflation, respectively. The inflation, π_t , is defined as $\frac{P_t}{P_{t-1}}$ and $\bar{\pi}_t$ is interpreted as the central bank's inflation target. The fraction $(1-\eta_p)$ of firms, on the other hand, are able to set their price. They maximize the present value of future profits by choosing the price P_t^*

$$E_t \sum_{s=0}^{\infty} \beta^s \frac{\lambda_{t+s}}{\lambda_t} \eta_p^s \left[P_t^*(i) (\bar{\pi}_t^{\chi_p s})^{(1-\mu_p)} (\pi_{t-1, t+s-1}^{\chi_p})^{\mu_p} - \frac{W_{t+s}}{Z_{t+s}} \right] Y_{t+s}(i), \tag{10}$$

such that

$$Y_{t+s}(i) = \left[\frac{P_t^*(i) (\bar{\pi}_t^{\chi_p s})^{(1-\mu_p)} (\pi_{t-1, t+s-1}^{\chi_p})^{\mu_p}}{P_{t+s}} \right]^{-\theta_p} Y_{t+s}, \tag{11}$$

where $\pi_{t+s-1} = \left(\frac{P_{t+2}}{P_{t+1}}\right) \dots \left(\frac{P_{t+s}}{P_{t+s-1}}\right)$ if $s = 1, 2, 3, \dots$, λ_t is the same as the Lagrangian multiplier on the household's budget constraints, and W_t denotes the nominal wage.

3.4. Authority's policy

3.4.1. Monetary policy

The authority sets the short-term nominal interest rates following a Taylor rule. In particular, the rule allows for interest rate smoothing and interest rate responses to deviations of inflation from the central bank's inflation target and deviations of output from the steady state:

$$R_t \bar{R} = (R_{t-1} \bar{R})^{\rho_R} \left[\left(\frac{\pi_t}{\bar{\pi}_t}\right)^{\phi_\pi} (y_t \bar{y})^{\phi_y} \right]^{1-\rho_R} \exp(\epsilon_{R_t}), \tag{12}$$

where \bar{R}, \bar{y} are the steady state of R_t and Y_t , respectively. The parameter ρ_R illustrates the degree of interest rate smoothing. ϵ_{R_t} is an i.i.d. monetary policy shock.

The evolution of trend inflation is described as a persistent AR(1) process as:

$$\ln(\bar{\pi}_t) = (1 - \rho_{\bar{\pi}}) \ln(\bar{\pi}^*) + \rho_{\bar{\pi}} \ln(\bar{\pi}_{t-1}) + \epsilon_{\bar{\pi}_t}, \quad (13)$$

where $\rho_{\bar{\pi}}$ denotes the degree of shock persistence and $\epsilon_{\bar{\pi}_t}$ is a standard normally distributed shock that is independent of time.

3.4.2. Fiscal policy

The public spending is given by

$$G_t = \left(1 - \frac{1}{g_t}\right) Y_t, \quad (14)$$

where g_t is an exogenous disturbance following the stochastic process

$$\ln(g_{t+1}) = (1 - \rho_g) \ln(\bar{g}) + \rho_g \ln(g_t) + \epsilon_{g_t}, \quad (15)$$

where $(1 - \rho_g)$ represents the steady-state value of government spending relative to output.

3.5. Market clearing condition

The market clearing condition in the labor market, the goods market and the bond can be expressed in turn as

$$H_t = \int H_t(i) di, \quad (16)$$

$$Y_t = C_t + G_t, \quad (17)$$

$$B_t = 0. \quad (18)$$

4. Welfare and welfare cost computation

Following Nakata (2014), we also use the perturbation method to compute the approximation to the policy functions around the deterministic steady-state, and use these to compute the welfare. We decompose the welfare into the three different components as given below:

$$\begin{aligned} E \left[\sum_{t=0}^{\infty} \beta^t u(x_t) \right] &\approx \sum_{t=0}^{\infty} \beta^t u(\bar{x}) + \sum_{t=0}^{\infty} \beta^t Mu(\bar{x}) E[x_t - \bar{x}] + \sum_{t=0}^{\infty} \beta^t Nu(\bar{x}) E[(x_t - \bar{x}) \otimes (x_t - \bar{x})] \\ &= U_d + U_l + U_v, \end{aligned}$$

where $x_t = [C_t, C_{t-1}, H_t]$; and $Mu(\bar{x})$ and $Nu(\bar{x})$ are vectors that contain the first and second derivative of $u(\cdot)$ evaluated at \bar{x} , which are the deterministic steady state of x_t . Three components consist of: the deterministic component, $U_d = \sum_{t=0}^{\infty} \beta^t u(\bar{x})$, the level component, $U_l = \sum_{t=0}^{\infty} \beta^t Mu(\bar{x})E[x_t - \bar{x}]$, and the volatility component, $U_v = \sum_{t=0}^{\infty} \beta^t Nu(\bar{x})E[(x_t - \bar{x}) \otimes (x_t - \bar{x})]$.

Then the welfare cost can be computed as:

$$E \left[\sum_{t=0}^{\infty} \beta^t u \left(\left(1 + \frac{wc}{100} \right) C_{A,t}, \left(1 + \frac{wc}{100} \right) C_{A,t-1}, H_{A,t} \right) \right] = E \left[\sum_{t=0}^{\infty} \beta^t u(C_{B,t}, C_{B,t-1}, H_{B,t}) \right], \tag{19}$$

where $C_{A,t}, H_{A,t}$ are consumption and labor supply in the economy with $\sigma_{\pi} > 0$ and $C_{B,t}, H_{B,t}$ are consumption and labor supply in the economy with $\sigma_{\pi} = 0$.

5. Estimation

5.1. Data

The system involves three observable variables, including output growth (g_t^y), inflation (π_t) and short-term nominal interest rate (r_t). This study uses quarterly Vietnamese data collected from 1996Q1 to 2015Q4. The raw data are taken from the database available at the General Statistics Office of Vietnam (GSO) and the International Financial Statistics (IFS). Seasonally-adjusted figures for real GDP, which are converted to GDP per capita by dividing by the total population, serves as a measure of output growth. Quarterly changes in seasonally-adjusted figures for Consumer Price Index and quarterly lending rate yield the measure of inflation and nominal interest rate, respectively. Regarding the yearly data, we collect figures for the private consumption, the number of employment and the government expenditure during the 2005–2016 period. All data are de-trended prior to the estimation of the model.

5.2. Simulated method of moment estimates

Following Ruge-Murcia (2012), the present study uses the Simulated Method of Moment (SMM). By using this method, we minimize the weighted distance between the empirical moments and the moments computed from the artificial data.

The model parameters are separated into two subsets. The first subset includes fixed parameters that are fixed prior to the estimation Table 2 shows the parameter values of this subset. We set the discount factor (β) and the inverse Frisch elasticity of labor supply (v) to 0.99 and 3.00, respectively. Regarding the production sector, the degree of indexation (χ) and the weight on lagged inflation (μ) are set to 0.00 and 1.00, as argued by Cogley and Sbordone (2008)⁵. The elasticity of the substitution parameter for differentiated intermediate goods is set to 10. We also set the probability of not being able to optimize (η_p) to 0.65 and then we let this value change to observe differences in welfare consequences. The share of government expenditure to output is set to its respective sample mean.

Table 2. Fixed parameters.

Parameter	Description	Value	Target
$\bar{\pi}$	Steady-state inflation	1.02 ^{0.25}	Two percent infl.steady state
β	Discount factor	0.99	Standard value
ν	Inverse Frisch elasticity of labor supply	3.00	Standard value
γ	Consumption habit	0.80	Standard value
θ	Elasticity of substitution	10.0	Standard value
χ	Degree of Indexation	0.00	Cogley & Sbordone,(2008)
μ	Weight on lagged inflation	1.00	Cogley & Sbordone,(2008)
G / Y	Government expenditure share	0.22	Sample Mean

Source: Author's calculation and collection from previous papers.

Table 3. SMM estimates.

Parameter	Description	Estimated Value	S.e.
ρ_R	Monetary shock persistence	0.8102*	0.0004
ρ_Z	Technology shock persistence	0.7999*	0.0005
$\rho_{\bar{\pi}}$	Shock to trend inflation persistence	0.9949*	0.0000
$100\sigma_R$	Monetary shock volatility	0.0024*	0.0063
$100\sigma_Z$	Technology shock volatility	0.0099*	0.0024
$100\sigma_{\bar{\pi}}$	Shock to trend inflation volatility	0.0007 *	0.0022
ϕ_{π}	Taylor coefficient on the inflation gap	2.4234*	0.0003
ϕ_y	Taylor coefficient on the output gap	0.5000*	0.0001

Note: S.E. is a standard error. The superscripts * denote that for the null hypothesis the true parameter value is zero and rejected at the 5 percent significance levels.

Source: Authors' calculation.

The second subset includes the remaining parameters for the persistence level and volatility level of monetary shock (ρ_R and σ_R), technology shock (ρ_Z and σ_Z), and shock to trend inflation ($\rho_{\bar{\pi}}$ and $\sigma_{\bar{\pi}}$), the Taylor coefficients on inflation (ϕ_{π}) and output growth (ϕ_y). Table 3 reports the SMM estimated parameters based on the second-order approximate solution for the Vietnamese data. The null hypothesis that each estimated parameter does not differ from zero is statistically rejected at 5 percent significance level. Regarding a shock to trend inflation, although previous work, such as Ascari and Sbordone (2014), Cogley et al. (2009), Fuhrer and Moore (1995) and Fuhrer (2010) holds the consensus on the high persistence of trend inflation, its exact magnitude still remains debated, especially considering the time-varying trend inflation in developing countries. Table 3 shows that the persistence of trend inflation is close to 0.995 and statistically significant at 5 percent.

Regarding the coefficients of Taylor rule, this study shows a fairly high persistence of monetary shock. Furthermore, the obtained parameters imply that the central bank responds considerably to the inflation gap, but weakly to the output gap. These results are consistent with Hieu (2012). Moreover, the monetary shock volatility is smaller than that of the shock to trend inflation (Figure 2).

5.3. SMM impulse responses

The top panel of Figure 2 shows a decrease in consumption and labor supply in response to a one-standard deviation increase in the monetary policy shock. Moreover, reductions in both output and inflation are also attributed to the monetary policy shock, as expected by the theory in the bottom panel of Figure 2. A higher magnitude of change, such as a two-standard deviation increase in exogenous

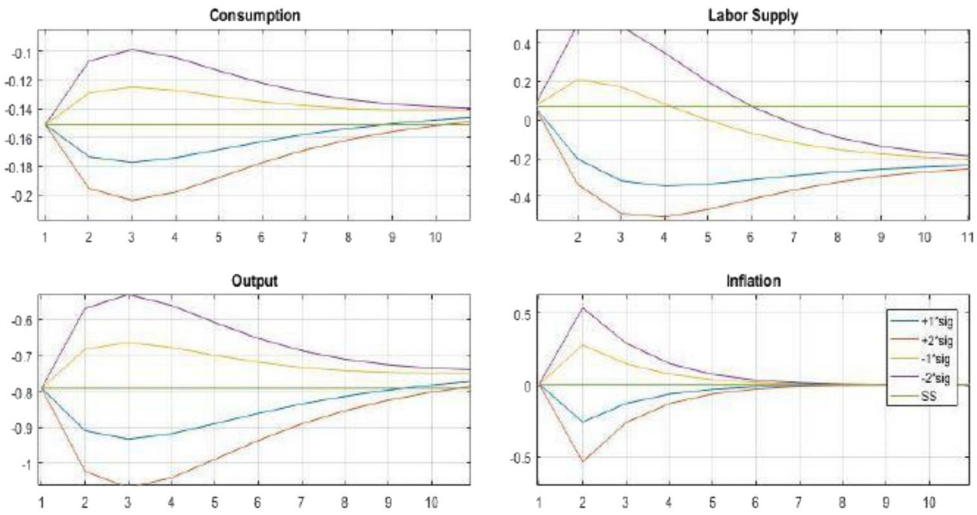


Figure 2. Dynamic responses to a monetary shock. Source: Authors' calculation.

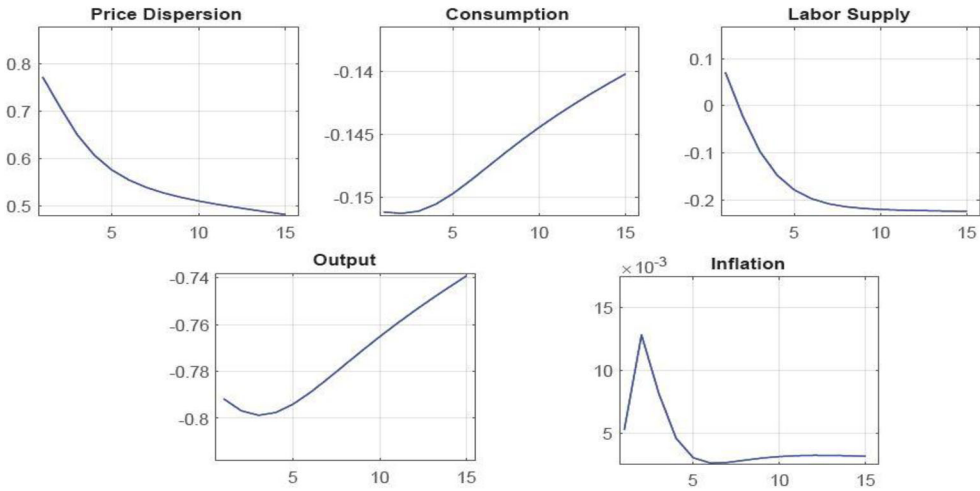


Figure 3. Dynamic responses to a shifting trend inflation shock. Source: Authors' calculation.

monetary policy shock, signifies changes in the respective macroeconomic variables. The converse happens when considering a negative exogenous shock.

It is essential to analyze the consequences of inconsistent policy implementation for the shock to trend inflation. The top panel of Figure 3 provides some implications to explain how the shock to trend inflation leads to welfare distortions. In particular, a one-standard deviation increase in exogenous shock to trend inflation leads to a decrease in consumption but a rise in labor supply. These opposite trends tend to expand over time. In addition, we also investigate the macroeconomic effects of exogenous shock to trend inflation in the bottom panel of Figure 3. A diminishing of output growth and a rise in inflation are explicit consequences of the shock to trend inflation. From the results, it can be seen that

Table 4. Welfare costs of constant trend inflation.

	$\bar{\pi}^* = 0\%$	$\bar{\pi}^* = 6\%$
Welfare Cost		3.14%
Welfare	-212.81	-219.22
U_d	-211.06	-212.11
U_l	-0.25	-4.94
U_v	-1.50	-2.16
Steady-state C	0.82	0.81
Steady-state H	1.04	1.05
E(C)(*)	-0.0019	-0.0386
E(H)(*)	0.0001	0.0017
$100\sigma_C$	1.69	2.01
$100\sigma_H$	1.54	1.94

Note: (*) expressed as percentage deviation from the deterministic steady state. U_d , U_l and U_v are the deterministic steady-state, level and volatility components, respectively.

Source: Authors' calculation.

ignoring the positive constant and time-varying property of trend inflation may lead to serious consequences.

6. Welfare and welfare cost results

This study firstly conducts exercises to observe the welfare effects of exogenous shock to trend inflation⁶. Moreover, we perform additional analyses to make some robust checks of some issues, such as a different price setting behavior, the accuracy of the second-order approximation, alternative parameters, and different nominal rigidities.

6.1. Welfare cost of constant positive trend inflation

6.1.1. Results

Table 4 compares the economy with a 0-annualized-percent level and a 6-annualized-percent level of trend inflation. When a central bank changes its inflation targets from 0 percent to 6 percent, it leads to a high welfare cost (3.14%) compared to the results in Lucas's study. The results suggest that the sudden change in inflation targets might cause severe welfare consequences in developing countries like Vietnam. A welfare cost due to a higher level of trend inflation mainly stems from changes in the level component (from -0.25 to -4.94), while changes in the deterministic component and volatility component are negligible (from -211.06 and -1.50 to -212.11 and -2.16, respectively). The economic properties reflected by the steady-state values, mean values, and volatility values of consumption and labor supply in Table 4 provide explanations for welfare differences between two economies. A reduction in the steady-state and mean values and a rise in the volatility values of consumption and leisure are sources of welfare distortions when a central bank sets up a constant positive level of trend inflation. The results are aligned with those of Amano et al. (2007) and Nakata (2014). The top panel of Figure 4 represents changes in welfare costs with respect to a rise in the trend inflation level and the bottom panel provides reasons to explain these changes. A given amount of rise in trend inflation causes welfare costs to grow non-linearly.

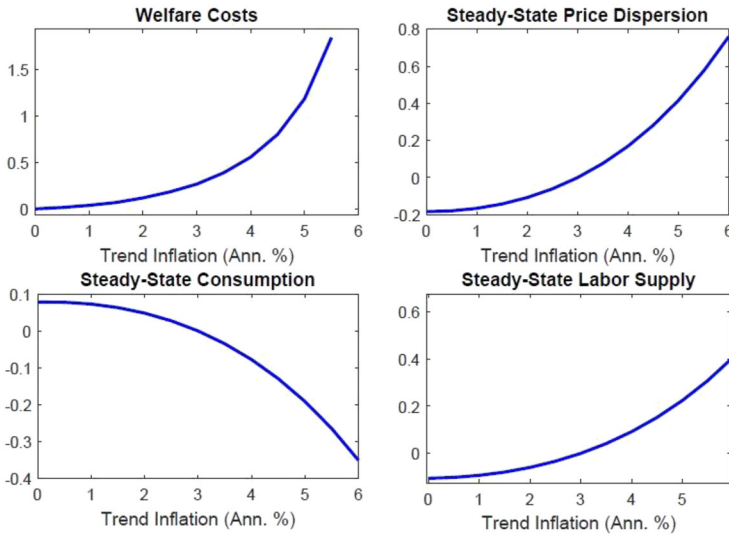


Figure 4. Welfare costs of constant positive trend inflation. *Source:* Authors' calculation.

6.1.2. The cost of price dispersion

The Calvo mechanism creates a price dispersion term, which generates a wedge between output and hours to cause welfare distortions. The wedge, however, is sensitive to trend inflation, i.e. it induces differences when trend inflation is positive and disappears when trend inflation is zero. In this section, we argue that positive trend inflation affects the steady-state price dispersion to create the cost of price dispersion. The steady state of price dispersion is represented as follows:

$$s(\bar{\pi}_t) = \frac{1-\eta}{1-\eta\bar{\pi}_t^{(1-\chi)\theta}} [\varphi^*(\bar{\pi}_t)]^{-\theta} = \frac{(1-\eta)^{\frac{1}{1-\theta}}}{(1-\eta\bar{\pi}_t^{(1-\chi)\theta})(1-\eta\bar{\pi}_t^{(1-\chi)(\theta-1)})^{\frac{\theta}{1-\theta}}}. \tag{20}$$

It can be seen that the steady-state price dispersion increases corresponding to an increase in η, θ , and $\bar{\pi}_t$ whereas a reduction of price indexation (χ) leads to an improvement of price dispersion. More intuitively, if the price is entirely flexible ($\eta = 0$), there is no price dispersion, $s(\bar{\pi}_t) = 1$. On the other hand, a greater level of substitution elasticity leads to a growth in price, due to more inefficient allocations among firms. More importantly, a rise in constant positive trend inflation drives the steady-state price dispersion up by inducing a gap between the price set by re-setting firms and the average price level, and this results in an inefficiency loss in aggregate production. Finally, a decrease in steady-state price dispersion can be explained by price indexation since it implies that non-optimizing firms can catch up with price changes by optimizing firms. Hence, a greater price indexation causes price to be less dispersed at any inflation rate.

Following Damjanovic and Nolan (2010) and Ascari and Sbordone (2014), this study also measures the cost of price dispersion, expressed as $\tilde{z}_t = \frac{z_t}{s_t}$, which is a measure of effective aggregate productivity and maps a percentage increase in price

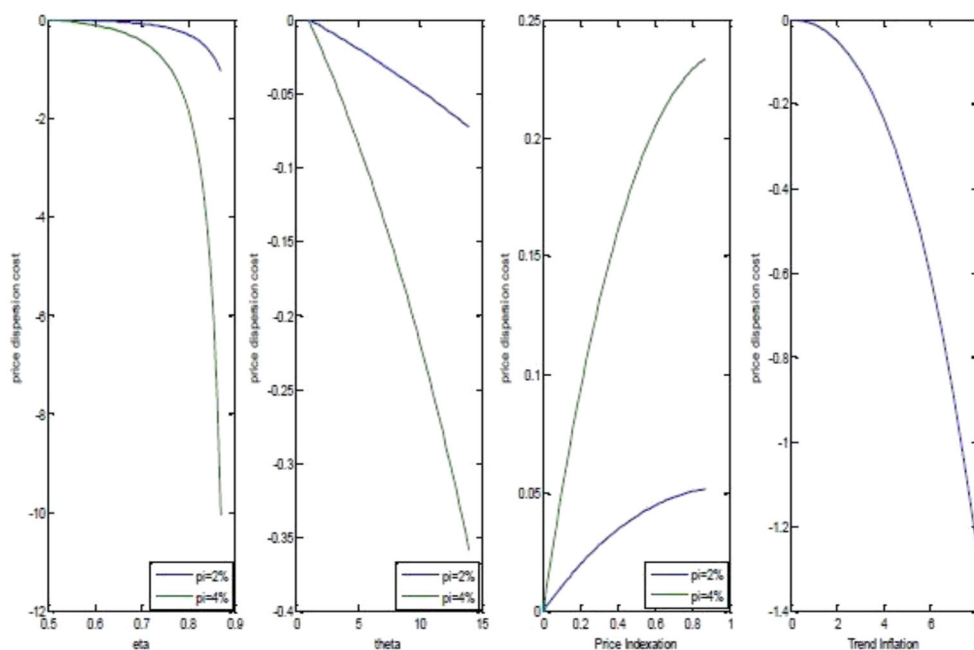


Figure 5. The cost of price dispersion. *Source:* Authors' calculation.

dispersion into an equivalent percentage. Figure 5 illustrates that trend inflation leads directly to a reduction in effective aggregate productivity. Furthermore, a rise in price stickiness and elasticity of substitution or a fall in price indexation causes effective aggregate productivity to diminish. This is due to the way in which these parameters impact the steady-state price dispersion, as discussed above. These effects, then, are magnified when trend inflation reaches a higher level. In short, trend inflation can impact the cost of price dispersion in both direct and indirect ways.

6.1.3. Determinacy regions

In this section, the paper examines the effects of changes in trend inflation on the ability of the monetary authority to guarantee a determinacy region and macroeconomic stability. As argued by Woodford (2003), a given increase in inflation, intuitively, requires a greater proportional rise in the nominal interest rate, inducing a rise in the real interest rate. As a result, a drop in output is recorded via the Euler equation to curb the initial growth of inflation via the NKPC. Figure 6 illustrates the determinacy region in the space of the policy parameters (ϕ_y, ϕ_π) . The left-hand side to the right-hand side of the top panel of Figure 6 correspond to changes in the determinacy region when trend inflation is 0, 4, and 8 percent. The bottom panel represents changes in the determinacy region when trend inflation increases.

For the interest rate rule, the determinacy region narrows rapidly with a rise in trend inflation. Visually, the determinacy region shrinks because the two lines governing the generalized principles rotate when trend inflation increases. Hence, a weaker policy toward output gap and a stronger policy toward inflation are required simultaneously to guarantee the determinacy region. Consistent with previous studies,

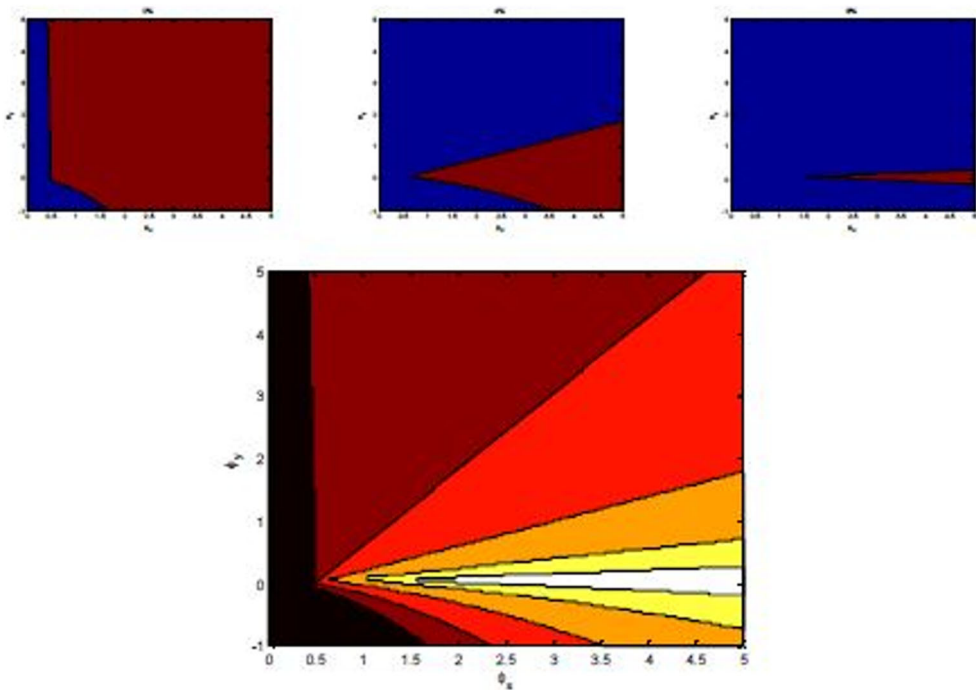


Figure 6. Determinacy region and trend inflation.

Note: The determinacy region is expressed by the red area.
Source: Authors' calculation.

for example, Ascari and Ropele (2009) and Ascari and Sbordone (2014), the monetary policies that respond more to deviations of inflation from the target and less to the output gap are preferred in order to ensure the determinacy region in the higher inflation rate regime.

6.2. Welfare cost of shifting trend inflation

Table 5 compares the economy with zero variance of shocks to trend inflation and the economy with positive variance of shocks to trend inflation. In both economies, we set a positive level of trend inflation but this exercise differs from the previous one by assuming the time-varying variance of trend inflation. The results show a lower welfare in the economy with shifting trend inflation compared to the economy with constant trend inflation. The welfare differences come mainly from a reduction in the level and volatility component, whereas the deterministic component remains unchanged. In this exercise, we also report changes in the properties of economies to explain the sources of the welfare costs of shifting trend inflation. Both mean consumption and leisure tend to decrease, while the economy becomes more volatile, reflected by its higher volatility levels due to a positive variance in shocks to trend inflation. The welfare cost is 0.13%, which is slightly larger than the result of Nakata (2014), who performed the same exercise to explain the persistently high inflation during the Great Inflation period in the U.S. In his study, Nakata also performs the sensitivity analysis to show that the welfare costs of trend inflation are contingent on

Table 5. Welfare costs of shifting trend inflation.

	$\sigma_{\bar{\pi}} = 0$	$\sigma_{\bar{\pi}} > 0\%$
Welfare Cost		0.13%
Welfare	-212.79	-213.05
U_d	-221.15	-211.15
U_l	-0.21	-0.45
U_v	-1.43	-1.45
Steady-state C	0.82	0.82
Steady-state H	1.05	1.05
$E(C)^{(*)}$	-0.0016	-0.0036
$E(H)^{(*)}$	0.0001	0.0001
$100\sigma_C$	1.65	1.66
$100\sigma_H$	1.63	1.63

Note: (*) expressed as percentage deviation from the deterministic steady state. U_d , U_l and U_v are the deterministic steady-state, level and volatility component, respectively.

Source: Authors' calculation.

the values of relevant parameters, such as the degree of price indexation, the frequency of price adjustment, the level of trend inflation and the persistence and variance level of shocks to trend inflation. Because we employ SMM for the Vietnamese data to obtain the different parameter values, these partly explain the welfare cost differences between our study and Nakata's.

7. Additional analyses

7.1. A different price setting: Rotemberg quadratic price adjustment costs

This section investigates whether the aforementioned conclusions still hold with an alternative price friction. For comparison purposes, we quantify the welfare costs of constant and shifting trend inflation in the Rotemberg pricing model. As in Nakata (2014), this analysis helps us to point out the differences in the welfare costs of inflation stemming from the price dispersion, causing the inefficient allocation of resources and those stemming from the physical adjustment cost of changing prices. An intermediate-goods producing firm (i) selects the prices to maximize the expected discounted future profits as follows:

$$E_t \sum_{j=0}^{\infty} \beta^j \frac{\lambda_{t+j}}{\lambda} P_{t+j} \left\{ \frac{P_{t+j}(i)}{P_{t+j} Y_{t+j}(i)} - \frac{W_t(i)}{P_{t+j}} N_{t+j}(i) - \frac{AC_{t+j}(i)}{P_{t+j}} \right\}, \tag{21}$$

subject to the quadratic price adjustment cost, $AC_t(i)$, which is given as:

$$AC_t(i) = \frac{\phi}{2} \left\{ \frac{P_t(i)}{(\pi_{t-1}^\mu \bar{\pi}^{1-\mu})^\lambda P_{t-1}(i)} - 1 \right\}^2 Y_t(i), \tag{22}$$

where ϕ is the parameter capturing the price adjustment cost. In this Rotemberg model, we need to calibrate ϕ such that the slope of the Phillips curve is the same as those in the Calvo pricing model at zero trend inflation. By mapping ϕ in the Rotemberg model to η in the Calvo model, these two models imply an identical form for the first-order approximated Phillips curve. Under the Calvo

Table 6. Welfare costs of constant and shifting trend inflation: Rotemberg model.

	Constant Trend Inflation		Shifting Trend Inflation	
	$\bar{\pi}^* = 0\%$	$\bar{\pi}^* = 6\%$	$\sigma_{\bar{\pi}} = 0$	$\sigma_{\bar{\pi}} > 0$
Welfare Cost		0.40%		0.08%
Welfare	-211.21	-212.02	-212.76	-212.92
U_d	-211.06	-211.74	-211.14	-211.14
U_l	-0.15	-0.16	-0.17	-0.32
U_v	-0.0001	-0.1220	-1.45	-1.46
Steady-state C	0.82	0.81	0.82	0.82
Steady-state H	1.04	1.05	1.05	1.05
E(C)(*)	-0.0012	-0.0012	-0.0014	-0.0026
E(H)(*)	0.0001	0.0001	-0.00001	-0.00001
$100\sigma_C$	0.01	0.08	1.66	1.67
$100\sigma_H$	0.70	0.71	1.69	1.69

Note: (*) expressed as percentage deviation from the deterministic steady state. U_d , U_l and U_v are the deterministic steady-state, level and volatility component, respectively.

Source: Authors' calculation.

pricing with zero trend inflation, the first-order approximation Phillips curve is presented as:

$$\hat{\Xi}_t = \frac{(1-\eta)(1-\beta\eta)}{\eta} \hat{w}_t + \beta E_t \hat{\Xi}_{t+1}, \tag{23}$$

where $\hat{\Xi}_t = \hat{\pi}_t - \chi\mu\hat{\pi}_{t-1}$ and $\hat{\pi} = \ln\left(\frac{\pi_t}{\bar{\pi}_t}\right)$. Under the Rotemberg pricing with zero trend inflation, the first-order approximation Phillips curve is given as

$$\hat{\Xi}_t = \frac{\theta-1}{\phi} \hat{w}_t + \beta E_t \hat{\Xi}_{t+1}. \tag{24}$$

Therefore, ϕ needs to be set as:

$$\phi = \frac{\eta(\theta-1)}{(1-\eta)(1-\beta\eta)}. \tag{25}$$

Accordingly, the values of ϕ are [33,48,70,107] with respect to $\eta = [0.6, 0.65, 0.7, 0.75]$.

Table 6 reports the welfare costs of constant and shifting trend inflation in the Rotemberg model. An increase in trend inflation leads to a rise in the price adjustment costs, then an asymmetric change in consumption and labor supply decisions. Although conclusions in the two models are the same, the welfare consequences due to constant and shifting trend inflation in the Calvo model are slightly larger than those in the Rotemberg model.

7.2. A third-order approximation

In the following exercise, we conduct a robust check of the accuracy of the second-order approximation by solving the model with a third-order approximation. We extend the method of Kim et al. (2008) to quantify a third-order welfare. The results do not indicate a significant quantitative difference between the second-order and third-order welfare costs⁷ (0.13 percent versus 0.16 percent). By performing the higher-order approximation, we have some evidence to confirm our results on welfare

Table 7. SMM estimates.

Parameter	Description	Calibration
η	Probability of not being able to optimize	0.7400
ρ_R	Monetary shock persistence	0.8500
ρ_Z	Technology shock persistence	0.9300
$\rho_{\bar{\pi}}$	Shock to trend inflation persistence	0.9950
$100\sigma_R$	Monetary shock volatility	0.0025
$100\sigma_Z$	Technology shock volatility	0.0110
$100\sigma_{\bar{\pi}}$	Shock to trend inflation volatility	0.0008
ϕ_{π}	Taylor coefficient on the inflation gap	2.2000
ϕ_Y	Taylor coefficient on the output gap	0.4000

Source: Authors' calculation.

costs. The third-order in the exercise, however, is computationally expensive, thus not convenient for further analyses.

7.3. A robust check of parameters

To conduct a robust check of parameters, we use an alternative set of parameters that are obtained from simulating the model to match the important moments of data. We select four moments: the output volatility (σ_Y); the consumption volatility (σ_C); the labor supply volatility (σ_H); and the correlation between consumption and output ($corr(Y, C)$). We choose these moments because they are closely related to the behavior of consumption and labor supply, which serve for welfare consequence analysis⁸. To obtain the information of these moments, we employ HP-filtered Vietnamese yearly data for output, consumption, and labor supply during the 2005–2016 period⁹ instead of quarterly data for output growth, inflation, and short-term interest rate as previously. Table 7 reports the calibrated parameters.

Table 8 compares the moments created by the calibrated model with the moments computed by the data. In general, the calibrated model is remarkably good at matching the selected moments, thus can provide an adequate laboratory for subsequent welfare analysis.

Table 9 represents the welfare costs and dynamic properties of the economy due to constant and shifting trend inflation. In general, all conclusions in the previous exercise remain the same. However, welfare costs of constant and shifting trend inflation from using the recalibrated parameters are larger. These results might suggest that the changes in implicit inflation targets set by a central bank might be a serious problem in the case of developing countries like Vietnam.

7.4. A model with staggered price and wage contracts

7.4.1. Model expansion

In the literature, Ascari et al. (2018) show the more sizable welfare costs of constant trend inflation in the medium-scale DSGE model, incorporating both staggered price and wage contracts. In this section, we examine whether staggered wage contracts are an important channel through which shifting trend inflation distorts the economic welfare more significantly in Vietnam. We follow Erceg et al. (2000) to expand the benchmark model by assuming that there is a fraction, η_w , of households who cannot freely set their wages but still can update their wages as follows:

Table 8. Moments.

	σ_Y	σ_C	σ_H	$\rho(Y, C)$
Data	0.006	0.020	0.014	0.86
Calibration	0.006	0.010	0.015	0.80

Note: moments in the first row are obtained from HP-filtered Vietnamese data (2005-2016) while the second row is the moments from simulations for the calibrated model.

Source: Authors' calculation.

Table 9. Welfare cost of constant and shifting trend inflation: An alternative parameter set.

	Constant Trend Inflation		Shifting Trend Inflation	
	$\bar{\pi}^* = 0\%$	$\bar{\pi}^* = 4\%$	$\sigma_{\bar{\pi}} = 0$	$\sigma_{\bar{\pi}} > 0$
Welfare Cost		6.80%		0.59%
Welfare	-213.94	-228.16	-214.66	-215.88
U_d	-211.06	-211.75	-211.25	-211.25
U_l	-0.69	-11.67	-1.04	-2.12
U_v	-2.18	-4.73	-2.37	-2.50
Steady-state C	0.82	0.81	0.82	0.82
Steady-state H	1.04	1.05	1.05	1.05
E(C)(*)	-0.005	-0.090	-0.0081	-0.0165
E(H)(*)	0.0003	0.0053	0.004	0.009
100 σ_C	2.03	2.99	2.11	2.18
100 σ_H	1.77	2.24	1.96	1.96

Note: (*) expressed as percentage deviation from the deterministic steady state. U_d , U_l and U_v are the deterministic steady-state, level and volatility component, respectively.

Source: Authors' calculation.

$$W_t(j) = (\pi_{t-1}^{\mu_w} \bar{\pi}_t^{1-\mu_w})^{\chi_w} W_{t-1}(j). \tag{26}$$

The remaining fraction of households can choose an optimal wage by maximizing

$$E_t \sum_{s=0}^{\infty} \eta_w^s \beta^s \left\{ -\omega \frac{H_{t+s}(j)^{1+\nu}}{1+\nu} \right\}, \tag{27}$$

subject to the labor demand function:

$$H_t(j) = \left[\frac{W_t(j)}{W_t} \right]^{-\theta_w} H_t. \tag{28}$$

7.4.2. Calibration

Table 12 in Appendix A lists all the calibrated parameters that we use for welfare cost computation in this exercise. In this exercise, we assume a fair probability of non-optimization for prices and wages so that η_p and η_w are calibrated at 0.69. In the exercise of quantifying the welfare costs of trend inflation, Ascari et al. (2018) also set similar values for these parameters. We also assume a fair degree of price and wage indexation (0.5). Table 10 compares the moments generated by the parameterized model with the moments computed by the data. The reported volatility and correlation statistics are for the HP-filtered Vietnamese data during the 2005–2016 period. In general, the key features of the data are matched reasonably well by the calibrated model.

Table 10. Moments.

	σ_Y	σ_C	σ_H	$\rho(Y, C)$
Data	0.006	0.020	0.014	0.86
Calibration	0.009	0.010	0.013	0.85

Note: moments in the first row are obtained from the HP-filtered Vietnamese data (2005-2016) while the second row is the moments from simulations for the calibrated model.

Source: Authors' calculation.

Table 11. Welfare cost of constant and shifting trend inflation.

	Welfare Cost(%)	
	Constant	Shifting
General Case ($\eta_p > 0, \eta_w > 0$)	2.73	0.25
Case 1 ($\eta_p > 0, \eta_w = 0$)	0.28	0.06
Case 2 ($\eta_p = 0, \eta_w > 0$)	2.17	0.16

Source: Authors' calculation.

7.4.3. Results

This section first represents the welfare costs of shifting trend inflation in the model with nominal price and wage rigidities (General Case). Subsequently, we consider two special cases: Case 1 - the model with staggered price contracts and completely flexible wages ($\eta_p > 0, \eta_w = 0$); and Case 2 - the model with completely flexible prices and staggered wage contracts ($\eta_p = 0, \eta_w > 0$), to analyse which channel is the most important for the transfer of the impacts of constant and shifting trend inflation.

Table 11 reports the welfare consequences of constant and shifting trend inflation. Regarding the costs of constant trend inflation, they are roughly 2.73%. In addition, the welfare costs in the staggered price model ($\eta_p > 0, \eta_w = 0$) are highly trivial, compared to the staggered wage model ($\eta_p = 0, \eta_w > 0$). By adopting the similar model with staggered price contracts, Ascari (2004), Amano et al. (2009), and Nakata (2014) also show the modest cost of constant trend inflation. The greater cost in the model with staggered wage contracts suggests that the staggered wage mechanism plays a vital role in transmitting the impacts of varying trend inflation levels into the economy. This argument is consistent with those of Ascari et al. (2018).

Regarding the welfare costs of shifting trend inflation, we provide striking results in this analysis. The welfare costs of shifting trend inflation in the model with staggered price and wage contracts are fairly high (0.25%). Comparing two special cases, the welfare costs of shifting trend inflation in the model with staggered wage contracts are remarkably higher than those in the model with staggered price contracts. The results reporting modest costs of shifting trend inflation in the model with nominal price rigidities are consistent with Nakata (2014). Our study emphasizes the role of staggered wage channel, through which exogenous variations in trend inflation significantly distort welfare.

8. Conclusions

This paper made its key contribution by exploiting the welfare consequences of shifting trend inflation, a salient property of developing countries like Vietnam, by building a New Keynesian model featuring a Calvo price setting. We used the Simulated Method

of Moment proposed by Ruge-Murcia (2012) to jointly calibrate parameters to match important moments of the Vietnamese data. Additional analyses such as the different price setting behavior, the higher order of approximation, the other parameter set, and the role of staggered wage contracts were performed to conduct robust checks on our arguments. Our results show that the consequences of constant positive trend inflation and shocks to trend inflation are severe, especially when trend inflation is high. Among the two channels, staggered wage contracts play a vital role in transmitting the adverse impacts of constant and shifting trend inflation in a developing economy.

The results of this study have crucial implications for both policy makers and economists. Based on the preceding analyses, raising inflation targets would seem to be a bad policy prescription. On the policy front, the significant welfare costs of constant positive and shifting trend inflation present a warning against policy proposals requiring central banks to raise their inflation targets.

Notes

1. Trend inflation can be interpreted as the central bank's target inflation rate.
2. In other words, trend inflation is assumed to be positive and is more likely to shift upward and downward over time.
3. See Clarida, Gali, and Gertler, (2000), Gali, (2002), Woodford, (2003) and among others. Furthermore, Woodford, (2003) and Goodfriend and King, (2009) argue that many specifications of the New Keynesian framework have the 0-percent long-run inflation.
4. Theoretically, some effects produced from the interaction of trend inflation, relative prices and the monopolistic competition framework like price dispersion, marginal mark-up (the ratio of newly adjusted price to marginal cost) and discounting (if firms discount the future more, they less likely worry about an erosion of future mark-up) are eliminated by the zero-steady-state inflation.
5. The research by Cogley and Sbordone, (2008) is the only paper that estimates the parameters of Calvo model permitting imperfect indexation and shifting trend inflation. In the literature, no-optimizing firms are commonly presumed to perfectly index their prices to a weighted average of past inflation and steady-state inflation so that the level of trend inflation does not affect the dynamics of the economy (Nakata, 2014).
6. We use Schmitt-Grohe and Uribe's toolbox for a second-order and third order approximation to policy rules. The codes will be provided by the author upon request.
7. The detailed results and codes will be provided by the authors upon request.
8. In our study, welfare costs can be defined as compensating variation in consumption that enhances the welfare of a typical household in one economy to make them as well-off as others in another economy.
9. In Vietnam, we have only collected the yearly data for consumption, and labor supply since 2005.

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Appendix

A Parameters

Table 12. Calibration: model with staggered price and wage contracts.

Parameter	Description	Calibrated Value
β	Discount factor	0.99
γ	Consumption habit	0.83
ω	Labor supply disutility	1.00
ν	Inverse Frisch elasticity of labor supply	1.00
$1-\bar{g}^{-1}$	Steady state share of Government expenditure	0.26
ρ_Z	AR(1) coefficient for technology shock	0.8
ρ_g	AR(1) coefficient for government spending shock	0.98
$100\sigma_Z$	Standard deviation of technology shock	1.10
$100\sigma_g$	Standard deviation of government spending shock	0.55
Monetary Policy		
ϕ_π	Taylor coefficient on the inflation gap	2.70
ϕ_y	Taylor coefficient on the output gap	0.10
ρ_R	AR(1) coefficient for monetary shock	0.81
$100\sigma_R$	Standard deviation of monetary shock	0.25
Calvo Price Setting		
θ_p	Price elasticity	10.0
η_p	Probability of not being able to optimize	0.74
χ_p	Degree of price indexation	0.50
μ_p	Weight on lagged inflation	0.50
Calvo Wage Setting		
θ_w	Wage elasticity	10.0
η_w	Probability of not being able to optimize	0.74
χ_w	Degree of wage indexation	0.50
μ_w	Weight on lagged inflation	0.50
Shifting Trend Inflation		
$\bar{\pi}^*$	Steady-state level of trend inflation	$1.02^{0.25}$
$\rho\bar{\pi}$	Persistence level of shocks to trend inflation	0.995
$100\sigma\bar{\pi}$	Standard deviation of shocks to trend inflation	0.08

Source: Authors' calculation.