

Tamegawa, Kenichi

Article

A closed-form analysis of anticipated monetary policy

EconomiA

Provided in Cooperation with:

The Brazilian Association of Postgraduate Programs in Economics (ANPEC), Rio de Janeiro

Suggested Citation: Tamegawa, Kenichi (2014) : A closed-form analysis of anticipated monetary policy, EconomiA, ISSN 1517-7580, Elsevier, Amsterdam, Vol. 15, Iss. 2, pp. 155-161, <https://doi.org/10.1016/j.econ.2014.06.007>

This Version is available at:

<https://hdl.handle.net/10419/179569>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/3.0/>

A closed-form analysis of anticipated monetary policy

Kenichi Tamegawa*

Faculty of Literature and Social Sciences, Yamagata University, 1-4-12 Kojirakawa-machi, Yamagata-shi, Yamagata 990-8560, Japan

Received 3 December 2013; received in revised form 19 April 2014; accepted 12 June 2014

Available online 22 July 2014

Abstract

In this short study, we use a simple new Keynesian model and carry out a closed-form analysis to observe the effects of anticipated monetary policy. For the assumed parameter space, we find that while an anticipated monetary easing always has inflationary effects, the effects on output depend on the parametric value of inflationary response to an interest-rate rule. If this parameter were low, an anticipated monetary easing would have a positive effect on output. However, if the parameter were sufficiently high, the policy would have a negative impact on output.

© 2014 National Association of Postgraduate Centers in Economics, ANPEC. Production and hosting by Elsevier B.V. All rights reserved.

JEL classification: E31; E52

Keywords: DSGE model; Closed form; Anticipated monetary policy

Resumo

Neste curto espaço de estudo, utilizamos um novo modelo Keynesiano simples e realizamos uma análise de forma fechada para observar os efeitos da política monetária antecipada. Para o espaço assumido de parâmetros, descobrimos que durante um afrouxamento monetário antecipado, sempre há efeitos inflacionários; os efeitos sobre a produção do valor paramétrico de resposta inflacionária a uma regra de taxa de juros. Se este parâmetro for baixo, um afrouxamento monetário antecipado terá um efeito positivo sobre a produção. No entanto, se o parâmetro for suficientemente elevado, a política terá um impacto negativo sobre a produção.

© 2014 National Association of Postgraduate Centers in Economics, ANPEC. Production and hosting by Elsevier B.V. All rights reserved.

Palavras chave: Modelo DSGE; Forma Fechada; Política Monetária Antecipada

* Tel.: +81 23 628 4295; fax: +81 23 628 4295.

E-mail address: tamegawa@human.kj.yamagata-u.ac.jp

Peer review under responsibility of National Association of Postgraduate Centers in Economics, ANPEC.

1. Introduction

Since the recent financial crisis, many countries have implemented low-interest rate policies. This situation and the attitude of central banks, such as the Federal Open Market Committee, toward transparent policymaking have made it easier to anticipate monetary policy. In this regard, to accurately evaluate unanticipated monetary policy or other policies, it is important that we consider the effects of anticipated monetary policies.

Mishkin (1982) and Kuttner (2001) empirically show the effects of anticipated monetary policy.¹ More recently, Milani and Treadwell (2012) and Gomes et al. (2013) use a dynamic stochastic general equilibrium (DSGE) model to empirically show that anticipated monetary policy has a large persistent effect. Laséen and Svensson (2011) introduce a numerical computation of the effects of anticipated monetary policy in DSGE models. Moreover, Verona et al. (2013) use numerical simulation with a DSGE model to show that anticipated monetary easing is one of the reasons for the recent boom-bust cycles. However, theoretical studies of this policy are rare. In this short study, we theoretically analyze the effects of anticipated monetary policy by using a simple new Keynesian model consisting of three equations (the IS curve, interest rate rule, and new Keynesian Philips curve). The model is a complete subset of that in Milani and Treadwell (2012) and therefore allows for obtaining a closed-form solution. The theoretical results of this paper are useful for considering the intuition behind complicated models.

Although we could use full-blown DSGE models such as those of Smets and Wouters (2003) or Christiano et al. (2005) and carry out numerical analysis, a theoretical analysis using a simple model would still be needed to assess how the parameters underlying the model affect the results. From our theoretical analysis, we find that the effect of anticipated monetary policy on current output critically depends on the parameter for inflationary response to a monetary policy rule. If this parameter were relatively low, an anticipated monetary easing would always have a positive effect on output. However, if the parameter were high, the policy would have a negative impact on output. This finding has not been obtained in the literature using numerical analysis. On the other hand, for the assumed parameter space, an anticipated monetary easing always has an inflationary response.

This paper is organized as follows. Section 2 presents our model and obtains a closed form of anticipated policy effects on the economy. Section 3 shows our theoretical analysis and presents our results. Section 4 performs a numerical analysis to obtain quantitative results. Finally, Section 5 concludes the paper.

2. A closed form of anticipated monetary policy

Consider the following simple new Keynesian model consisting of three equations,

$$y_t = E_t[y_{t+1}] - R_t + E_t[\pi_{t+1}], \quad (1)$$

$$\pi_t = \beta E_t[\pi_{t+1}] + \kappa y_t, \quad (2)$$

$$R_t = \phi_y y_t + \phi_\pi \pi_t + e_t, \quad (3)$$

where y_t , π_t , and R_t denote the deviation from the steady state of output, the inflation rate, and the interest rate, respectively. Eq. (1) is the Euler equation obtained by assuming logarithmic preferences, and Eq. (2) is the new Keynesian Philips curve. Eq. (3) denotes a monetary policy rule, where e_t for all $T \geq t+1$ represents an anticipated monetary policy shock.² This shock can also be identified as a news shock. In this paper, this shock can be defined as

$$e_t = v_{0,t} + v_{1,t-1} + v_{2,t-2} + \dots + v_{T,t-T}, \quad (4)$$

where $v_{i,t}$ denotes the anticipation at period t for monetary policy i periods later.³ In this paper, we assume that $E_t[v_{i,t}] = m$ for all t and for all $i \in \{s, \dots, T\}$, where $1 \leq s \leq T$ denotes the start period of an anticipated monetary policy. This assumption is for simplicity and is not crucial for our qualitative results.

¹ Investigating the effects of news shock is an expanding field, especially since the seminal paper of Beaudry and Portier (2004). They show that shocks to future productivity can generate business cycles.

² When e_t , $T=t$, it is an unanticipated monetary shock.

³ This treatment of anticipation for a certain variable is the same as in the literature on news shocks for productivity; see, for example, Beaudry and Portier (2004) and Jaimovich and Rebelo (2009). Fujiwara et al. (2011) empirically investigate the importance of news shock.

Eqs. (1)–(3) are summarized as follows:

$$E_t \begin{bmatrix} \pi_{t+1} \\ y_{t+1} \end{bmatrix} = A \begin{bmatrix} \pi_t \\ y_t \end{bmatrix} + B e_t, \quad A = \begin{bmatrix} \frac{1}{\beta} & -\frac{\kappa}{\beta} \\ -\frac{1}{\beta} + \phi_\pi & \frac{\kappa}{\beta} + 1 + \phi_y \end{bmatrix}, \quad B = \begin{bmatrix} \frac{1}{\beta} \\ 1 \end{bmatrix} \quad (5)$$

The coefficient matrix A can be diagonalized as $A = Q\Lambda Q^{-1}$, where Λ is a diagonal matrix with an eigenvalue (denoted as λ_1 and λ_2) of A as its diagonal elements and Q is a matrix in which the column vector is an eigenvector.

Note that the Taylor principle ($\phi_\pi > 1$) is necessary for $1 < \lambda_1 < \lambda_2$. The standard technique to solve a dynamic linear rational expectation model, like the method of Blanchard and Kahn (1980) or Klein (2000), in general, yields the following closed form of endogenous variables:

$$z_t = -\Lambda^{-1} Q^{-1} B e_t - \sum_{i=s+1}^{T+1} \Lambda^{-i} Q^{-i} B m, \quad (6)$$

where $z_t = Q^{-1} [\pi_t \ y_t]$. Therefore, from $Q\Lambda^{-1}Q^{-1} = A^{-1}$, we have

$$\begin{bmatrix} \pi_t \\ y_t \end{bmatrix} = -A^{-1} B e_t - \sum_{i=s+1}^{T+1} A^{-i} B m. \quad (7)$$

Note that

$$A^{-1} B = \frac{1/\beta}{\det(A)} \begin{bmatrix} \frac{\kappa}{\beta} + 1 + \phi_y + \kappa \\ \frac{1}{\beta} - \phi_\pi + 1 \end{bmatrix}, \quad (8)$$

where $\det(A) = (1 + \phi_y + \kappa\phi_\pi)/\beta > 0$.

Let $\gamma_n^j, n = \pi, y$ be the first and second elements of $A^{-j}B$. Note that when $j = 1$, γ_i^1 denotes the effects of the current monetary policy. In this notation, the effects of an anticipated monetary policy, which starts s periods later and ends at T , on the current economy are captured by $-\sum_{j=s+1}^{T+1} \gamma_n^j m$.

From Eq. (8), we have $\gamma_\pi^1 > 0$. On the other hand, $\gamma_y^1 \geq 0$ as long as $1/\beta + 1 \geq \phi_\pi$. Therefore, in this case, the current monetary easing has a positive effect on output and the inflation rate.

3. Theoretical analysis

In this section, we theoretically investigate the effects of an anticipated monetary policy by using Eq. (8). First, we note the effects of the current policy on the current economy. If $1/\beta + 1 \geq \phi_\pi$, the current monetary easing has a positive effect on output and the inflation rate.

What are the effects of an anticipated policy on the economy? The key parameter is the monetary policy response to inflation ϕ_π . We show that if $1/\beta \geq \phi_\pi$, an anticipated monetary easing ($m < 0$) has an inflationary effect and a positive effect on output: $\gamma_\pi^i > 0$ and $\gamma_y^i \geq 0$ for any i . This proof is straightforward because the entries of both A^{-1} and B are non-negative. Consider the intuition in the case of anticipated monetary easing. The expectation of future low real interest rates decreases the households' incentives to save.

In the case of $1/\beta < \phi_\pi$, an anticipated monetary easing does not have the same effect of current policy. In this case, although the procedure to definitely confirm policy effects is complicated, we can at least show that if

$$\frac{(a+1)}{a\beta} < \phi_\pi \leq 1 + \phi_y, \quad a = \frac{\kappa}{\beta} + 1 + \phi_y + \kappa + \frac{1}{\beta}, \quad (9)$$

an anticipated monetary policy has an inflationary effect as well as a negative effect on output; that is, $\gamma_\pi^i \geq 0$ and $\gamma_y^i \leq 0$, $i = 2, 3, \dots$ Condition (9) is satisfied by a frequently assumed parameterization such as $\phi_\pi = 1.5$, $\phi_y = 0.5$. Thus, the effects of an anticipated monetary policy on inflation and output are opposite. In the case of anticipated monetary easing, the relatively high response of monetary policy rules to inflation raises the current real interest rate, and the

degree of decrease in the future real interest rate becomes dampened. This motivates current savings, and as a result of high current savings, the future consumption increases. Thus, while a decrease in current output exerts deflationary pressure on the current inflation rate, an increase in future output creates inflationary pressure. Under condition (9), the latter exceeds the former and the result is current inflation.

In the case of the rest, that is, $1/\beta < \phi_\pi \leq (a+1)/(a\beta)$, we show that $\gamma_\pi^i > 0$, $i = 1, 2, \dots$ as long as $\phi_\pi \leq 1 + \phi_y$, although the sign of γ_y^i is not certain. Therefore, in the assumed parameter space ($1 < \phi_\pi < 1 + \phi_y$), the current and anticipated monetary easing always have inflationary effects.

Summing up, we have the following proposition:

Proposition. As a general restriction for ϕ_π , assume that $1 < \phi_\pi \leq 1/\beta + 1$.

- (1) $0 < \gamma_\pi^1$ and $0 \leq \gamma_y^1$.
- (2) If $\phi_\pi \leq 1/\beta$, $0 < \gamma_\pi^i$ and $0 \leq \gamma_y^i$, $i = 1, 2, \dots$
- (3) If condition (9) holds, $0 < \gamma_\pi^1$, $0 \leq \gamma_y^1$, $0 \leq \gamma_\pi^i$, and $\gamma_y^i \leq 0$, $i = 2, 3, \dots$
- (4) If $1/\beta < \phi_\pi \leq 1 + \phi_y$, $0 < \gamma_\pi^i$, $i = 1, 2, \dots$

Furthermore, if the two eigenvalues of A exceed 1, γ_π^i and γ_y^i converge to zero.

Proof. See [Appendix](#).

It is noteworthy that the general restriction in the above proposition is equivalent to the Taylor principle and consistent with standard monetary policy (i.e., monetary easing leads to an increase in output and vice versa). Furthermore, since the condition of result (3) is sufficient to obtain $\gamma_y^i \leq 0$, $i = 2, 3, \dots$, we could find this in the case of $\phi_\pi > 1 + \phi_y$.

4. Numerical example

In this section, we quantitatively analyze the effects of an anticipated monetary policy on the economy. First, we assume the following: $\beta = 0.99$, $\phi_y = 0.5$, and $\kappa = 0.086$.⁴ As for ϕ_π , we consider two cases, (i) $\phi_\pi = 1.001$ and (ii) $\phi_\pi = 1.5$. The parameterization of these cases yields [Fig. 1](#), which depicts the value of γ_n^i , $i = 1, 2, \dots, 30$.

From the figure, we can confirm the proposition. A relatively high value of ϕ_π , typically assumed in explaining the new Keynesian model in a classroom, indicates that inflation rates and output move in opposite directions.

Our analysis shows that theoretically an anticipated monetary policy can lead to rather unexpected results for output. [Milani and Treadwell \(2012\)](#), [Gomes et al. \(2013\)](#), and [Verona et al. \(2013\)](#) empirically investigate the effects of news shocks on the economy. While [Milani and Treadwell \(2012\)](#) use a new Keynesian model consisting of three equations (the IS curve, Taylor rule, and new Keynesian Philips curve), where each equation has a variable of own lag to incorporate inertia into the model, the other two construct a medium-scale new Keynesian model with interest rate smoothing. Although the terms for inertia make it difficult to obtain analytical solutions, empirical fits to actual data and the model are improved. Their estimation results indicate that the responses of news shocks to monetary policy on output and inflation is similar to case (i) in this section. As we show, the case occurs because of a relatively low response of the central bank to inflation. In the majority of empirical studies, including the papers mentioned above, that estimate DSGE models with a smoothing of interest rates, the term representing the smoothing (in our paper ϕ_π) is estimated at a lower value. Therefore, in an actual economy, news shocks to monetary policy easing might result in an increase in output and inflation.

5. Concluding remarks

In this short study, we used a simple new Keynesian model and carried out a closed-form analysis to observe the effects of anticipated monetary policy. For the assumed parameter space, we found that the effect of anticipated monetary easing is always inflationary whereas the effect on output depends on the parametric value of the inflationary

⁴ This is the implicit value when the probability of price change is set to 0.25.

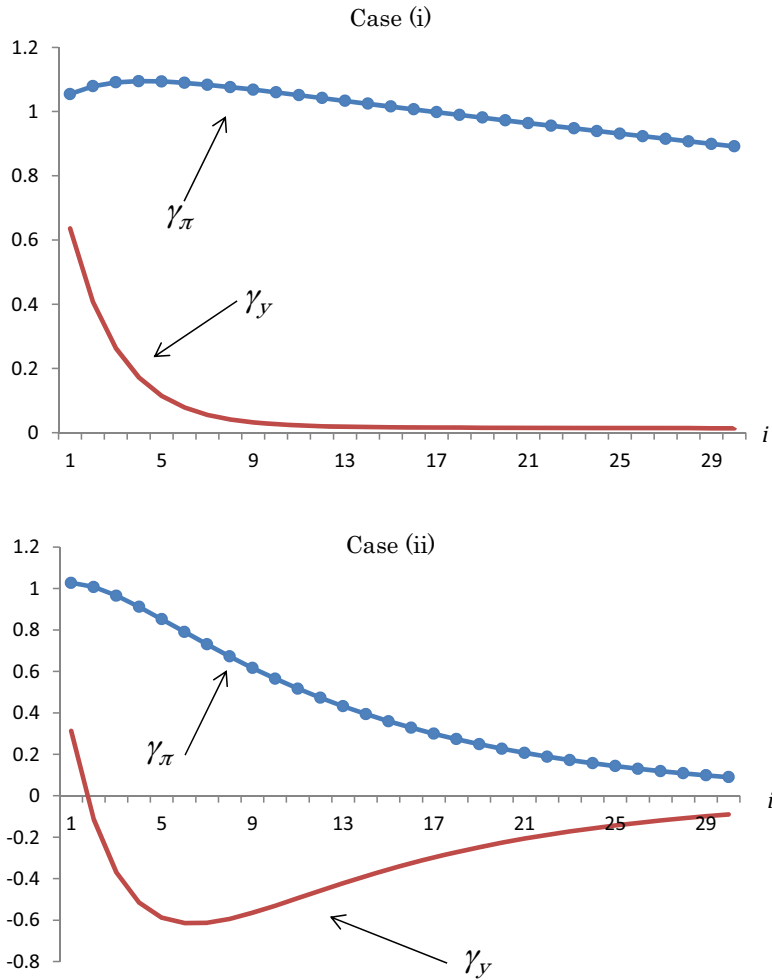


Fig. 1. Time plot of γ_π^i and γ_y^i .

response in an interest-rate rule. If this parameter is low, the anticipated monetary easing has a positive effect on output. However, if the parameter is sufficiently high, the policy has a negative impact on output. This result, which appears somewhat surprising, indicates that if there is a strong response to inflation, the future real interest rate would rise and induce households to save in the current period through wealth effects.

Acknowledgements

I am grateful to two anonymous referees and the editor for their helpful comments. This work was supported by a Grant-in-Aid for Scientific Research (No. 22330090) from the Ministry of Education, Culture, Sport, Science and Technology, Japan.

Appendix.

Proof

(1) Under parameter restriction and $1/\beta + 1 \geq \phi_\pi$, we obtain $\gamma_\pi^1 > 0$ and $\gamma_y^1 \geq 0$ from the following equations:

$$\begin{bmatrix} \gamma_\pi^1 \\ \gamma_y^1 \end{bmatrix} = \frac{1/\beta}{\det(A)} \begin{bmatrix} \frac{k}{\beta} + 1 + \phi_y + \kappa \\ \frac{1}{\beta} - \phi_\pi + 1 \end{bmatrix}.$$

Furthermore, note that

$$\det(A) = \frac{1}{\beta} \left(\frac{\kappa}{\beta} + 1 + \phi_y \right) - \frac{\kappa}{\beta} \left(\frac{1}{\beta} - \phi_\pi \right) = \frac{1}{\beta} (1 + \phi_y + \kappa\phi_\pi) > 0.$$

(2) First, γ_π^2 and γ_y^2 are as follows:

$$\begin{bmatrix} \gamma_\pi^2 \\ \gamma_y^2 \end{bmatrix} = \frac{1}{\det(A)} \begin{bmatrix} \frac{\kappa}{\beta} + 1 + \phi_y & \frac{\kappa}{\beta} \\ \frac{1}{\beta} - \phi_\pi & \frac{1}{\beta} \end{bmatrix} \begin{bmatrix} \gamma_\pi^1 \\ \gamma_y^1 \end{bmatrix}.$$

From the fact that $\gamma_\pi^1 > 0$ and $\gamma_y^1 \geq 0$, we have $\gamma_\pi^2 > 0$ and $\gamma_y^2 \geq 0$ because $1/\beta - \phi_\pi \geq 0$. For $\gamma_\pi^i > 0$ and $\gamma_y^i \geq 0$, $i = 3, 4, \dots$, we can deduce this by mathematical induction.

(3) Let γ_i^{N+1} , $i = \pi, y$ be the i th element of $A^{-N-1}B$. First, we show that $\gamma_\pi^2 > 0 > \gamma_y^2$ and $\gamma_\pi^2 \geq |\gamma_y^2|$. Note that γ_π^2 and γ_y^2 are calculated as follows:

$$\begin{aligned} \begin{bmatrix} \gamma_\pi^2 \\ \gamma_y^2 \end{bmatrix} &= \frac{1}{\det(A)} \begin{bmatrix} \frac{\kappa}{\beta} + 1 + \phi_y & \frac{\kappa}{\beta} \\ \frac{1}{\beta} - \phi_\pi & \frac{1}{\beta} \end{bmatrix} \begin{bmatrix} \gamma_\pi^1 \\ \gamma_y^1 \end{bmatrix} = \frac{1}{\det(A)} \begin{bmatrix} \frac{\kappa}{\beta} + 1 + \phi_y & \frac{\kappa}{\beta} \\ \frac{1}{\beta} - \phi_\pi & \frac{1}{\beta} \end{bmatrix} \begin{bmatrix} \frac{1}{\beta} \left(\frac{\kappa}{\beta} + 1 + \phi_y \right) + \frac{\kappa}{\beta} \\ \left(\frac{1}{\beta} - \phi_\pi \right) / \beta + \frac{1}{\beta} \end{bmatrix} \\ &= \frac{1/\beta}{\det(A)^2} \begin{bmatrix} d(d+k) + \left(\frac{\kappa}{\beta} + \kappa \right) / \beta - \frac{\kappa\phi_\pi}{\beta} \\ \left(\frac{1}{\beta} - \phi_\pi \right) (d+\kappa) + \left(\frac{1}{\beta} - \phi_\pi + 1 \right) / \beta \end{bmatrix}, \end{aligned}$$

where $d = \kappa/\beta + 1 + \phi_y$. From the first element in the vector of the right-hand side, $\gamma_\pi^2 > 0$. On the other hand, the condition $((a + 1)/a\beta) < \phi_\pi$ yields $\gamma_y^2 \leq 0$, where $a = d + \kappa + 1/\beta$. Furthermore, we define the following scalar value for notational simplicity:

$$e = d(d + \kappa) + \frac{(\kappa/\beta + \kappa)}{\beta} - \frac{\kappa\phi_\pi}{\beta},$$

$$f = \left(\frac{1}{\beta} - \phi_\pi \right) (d + \kappa) + \frac{(1/\beta - \phi_\pi + 1)}{\beta}$$

Next, note that $1/\beta - \phi_\pi + 1 > 0$ and $1/\beta - \phi_\pi < 0$ yield

$$0 < \left| \frac{1}{\beta} - \phi_\pi \right| < 1$$

From this, we can confirm that

$$\begin{aligned} e + f &= d(d + \kappa) + \frac{\kappa}{\beta} + \left(\frac{1}{\beta} - \phi_\pi \right) \left(\frac{\kappa}{\beta} + d + k + \frac{1}{\beta} \right) + \frac{1}{\beta} = d(d + \kappa) + \frac{\kappa}{\beta} + \frac{1}{\beta} \\ &\quad + \left(\frac{1}{\beta} - \phi_\pi \right) \left(d + \kappa + \frac{\kappa}{\beta} + \frac{1}{\beta} \right) > d(d + \kappa) + \frac{\kappa}{\beta} + \frac{1}{\beta} - \left(d + \kappa + \frac{\kappa}{\beta} + \frac{1}{\beta} \right) \\ &= d(d - 1) + (d - 1)\kappa \geq 0. \end{aligned}$$

Therefore, $e > |f|$ since $e > 0$ and $f \leq 0$; from this, we obtain $\gamma_\pi^2 \geq |\gamma_y^2|$.

The rest of the proof is deduced by mathematical induction.

(i) $N = 1$

This has already been confirmed above; that is, from the proposition condition,

$$\gamma_\pi^2 > 0 > \gamma_y^2 \text{ and } \gamma_\pi^2 \geq |\gamma_y^2|$$

(ii) Assume that when $N=k$, $\gamma_\pi^{k+1} > 0 > \gamma_y^{k+1}$ and $\gamma_\pi^{k+1} > |\gamma_y^{k+1}|$. Thus, when $N=k+1$, we have

$$\begin{bmatrix} \gamma_\pi^{k+2} \\ \gamma_y^{k+2} \end{bmatrix} = \frac{1}{\det(A)} \begin{bmatrix} \frac{\kappa}{\beta} + 1 + \phi_y & \frac{\kappa}{\beta} \\ \frac{1}{\beta} - \phi_\pi & \frac{1}{\beta} \end{bmatrix} \begin{bmatrix} \gamma_\pi^{k+1} \\ \gamma_y^{k+1} \end{bmatrix}, \tag{A.1}$$

$\kappa/\beta + 1 + \phi_y > \kappa/\beta$, and $\gamma_\pi^{k+1} > |\gamma_y^{k+1}|$, implying that $\gamma_\pi^{k+2} > 0$. On the other hand, when $1/\beta - \phi_\pi < 0$, $\gamma_\pi^{k+1} > 0 > \gamma_y^{k+1}$ yields $\gamma_y^{k+2} < 0$. Next, noting that

$$\begin{aligned} \gamma_\pi^{k+2} &= \frac{1}{\det(A)} \left[\left(\frac{\kappa}{\beta} + 1 + \phi_y \right) \gamma_\pi^{k+1} + \frac{\kappa \gamma_y^{k+1}}{\beta} \right], \\ \gamma_y^{k+2} &= \frac{1}{\det(A)} \left[\left(\frac{1}{\beta} - \phi_\pi \right) \gamma_\pi^{k+1} + \frac{\gamma_y^{k+1}}{\beta} \right], \end{aligned}$$

we obtain the following inequality:

$$\gamma_\pi^{k+2} + \gamma_y^{k+2} = \frac{1}{\det(A)} \left[(\gamma_\pi^{k+1} + \gamma_y^{k+1}) \left(\frac{\kappa}{\beta} + \frac{1}{\beta} \right) + (1 + \phi_y - \phi_\pi) \gamma_\pi^{k+1} \right] \geq 0.$$

Therefore, $\gamma_\pi^{k+2} \geq |\gamma_y^{k+2}|$ because $\gamma_\pi^{k+2} > 0 > \gamma_y^{k+2}$.

(4) Note that in Eq. (A.1), $\gamma_\pi^{k+2} \geq 0$, whatever the sign of γ_y^i is, if $1/\beta < \phi_\pi \leq 1 + \phi_y$. Therefore, we can show that $\gamma_\pi^i \geq 0$ through mathematical induction.

Our final remark that γ_π^i and γ_y^i , $i = 1, 2, \dots$ converge to zero is clear from the condition of the eigenvalues and

$$\begin{bmatrix} \gamma_\pi^i \\ \gamma_y^i \end{bmatrix} = Q \Lambda^{-1} Q^{-1} B.$$

References

- Beaudry, P., Portier, F., 2004. An exploration into Pigou’s theory of cycle. *J. Monetary Econ.* 51, 1183–1216.
- Blanchard, O.J., Kahn, C.M., 1980. The solution of linear difference models under rational expectations. *Econometrica* 48, 1305–1311.
- Christiano, L., Eichenbaum, M., Evans, C., 2005. Nominal rigidities and the dynamic effects of a shock to monetary policy. *J. Pol. Econ.* 113, 1–45.
- Fujiwara, I., Hirose, Y., Shintani, M., 2011. Can news be a major source of aggregate fluctuations? A Bayesian DSGE approach. *J. Money Credit Bank.* 43, 1–29.
- Gomes, S., Iskrev, N., Mendicino, C., 2013. Monetary Policy Shocks: We Got News! Banco de Portugal, Working Paper 07-2013.
- Jaimovich, N., Rebelo, S., 2009. Can news about the future drive the business cycle? *Am. Econ. Rev.* 99, 1097–1118.
- Klein, P., 2000. Using the generalized Schur form to solve a multivariate linear rational expectations model. *J. Econ. Dyn. Control* 24, 1405–1423.
- Kuttner, K.N., 2001. Monetary policy surprises and interest rates: evidence from the Fed funds futures market. *J. Monetary Econ.* 47, 523–544.
- Laséen, S., Svensson, L.E., 2011. Anticipated alternative policy rate paths in policy simulations. *Int. J. Cent. Bank.* 7, 1–35.
- Milani, F., Treadwell, J., 2012. The effects of monetary policy “news” and “surprises”. *J. Money Credit Bank.* 44, 1667–1692.
- Mishkin, F.S., 1982. Does anticipated monetary policy matter? An econometric investigation. *J. Pol. Econ.* 90, 22–51.
- Smets, F., Wouters, R., 2003. An estimated dynamic stochastic general equilibrium model of the Euro area. *J. Eur. Econ. Assoc.* 20, 1123–1175.
- Verona, F., Martins, M.M.F., Drumond, I., 2013. (Un)anticipated monetary policy in a DSGE model with a shadow banking system. *Int. J. Cent. Bank.* 9, 73–117.