NORTH-HOLLAND

International Review of Economics and Finance
11 (2002) 229–249

International Review of Economics & Finance

Targeting nominal income versus targeting price level: A target zone perspective

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Received 16 March 2000; received in revised form 28 April 2001; accepted 13 June 2001

Abstract

Based on a simple stochastic macro model, this paper first addresses the relative stabilizing performance between targeting nominal income and targeting money supply from the viewpoint of target zones. Similar to the conclusion found in Bean [Econ. J. 93 (1983) 803.] and in West [Econ. J. 96 (1986) 1077.], upon the shock of a change in commodity production, the elasticity of aggregate demand to real money balances is the crucial factor for the desirability of targeting nominal income. Second, comparing nominal income with price target zones, we find that, with the plausible parameter values, a price target zone policy is a better strategy for price stabilization. However, a nominal income target zone policy will be the better choice for output stabilization. © 2002 Elsevier Science Inc. All rights reserved.

JEL classification: F31; E52

Keywords: Nominal income targeting; Price targeting; Stochastic processes; Target zones

1. Introduction

Ever since Poole (1970) published his pioneering paper, there has been a substantial amount of literature concerning the issue of intermediate monetary target choices. Following

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PII: S1059-0560(02)00100-4

Poole, early studies such as Benavie and Froyen (1983) and Turnovsky (1975, 1980) focused on the debate that the monetary authority should choose either a pegged monetary stock or a pegged interest rate as its policy rule. In recent years, two Nobel laureates, Meade (1978) and Tobin (1980), have advocated nominal income as an alternative target for monetary policy. As explained by Asako and Wagner (1992), the simplest reason is that targeting nominal income is one step closer to the ultimate goal of the stabilization of real economic activity.[1]

Bean (1983) first develops a simple macro model to deal with the advantage of nominal income targeting. Given that the welfare loss is measured by the discrepancy between actual output and "full-information" output (i.e., long-run equilibrium output), some important findings emerge in his analysis. Bean argues that the nominal income rule is always superior to the money supply rule in the face of aggregate demand disturbances. However, with respect to aggregate supply disturbances, nominal income targeting is again superior to money supply targeting when the aggregate demand's elasticity with respect to real money balances is *less* than unity.

A number of papers provide alternative viewpoints on the validity of Bean's (1983) favored proposal for nominal income targeting. In the literature, West (1986) alternatively defines the welfare loss that is associated with the discrepancy between actual and expected output. With this amendment, he finds that, when the economy experiences aggregate supply shocks, nominal income targeting is preferable to money supply targeting if the elasticity of aggregate demand with respect to real money balances is *greater* than unity. McCallum (1987) proposes that nominal income targeting is a possible solution to the time inconsistency problem. Brandley and Jansen (1989) consider the mechanism of nominal wage contracts indexed to the price level. They conclude that the output can be stabilized perfectly with the combination of nominal income targeting and optimal wage indexation in the presence of aggregate supply disturbances. Jansen and Kim (1993) introduce both intertemporal and wealth effects of labor supply into the theoretical structure, finding that nominal income targeting coupled with optimal wage indexing is no longer perfectly stabilizing. McCallum and Nelson (1999) present a simulation analysis regarding the performance of nominal income targeting. In calibrating US quarterly data, their results suggest that, in comparison with other targeting strategies, nominal income targeting exhibits better performance.[2]

In line with these studies, this paper constructs a simple stochastic macro model and uses it to evaluate whether Bean's (1983) favored belief of nominal income targeting is valid. However, as stressed by Kahn (1988), in reality the members of the Federal Open Market Committee and the presidents of the Reserve Bank all target nominal income in a specific *zone*, rather than a specific *level*. This paper thus departs from existing literature to examine the desirability of nominal income targeting from the perspective of target zones.[3] Running in

[1] For the other rationale in advocating nominal income targeting, see Kahn (1988).

[2] Other studies on this issue include Aizenman and Frenkel (1986a, 1986b), Ball (1997), Frankel and Chinn (1995), Koenig (1996), McCallum (1997), and Ratti (1997), to name a few.

[3] For the implementation of the ranges for nominal income targeting, see Kahn (1988, pp. 33–35 and footnote 24).

contrast to existing literature, we find that the authorities' commitment to target ranges for nominal income will affect the public's inflation expectations, and in turn govern the stabilization of relevant macro variables.

The inflation target zone policy has recently become an important issue in the field of macroeconomics. The popularity of the issue stems from the fact that the policy fits some practical relevance. Monetary authorities from some developed countries, including Switzerland, New Zealand, Canada, the United Kingdom, Sweden, Israel, Spain, and Australia, have generally taken a more active role in the management of commodity prices. Typically, they set a finite band within which commodity prices are allowed to adjust freely. Once consumer prices reach the bounds of the target zone, the monetary authorities intervene in the money market to alter the money supply.[4] In view of this fact, the other purpose of this paper is to address whether this price management policy has the stabilizing effect on the relevant variables in the presence of aggregate supply shocks. In addition, we try to highlight the relative stabilizing performance between nominal income and price target zone policies by comparing the variability of relevant variables.

The analytical method we used is essentially similar to that of the exchange rate target zones developed by Krugman (1991). The issue of exchange rate target zones has attracted a lot of interest since it is a more realistic alternative to pure fixed or flexible exchange regimes. In his pioneering article, Krugman sets out a monetary model embodying rational expectations, and specifies that a monetary disturbance follows a regulated Brownian motion. In addition, he assumes that the monetary authorities set the upper and lower bounds for the exchange rate. When the exchange rate touches the edge of the bands, the monetary authorities adjust the money supply to keep the exchange rate within a specified band. Given that the public knows the intervention rule of monetary authorities, Krugman shows that exchange rate target zones will make the exchange rate more stable than the underlying fundamentals. This result is dubbed the "honeymoon effect." In line with Krugman, many studies are devoted to this topic, such as Froot and Obstfeld (1991), Miller and Weller (1991a, 1991b), Sutherland (1995), and Svensson (1991, 1992), among others.

This paper applies techniques of a regulated Brownian motion proposed by Krugman (1991) to study the stabilizing performance of nominal income target zones. The framework we set up can be regarded as an extension of the Poole (1970) model. The main concern is whether the policy of nominal income target zones will reduce the variability of other macro variables even when the nominal income variability is damped. At the same time, we will discuss whether implementing the price target zone policy will lead to a reduction in price fluctuation at the cost of increases in the variability of relevant variables.

The rest of this paper is arranged as follows. The basic framework is outlined in Section 2. Section 3 addresses the stabilizing performance of a nominal income target zone. Section 4 addresses the stabilizing performance of a price target zone. A comparison of the relevant stabilization between nominal income and price target zone policies is reported in Section 5. Finally, Section 6 concludes the main findings of our analysis.

[4] See the articles in Bernanke, Laubach, Mishkin, and Posen (1999), Leiderman and Svensson (1995). Mishkin (1998, p. 500) points out that inflation targets "might become the wave of the future for central bank strategy."

2. The theoretical model

In order to sharpen the salient feature of nominal income target zones, the modeling strategy we adopt is to keep the model as simple as possible. Basically, the theoretical framework of this paper is modified from the Poole (1970) model. Assuming that economic agents form their expectations with a rational manner, we can use the following equations to represent this simple stochastic macro model:

$$y = \alpha p - \varepsilon; \qquad \alpha > 0 \tag{1}$$

$$y = -a\left[i - \frac{E(\mathrm{d}p)}{\mathrm{d}t}\right] + g; \qquad a > 0 \tag{2}$$

$$m - p = \delta y - \eta i; \qquad \delta,\eta > 0 \tag{3}$$

$$\mathrm{d}\varepsilon = \sigma \mathrm{d}Z. \tag{4}$$

With the exception of the domestic nominal interest rate i, all variables are expressed in natural logarithms. The variables are defined as follows: y=real output; p=price of goods; g=government expenditure; m=nominal money supply; ε=random disturbance terms of aggregate supply side. In addition, E denotes expectations operators, σ is the instantaneous standard deviation of the movement of ε, and $\mathrm{d}Z$ is the increment of a standard Wiener Process.[5]

Eq. (1) is the aggregate supply function in which aggregate production is specified to be positively related to commodity prices. The rationale for this setting can be justified by the fact that workers have imperfect information about price changes and wages are set with contracts.[6] Eq. (2) is the aggregate demand function for commodities, specifying that aggregate demand is a decreasing function of the real interest rate, $i - E(\mathrm{d}p)/\mathrm{d}t$. Eq. (3) is the money market equilibrium condition, stating that real money supply equals real money demand. Eq. (4) specifies that a stochastic supply shock ε follows a Brownian motion process without drift.

From Eqs. (1)–(3), we have the following matrix form (Eq. (5)):

$$\begin{pmatrix} 1 & -\alpha & 0 \\ 1 & 0 & a \\ \delta & 1 & -\eta \end{pmatrix} \begin{pmatrix} y \\ p \\ i \end{pmatrix} = \begin{pmatrix} -\varepsilon \\ a(E(\mathrm{d}p)/\mathrm{d}t) + g \\ m \end{pmatrix}. \tag{5}$$

Using Cramer's rule, we get the following "pseudo"-reduced forms:[7]

$$y = C\left(\alpha m + \frac{\alpha\eta}{a} g\right) - C\varepsilon + \alpha\eta C \frac{E(\mathrm{d}p)}{\mathrm{d}t}, \tag{6}$$

[5] To save space, in this paper we only deal with output supply shocks. The discussion of monetary shocks and aggregate output demand shocks is available upon request from the authors.

[6] See Miller and VanHoose (1998, Chap. 8) for a detailed explanation.

[7] Note that $E(\mathrm{d}p)/\mathrm{d}t$ is an endogenous variable.

$$p = C\left(m + \frac{\eta}{a}g\right) + \left(\delta + \frac{\eta}{a}\right)C\varepsilon + \eta C\frac{E(\mathrm{d}p)}{\mathrm{d}t}, \tag{7}$$

$$i = C\left(-\frac{\alpha}{a}m + \frac{\alpha\delta + 1}{a}g\right) + \frac{1}{a}C\varepsilon + (\alpha\delta + 1)C\frac{E(\mathrm{d}p)}{\mathrm{d}t}, \tag{8}$$

where $C=a/(a+\alpha\eta+a\alpha\delta)>0$.

Eq. (7) is a stochastic differential equation. It states that the level of product prices is related to both fundamentals and expectations of the prices' future value. The general solution of p is:

$$p = Cm + \frac{\eta}{a}Cg + \left(\delta + \frac{\eta}{a}\right)C\varepsilon + A\mathrm{e}^{s\varepsilon} + B\mathrm{e}^{-s\varepsilon}, \tag{9}$$

where $s = \sqrt{2/\eta C\sigma^2}$ and A and B are undetermined parameters.

Comparing Eq. (9) with Eq. (7) yields the expectation of the price movement:

$$\frac{E(\mathrm{d}p)}{\mathrm{d}t} = \frac{1}{\eta C}(A\mathrm{e}^{s\varepsilon} + B\mathrm{e}^{-s\varepsilon}). \tag{10}$$

Plugging Eq. (10) into Eqs. (6) and (8), we can obtain a general solution for the output and interest rate exhibited within the target zone:

$$y = C\left(\alpha m + \frac{\alpha\eta}{a}g\right) - C\varepsilon + \alpha(A\mathrm{e}^{s\varepsilon} + B\mathrm{e}^{-s\varepsilon}), \tag{11}$$

$$i = C\left(-\frac{\alpha}{a}m + \frac{\alpha\delta + 1}{a}g\right) + \frac{1}{a}C\varepsilon + \frac{\alpha\delta + 1}{\eta}(A\mathrm{e}^{s\varepsilon} + B\mathrm{e}^{-s\varepsilon}). \tag{12}$$

In the next section, we will use the results reported in Eqs. (9), (11), and (12) to illustrate the stabilizing performance of a nominal income target zone.

3. The variability related to nominal income target zones

In this pioneering article, Bean (1983) finds that nominal income's superiority is related to the elasticity of aggregate demand with respect to real money balances. We thus need to deal with the aggregate demand function at this stage. Putting Eqs. (2) and (3) together and deleting nominal interest rates i, we can derive the aggregate demand function:

$$y = \kappa(m - p) + \frac{\eta\kappa}{a}g + \eta\kappa\frac{E(\mathrm{d}p)}{\mathrm{d}t}, \tag{13}$$

where $\kappa=1/[\eta/a)+\delta]>0$. It is clear from Eq. (13) that κ is the elasticity of aggregate demand with respect to real money balances.[8]

Let n denote the nominal income. It then follows from Eqs. (9) and (11) that:[9]

$$n = p + y = (1+\alpha)Cm + \frac{\eta}{a}(1+\alpha)Cg + \left(\frac{1}{\kappa} - 1\right)C\varepsilon + (1+\alpha)(A\mathrm{e}^{s\varepsilon} + B\mathrm{e}^{-s\varepsilon}). \quad (14)$$

Assume that the authorities stand ready to adjust the money supply at the upper bound of nominal income n^{u} and the lower bound of nominal income n^{l}. While nominal income stays within the interior of the band, the monetary authorities do not alter the money stock. Based on this intervention rule, the dynamic locus of n can be expressed as:

$$n = \begin{cases} n^{\mathrm{u}}; & \varepsilon_{+}^{\mathrm{u}} \le \varepsilon \\ (1+\alpha)Cm + [\eta(1+\alpha)/a]Cg & \varepsilon_{+}^{\mathrm{l}} \le \varepsilon \le \varepsilon_{-}^{\mathrm{u}}, \\ \quad +(1/\kappa - 1)C\varepsilon + (1+\alpha)(A\mathrm{e}^{s\varepsilon} + B\mathrm{e}^{-s\varepsilon}); & \\ n^{\mathrm{l}}; & \varepsilon \le \varepsilon_{-}^{\mathrm{l}} \end{cases} \quad (15)$$

where ε^{u} and ε^{l} are the corresponding values that the monetary authorities decrease and increase the money supply to defend nominal income target zones, respectively. Terms $\varepsilon_{+}^{\mathrm{u}}$ and $\varepsilon_{-}^{\mathrm{u}}$ represent the right- and left-hand side limits of ε^{u}, respectively; and $\varepsilon_{+}^{\mathrm{l}}$ and $\varepsilon_{-}^{\mathrm{l}}$ represent the right- and left-hand side limits of ε^{l}, respectively.

We now proceed to solve the undetermined variables: A, B, ε^{u}, and ε^{l}. These unknown parameters are determined by two continuity conditions and two smooth pasting conditions. Since the agents know that the monetary authorities will adjust the money stock when nominal income reaches the upper or lower bounds of the target zone, they readjust their portfolio in advance. Thus, the continuity condition prevents nominal income from jumping discretely when the monetary authorities intervene in the money market. Furthermore, the smooth pasting condition means that the nominal income dynamic locus is tangent to the horizontal lines at the band's edges.[10] These simply:

$$n_{\varepsilon_{+}^{\mathrm{u}}} = n_{\varepsilon_{-}^{\mathrm{u}}}, \quad (16)$$

$$n_{\varepsilon_{+}^{\mathrm{l}}} = n_{\varepsilon_{-}^{\mathrm{l}}}, \quad (17)$$

$$\frac{\partial n_{\varepsilon_{-}^{\mathrm{u}}}}{\partial \varepsilon} = 0, \quad (18)$$

$$\frac{\partial n_{\varepsilon_{+}^{\mathrm{l}}}}{\partial \varepsilon} = 0. \quad (19)$$

[8] Asako and Wagner (1992) set up a similar aggregate demand function.

[9] It follows from Eqs. (6) and (7) that n can be alternatively expressed as: $n=p+y=(1+\alpha)Cm+[\eta(1+\alpha)/a]Cg+(1/\kappa-1)C\varepsilon+(1+\alpha)\eta CE(\mathrm{d}p)/\mathrm{d}t$.

[10] Flood and Garber (1991) provide an intuitive explanation for the smooth pasting condition.

Substituting Eq. (15) into Eqs. (16)–(19) yields:

$$n^{\mathrm{u}} = (1+\alpha)Cm + \frac{\eta}{a}(1+\alpha)Cg + \left(\frac{1}{\kappa} - 1\right)C\varepsilon^{\mathrm{u}} + (1+\alpha)\left(A\mathrm{e}^{s\varepsilon^{\mathrm{u}}} + B\mathrm{e}^{-s\varepsilon^{\mathrm{u}}}\right), \tag{16a}$$

$$n^{\mathrm{l}} = (1+\alpha)Cm + \frac{\eta}{a}(1+\alpha)Cg + \left(\frac{1}{\kappa} - 1\right)C\varepsilon^{\mathrm{l}} + (1+\alpha)\left(A\mathrm{e}^{s\varepsilon^{\mathrm{l}}} + B\mathrm{e}^{-s\varepsilon^{\mathrm{l}}}\right), \tag{17a}$$

$$\left(\frac{1}{\kappa} - 1\right)C + (1+\alpha)s\left(A\mathrm{e}^{s\varepsilon^{\mathrm{u}}} - B\mathrm{e}^{-s\varepsilon^{\mathrm{u}}}\right) = 0, \tag{18a}$$

$$\left(\frac{1}{\kappa} - 1\right)C + (1+\alpha)s\left(A\mathrm{e}^{s\varepsilon^{\mathrm{l}}} - B\mathrm{e}^{-s\varepsilon^{\mathrm{l}}}\right) = 0. \tag{19a}$$

It follows from Eqs. (18a) and (19a) that the smooth pasting conditions can be solved for A and B as functions of ε^{u} and ε^{l}:

$$A = A(\varepsilon^{\mathrm{u}},\varepsilon^{\mathrm{l}}) = \frac{(1-\kappa)C\left(\mathrm{e}^{-s\varepsilon^{\mathrm{u}}} - \mathrm{e}^{-s\varepsilon^{\mathrm{l}}}\right)}{\kappa s(1+\alpha)\left[\mathrm{e}^{s(\varepsilon^{\mathrm{u}}-\varepsilon^{\mathrm{l}})} - \mathrm{e}^{s(\varepsilon^{\mathrm{l}}-\varepsilon^{\mathrm{u}})}\right]}, \tag{20}$$

$$B = B(\varepsilon^{\mathrm{u}},\varepsilon^{\mathrm{l}}) = \frac{(1-\kappa)C\left(\mathrm{e}^{s\varepsilon^{\mathrm{u}}} - \mathrm{e}^{s\varepsilon^{\mathrm{l}}}\right)}{\kappa s(1+\alpha)\left[\mathrm{e}^{s(\varepsilon^{\mathrm{u}}-\varepsilon^{\mathrm{l}})} - \mathrm{e}^{s(\varepsilon^{\mathrm{l}}-\varepsilon^{\mathrm{u}})}\right]}. \tag{21}$$

Assume that the bounds of the band are symmetric around zero (i.e., $n^{\mathrm{l}}=-n^{\mathrm{u}}$) and $m=g=0$ initially. With these relations and Eqs. (20) and (21), the continuity conditions in Eqs. (16a) and (17a) can be rewritten as:

$$n^{\mathrm{u}} = \left(\frac{1}{\kappa} - 1\right)C\varepsilon^{\mathrm{u}} + (1+\alpha)\left(A(\varepsilon^{\mathrm{u}},\varepsilon^{\mathrm{l}})\mathrm{e}^{s\varepsilon^{\mathrm{u}}} + B(\varepsilon^{\mathrm{u}},\varepsilon^{\mathrm{l}})\mathrm{e}^{-s\varepsilon^{\mathrm{u}}}\right), \tag{16b}$$

$$-n^{\mathrm{u}} = \left(\frac{1}{\kappa} - 1\right)C\varepsilon^{\mathrm{l}} + (1+\alpha)\left(A(\varepsilon^{\mathrm{u}},\varepsilon^{\mathrm{l}})\mathrm{e}^{s\varepsilon^{\mathrm{l}}} + B(\varepsilon^{\mathrm{u}},\varepsilon^{\mathrm{l}})\mathrm{e}^{-s\varepsilon^{\mathrm{l}}}\right). \tag{17b}$$

Substituting Eqs. (20) and (21) into Eqs. (16b) and (17b), we can infer that:

$$\varepsilon^{\mathrm{u}} = -\varepsilon^{\mathrm{l}}. \tag{22}$$

Eq. (22) reveals an important implication: when the random market fundamentals follow a Brownian motion without drift and $m=g=0$ initially, the symmetrical nominal income bounds can be alternatively expressed by the symmetrical market fundamental bounds.[11]

[11] See Svensson (1992) for a detailed intuitive explanation.

Substituting $\varepsilon^{u}=-\varepsilon^{l}$ into Eqs. (20) and (21), we have:

$$A = -B = -\frac{1}{2}\left[\frac{(1-\kappa)C}{\kappa s(1+\alpha)[\cosh(s\varepsilon^{u})]}\right]. \tag{23}$$

Combining Eq. (23) with Eqs. (9), (11), (12), and (14) and recalling that $m=g=0$ initially will yield the closed dynamic loci of nominal income, output, prices, and interest rates within the bands:

$$n = C\left(\frac{1}{\kappa}-1\right)\varepsilon - \frac{C(1-\kappa)[\sinh(s\varepsilon)]}{\kappa s[\cosh(s\varepsilon^{u})]}, \tag{24}$$

$$y = -C\varepsilon - \frac{\alpha C(1-\kappa)[\sinh(s\varepsilon)]}{\kappa s(1+\alpha)[\cosh(s\varepsilon^{u})]}, \tag{25}$$

$$p = C\left(\delta+\frac{\eta}{a}\right)\varepsilon - \frac{C(1-\kappa)[\sinh(s\varepsilon)]}{\kappa s(1+\alpha)[\cosh(s\varepsilon^{u})]}, \tag{26}$$

$$i = C\frac{1}{a}\varepsilon - \frac{C(1+\alpha\delta)(1-\kappa)[\sinh(s\varepsilon)]}{\eta\kappa s(1+\alpha)[\cosh(s\varepsilon^{u})]}. \tag{27}$$

If the monetary authorities do not set a nominal income band, implying $n^{u}\to\infty$ and $n^{l}\to-\infty$, then the edges of the market fundamental have the properties $\varepsilon^{u}\to\infty$ and $\varepsilon^{l}\to-\infty$. With this relation, from Eqs. (20) and (21) we have $A=B=0$. It should be noted that under this situation the monetary authorities do not intervene in the money market to alter the money stock, and hence the regime of a float nominal income is equivalent to that of a pegged monetary stock. It then follows from Eqs. (9), (11), (12), and (14) that the dynamic behavior of n, y, p, and i in the regime of a pegged monetary stock is:

$$n = C\left(\frac{1}{\kappa}-1\right)\varepsilon, \tag{24a}$$

$$y = -C\varepsilon, \tag{25a}$$

$$p = C\left(\delta+\frac{\eta}{a}\right)\varepsilon, \tag{26a}$$

$$i = C\frac{1}{a}\varepsilon. \tag{27a}$$

Eqs. (24a)–(27a) reveal that, if the monetary authorities do not set any edge for nominal income, then public agents will expect that the instantaneous change in output prices is nil. From footnote 9 and Eqs. (6)–(8), n, y, p, and i are then completely determined by the market fundamentals.

Eqs. (24)–(27) indicate that whether κ is greater than unity of not will govern the dynamic behavior of n, y, p, and i within the target zones. Accordingly, in what follows the discussion is classified by the two cases: aggregate demand is inelastic (κ<1) and elastic (κ>1).

3.1. Inelastic aggregate demand (κ<1)

Based on Eqs. (24)–(27) with κ<1, we can graph the nominal income, output, price, and interest rate loci within the bands, which are labeled with the superscript "NTZ" to the relevant variables in panels (a)–(d) in Fig. 1, respectively. Similarly, according to Eqs. (24a)–(27a), we can depict the dynamic loci of n, y, p, and i under the floating nominal income regime, which are labeled the superscript "FM" to the relevant variables in panels (a)–(d) in Fig. 1, respectively.

In panels (a), (c), and (d) of Fig. 1, for a given fluctuation in ε within the interval ε^u and ε^l, all nominal income, price, and interest rate variabilities under the regime of a nominal income target zone are smaller than those under the regime of a floating nominal income. Hence, the commitment that the monetary authorities intend to defend a zone will stabilize n, p, and i. This is the famous "honeymoon effect" in the target zone literature. However, it is clear in panel (b)

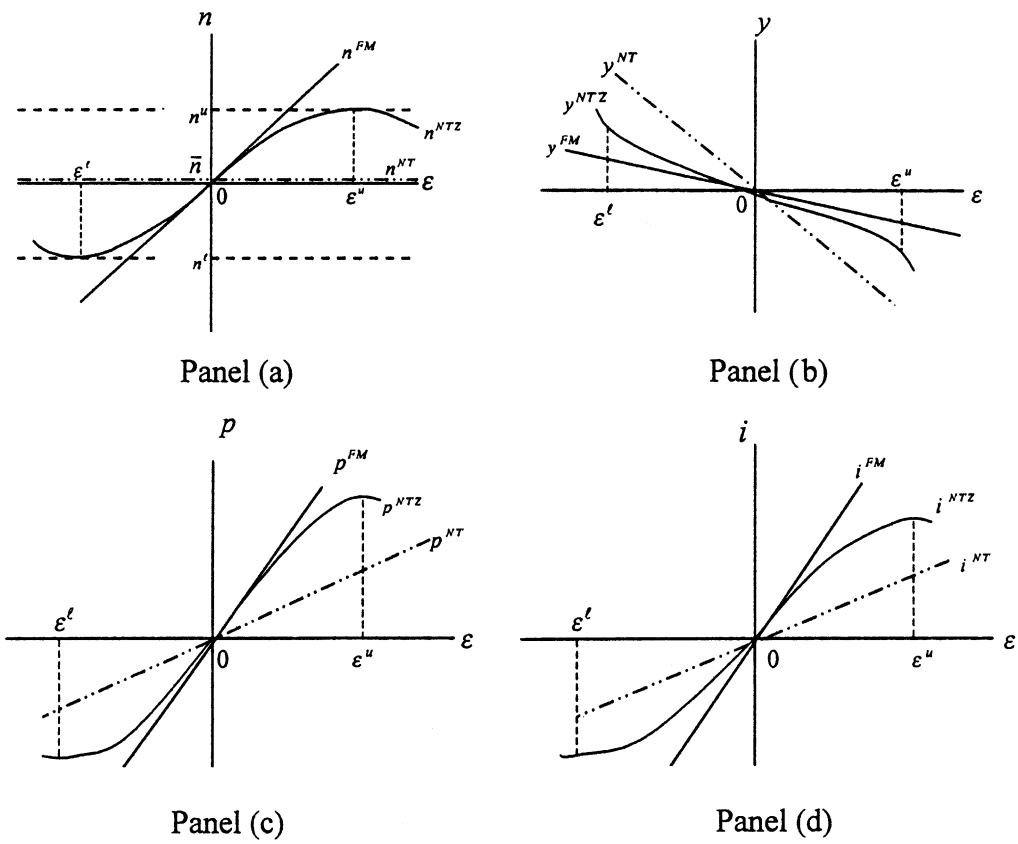

Fig. 1. The dynamic loci of macroeconomic variables under alternative nominal income regimes (κ<1).

of Fig. 1 that, in response to a change in ε, the output variability under the regime of a nominal income target zone is greater than that under the regime of a floating nominal income. More precisely, a nominal income target zone tends to destabilize, rather than stabilize, output. These results indicate an important policy implication that, when the monetary authorities undertake a nominal income target zone policy, the economy benefits from lower nominal income, price, and interest rate variabilities at the expense of higher output variability.

The intuition behind these results is obvious. When the economy experiences a decline in commodity production, both p and i will increase, but y will decrease in response. However, as indicated in Eq. (14), given that aggregate demand is inelastic, the strength of a rise in p outweighs that of a fall in y. Nominal income n $(=p+y)$ thus will increase. When n is higher and closer to the upper bound of the nominal income band, the probability that it will reach the upper edge increases. Accordingly, the probability of a future intervention to *reduce* the money supply to defend the band also increases, implying that a future lower price is expected by the public (i.e., $E(\mathrm{d}p)/\mathrm{d}t<0$). The change in expectations will in turn lead to a decline in n, y, p, and i since it will increase real interest rates and lower commodity demand.[12] Obviously, the adjustment of n, p, and i originating from expectations will mitigate the adjustment of these three variables originating from the change in fundamentals, thereby narrowing the range of their variation. However, the adjustment of y originating from expectations will enhance the adjustment originating from the change in fundamentals; hence, the range of y's variation increases. The same reasoning must hold at the bottom of the band.

3.2. Elastic aggregate demand ($\kappa>1$)

According to Eqs. (24)–(27) with $\kappa>1$ and Eqs. (24a)–(27a), we can similarly depict the dynamic loci of n, y, p, and i under the two different regimes. The dynamic loci of the relevant variables are added the superscripts "NTZ" and "FM" in panels (a)–(d) in Fig. 2, respectively. It is quite clear in panels (a)–(d) of Fig. 2 that, if the economy faces an aggregate supply shock, then the nominal income target zone policy will stabilize both nominal income and real output, but destabilize both commodity prices and interest rates.

The inference made in panels (a)–(d) of Fig. 1 can be applied to panels (a)–(d) of Fig. 2. Given that the economy experiences an adverse aggregate supply shock, both p and i will increase, but y will decrease in response. However, as indicated in Eq. (14), given that aggregate demand is elastic, the strength of a rise in p falls short of a decline in y. Nominal income n $(=p+y)$ thus will decrease. When n is lowered and closer to the lower bound of the nominal income band, the probability that it will reach the lower edge increases. Accordingly, the probability of a future intervention that *raises* the money supply to defend the band rises, implying that a higher future price is expected by the public agents (i.e., $E(\mathrm{d}p)/\mathrm{d}t>0$). The change in expectations further leads to an increase in n, y, p, and i since it will lower real interest rates and boost commodity demand.[13] Obviously, the adjustment of n and y emerging

[12] Given $\kappa<1$, Eqs. (6)–(8) and footnote 9 reveal that a fall in $E(\mathrm{d}p)/\mathrm{d}t$ will reduce y, p, and i, and hence n.

[13] Given $\kappa>1$, Eqs. (6)–(8) and footnote 9 reveal that a rise in $E(\mathrm{d}p)/\mathrm{d}t$ will increase y, p, and i, and hence n.

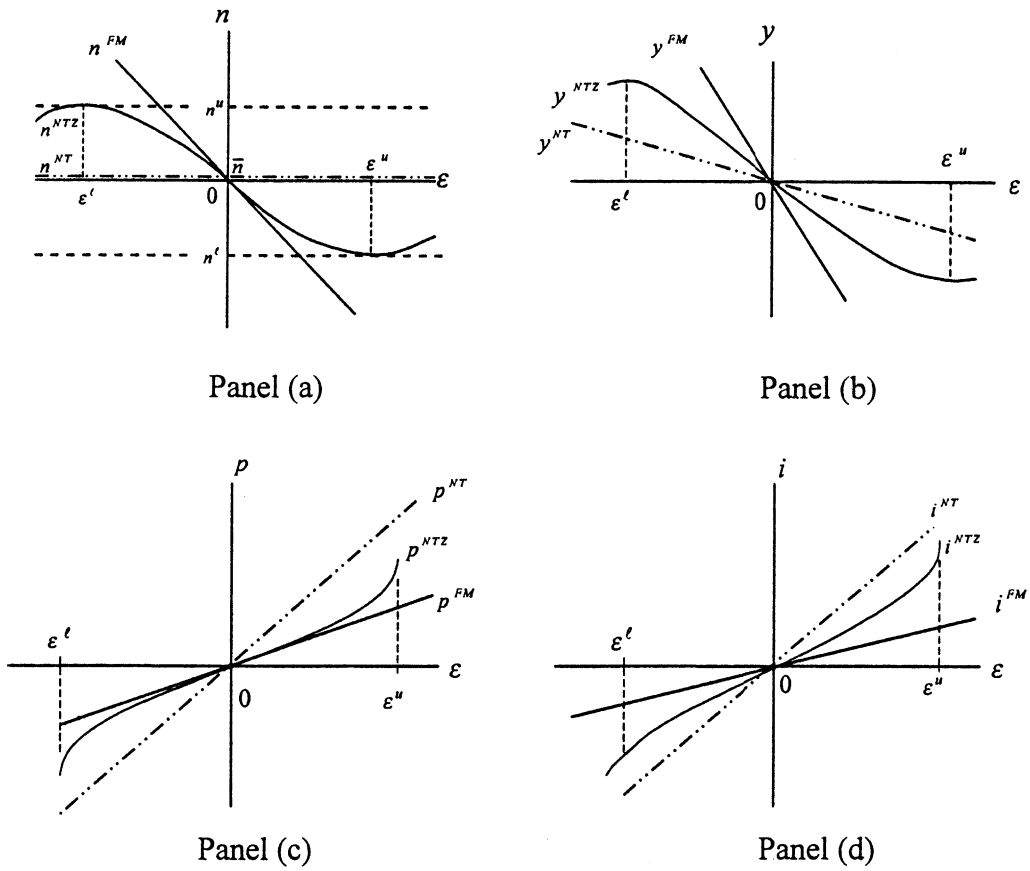

Fig. 2. The dynamic loci of macroeconomic variables under alternative nominal income regimes (κ>1).

from expectations will lessen the adjustment of both variables emerging from the change in fundamentals, thereby narrowing the range of variation. However, the adjustment of p and i emerging from expectations enhances the adjustment emerging from the change in fundamentals; hence, the range of variation for both p and i increases. The same reasoning must hold at the ceiling edge of the band.

In their often-cited papers, Bean (1983) and West (1986) compare the relative superiority of a fixed nominal income policy and a fixed money supply policy, concluding that the elasticity of aggregate demand to real money balances being greater or less than unity is the crucial factor for the policy choice. Based on the observation in this section, we find that, running in contrast with the channel emphasized in existing literature, whether the elasticity of aggregate demand with respect to real money balances is greater than unity will affect the public's inflation expectations. This change in inflation expectations further plays an important role in governing the relative superiority between a nominal income target zone policy and a fixed money supply policy.

It would be interesting to address the relative stabilization between a target band for nominal income and a point target.[14] The nominal income target zones will become the nominal income point targeting if $n^{u}=n^{l}=0$, meaning that the central bank adjusts the money stock instantaneously to keep the nominal income always constant at the point level $\bar{n}(=0)$. Under this extreme scenario, the public's expected inflation will vanish (i.e., $E(\mathrm{d}p)/\mathrm{d}t=0$). With the restriction $\bar{n}=p+y$ $(=0)$[15], Eqs. (1) and (2) with $E(\mathrm{d}p)/\mathrm{d}t=0$, and Eq. (3), there are four equations that determine four endogenous variables: y, p, i, and m. To save space, we do not express the solution and only graph the loci of n, y, p, and i under a nominal income point, which are labeled with the superscript "NT" to the relevant variables in panels (a)–(d) of both Figs. 1 and 2, respectively.[16]

Comparing the relative steepness of the loci of n, y, p, and i under a target band for nominal income and a point target, the following conclusions can be established. First, when $\kappa<1$, a nominal income target zone has a better stabilizing performance on output than a nominal income point target, but has a destabilizing performance on nominal income, commodity prices, and interest rates. Second, when $\kappa>1$, a nominal income target zone has a better stabilizing performance on both commodity prices and interest rates than a nominal income point targeting, but has a destabilizing performance on both nominal income and output.

4. The variability related to price target zones

This section addresses the stabilizing effect of a price target zone policy. Similar to the implementation of a nominal income target zone, assume that the authorities stand ready to adjust the money supply at the level of maximum price p^{u} and minimum price p^{l}, while the price is in the interior of the band, the monetary authorities do not alter the money stock. Based on this intervention rule and Eq. (9), the dynamic locus of p can be expressed as (Eq. (28)):

$$p=\begin{cases} p^{u}; & \tilde{\varepsilon}^{u}_{+}\leq\varepsilon \\ C[m+(\eta/a)g]+[\delta+\eta/a]C\varepsilon+A'\mathrm{e}^{s\varepsilon}+B'\mathrm{e}^{-s\varepsilon}); & \tilde{\varepsilon}^{l}_{+}\leq\varepsilon\leq\tilde{\varepsilon}^{u}_{-}, \\ p^{l}; & \varepsilon\leq\tilde{\varepsilon}^{l}_{-} \end{cases} \tag{28}$$

where $\tilde{\varepsilon}^{u}$ and $\tilde{\varepsilon}^{l}$ are the corresponding values that the monetary authorities decrease and increase the money supply to defend the price target zone, respectively. Terms $\tilde{\varepsilon}^{u}_{+}$ and $\tilde{\varepsilon}^{u}_{-}$ represent the right- and left-hand side limits of $\tilde{\varepsilon}^{u}$, respectively; and $\tilde{\varepsilon}^{l}_{+}$ and $\tilde{\varepsilon}^{l}_{-}$ represent the right- and left-hand side limits of $\tilde{\varepsilon}^{l}$, respectively.

[14] An anonymous reviewer, to whom we are grateful, raised this point.

[15] Recalling that the central parity of nominal income target zones is 0, $n^{u}=n^{l}=0$ thus implies that the point level of nominal income ($\bar{n}$) is 0.

[16] A detailed derivation of n, y, p, and i under a nominal income point targeting can be obtained from the authors upon request.

Following the same procedures as that of nominal income targeting, we can derive the closed dynamic loci of output, prices, and the interest rate within the bands as follows:

$$y = -C\varepsilon - \frac{\alpha(a\delta + \eta)[\sinh(s\varepsilon)]}{(a + a\alpha\delta + \alpha\eta)s[\cosh(s\tilde{\varepsilon}^{u})]}, \tag{29}$$

$$p = \left(\delta + \frac{\eta}{a}\right)C\varepsilon - \frac{(\alpha\delta + \eta)[\sinh(s\varepsilon)]}{(a + a\alpha\delta + \alpha\eta)s[\cosh(s\tilde{\varepsilon}^{u})]}, \tag{30}$$

$$i = \frac{1}{a}C\varepsilon - \frac{(\alpha\delta + 1)(a\delta + \eta)[\sinh(s\varepsilon)]}{\eta(a + a\alpha\delta + \alpha\eta)s[\cosh(s\tilde{\varepsilon}^{u})]}. \tag{31}$$

Given Eqs. (29)–(31), we can graph output, price, and interest rate loci within the bands, the dynamic loci of the relevant variables are added the superscript "PTZ" in panels (a)–(c) of Fig. 3, respectively.

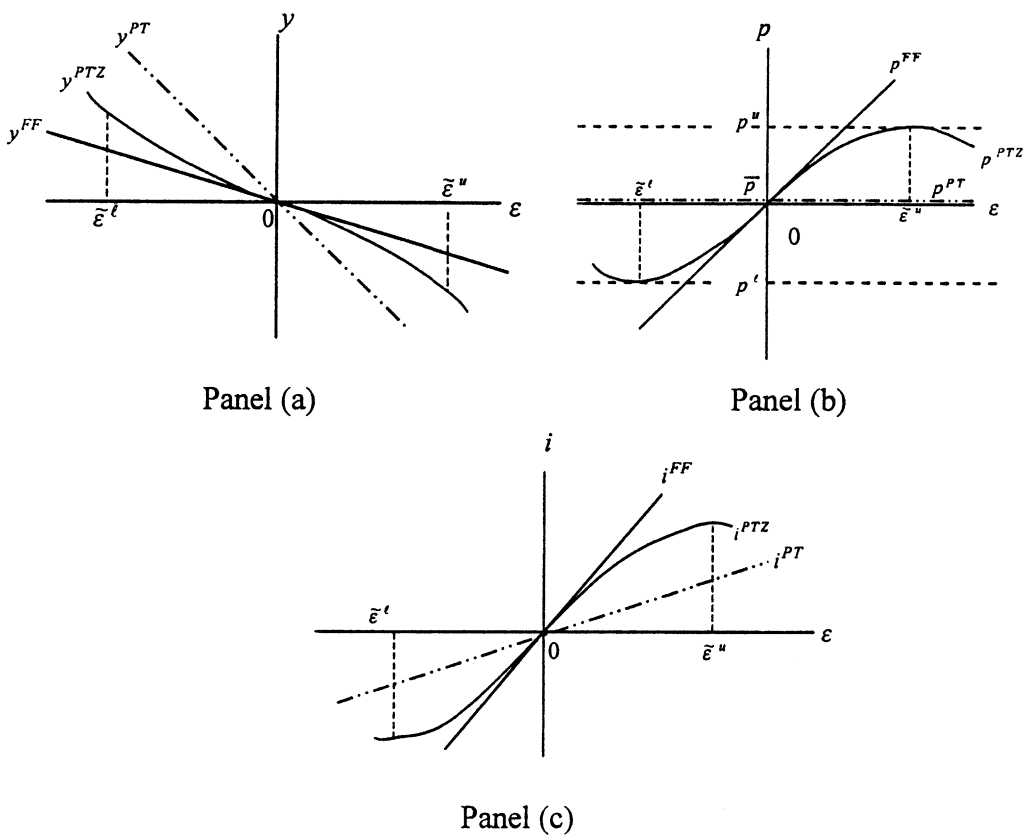

Fig. 3. The dynamic loci of macroeconomic variables under alternative price regimes.

If the monetary authorities do not set a price band and let prices adjust freely, implying $p^{u} \to \infty$ and $p^{l} \to -\infty$, then the edges of the market fundamental have the properties $\tilde{\varepsilon}^{u} \to \infty$ and $\tilde{\varepsilon}^{l} \to -\infty$. Hence, similar to Eqs. (20) and (21), we have $A' = B' = 0$. It then follows from Eqs. (9), (11), and (12) that the dynamic behavior of y, p, and i in the regime of a float price is:

$$y = -C\varepsilon, \tag{29a}$$

$$p = \left(\delta + \frac{\eta}{a}\right) C\varepsilon, \tag{30a}$$

$$i = \frac{1}{a} C\varepsilon. \tag{31a}$$

Eqs. (29a)–(31a) reveal that, if the monetary authorities do not set any edge for commodity prices, then public agents will expect that the instantaneous change in the price is nil. Consequently, from Eqs. (6)–(8), y, p, and i are completely determined by the market fundamentals. According to Eqs. (29a)–(31a), we can depict the dynamic loci of y, p, and i under the floating price regime, which are labeled with the superscript "FF" to the relevant variables in panels (a)–(c) of Fig. 3, respectively.

In both panels (b) and (c) of Fig. 3, given a change in ε within the interval $\tilde{\varepsilon}^{u}$ and $\tilde{\varepsilon}^{l}$, both price variability and interest rate variability under the regime of a price target zone are smaller than those under the regime of a float price. Hence, the commitment that the monetary authorities intend to defend a zone will stabilize both p and i. However, it is clear in panel (a) of Fig. 3 that, in response to a change in ε, the output variability under the regime of a price target zone is greater than that under the regime of a float price. More precisely, a price target zone will destabilize, rather than stabilize, output. These results indicate an important policy implication: when the monetary authorities undertake a price target zone policy, the economy benefits from lower prices and interest rate fluctuations at the expense of higher output variability.

The intuition behind these results is obvious. When the economy experiences a fall in commodity production shock, both p and i increase, but y will decrease. When the commodity price is higher and closer to the upper bound of the price band, the probability that it will reach the upper edge increases. Accordingly, the probability of a future intervention to *reduce* the money supply to defend the band rises, implying that a lower future price is expected by the public (i.e., $E(\mathrm{d}p)/\mathrm{d}t < 0$). The change in expectations will in turn lead to a decline in y, p, and i since it increases the real interest rate and lower commodity demand.[17] Obviously, the adjustment of p and i originating from expectations will lessen the adjustment of both variables originating from the change in fundamentals, thereby narrowing the range of variation.[18] However, the adjustment of y originating from expectations will enhance the adjustment originating from the change in fundamentals, and hence the range of variation of y increases. The same reasoning must be true at the bottom of the band.

[17] Eqs. (6)–(8) reveal that a fall in $E(\mathrm{d}p)/\mathrm{d}t$ will reduce y, p, and i.

[18] In panel (c) of Fig. 3, the adjustment of i is depicted with the assumption that the effect stemming from the change in expectations is less than that from the change in fundamentals.

Similar to the illustration in Section 3, the price target zones become the price point targeting if $p^{u}=p^{l}=0$, implying that the central bank adjusts the money stock instantaneously to keep commodity prices at the point level $\bar{p}$ (=0).[19] Under this extreme scenario, the public's expected inflation will vanish (i.e., $E(\mathrm{d}p)/\mathrm{d}t=0$). With the restriction $p=\bar{p}(=0)$, Eqs. (1) and (2) with $E(\mathrm{d}p)/\mathrm{d}t=0$, and Eq. (3), there are four equations that determine four endogenous variables: y, p, i, and m. To save space, we do not express the solutions and only graph the loci of y, p, and i under a price point target, which are labeled with the superscript "PT" to the relevant variables in panels (a)–(d) of Fig. 3. Comparing the relative steepness of the loci of y, p, and i under a target band for prices and a point target, the following conclusion is established: When the economy experiences aggregate supply disturbances, a price target zone reduces the variability of both output and the interest rates, but raises the variability of prices relative to a price point target.

5. Nominal income versus price target zones

Two important results emerge from the discussions in the previous section. First, upon the shock of aggregate supply, the nominal income target zone policy tends to lower the variability of the price and interest rate, but raises the variability of output when aggregate demand is inelastic. With elastic aggregate demand, however, the nominal income target zone policy leads to a smaller output fluctuation at the expense of larger price and interest rate fluctuations. Second, regardless of whether aggregate demand is elastic or inelastic, the price target zone policy always tends to lower the variability of output prices and interest rates, but raises the variability of output. It is of interest to highlight relative stabilization between price targeting and nominal income targeting. This is the issue that this section intends to address.

Rather than hypothesizing a specific ad hoc loss function, it is more useful to separately analyze the stabilization of relevant macro variables, such as output and prices. We first consider output stabilization. It is quite obvious from Eqs. (25), (25a), (29), and (29a) that the output's variability under different regimes is (Eqs. (32)–(35)):

$$y^{\mathrm{NTZ}} = -C\varepsilon - \frac{\alpha C(1-\kappa)[\sinh(s\varepsilon)]}{\kappa s(1+\alpha)[\cosh(s\varepsilon^{\mathrm{u}})]}, \tag{32}$$

$$y^{\mathrm{FM}} = -C\varepsilon, \tag{33}$$

$$y^{\mathrm{PTZ}} = -C\varepsilon - \frac{\alpha(a\delta+\eta)[\sinh(s\varepsilon)]}{(a+a\alpha\delta+\alpha\eta)s[\cosh(s\tilde{\varepsilon}^{\mathrm{u}})]}, \tag{34}$$

$$y^{\mathrm{FF}} = -C\varepsilon, \tag{35}$$

[19] Recalling that the central parity of price target zones is 0, $p^{u}=p^{l}=0$ thus implies that the point level of prices ($\bar{p}$) is 0.

where y^{NTZ}, y^{FM}, y^{PTZ}, and y^{FF} are the output's variabilities in the context of nominal income target zones, float nominal income (fixed money supply), price target zones, and float prices, respectively.

If the monetary authorities are concerned about price stabilization, then it can be verified from Eqs. (26), (26a), (30), and (30a) that the variability of prices under different regimes can be expressed as (Eqs. (32a)–(35a)):

$$p^{NTZ} = C\left(\delta + \frac{\eta}{a}\right)\varepsilon - \frac{C(1-\kappa)[\sinh(s\varepsilon)]}{\kappa s(1+\alpha)[\cosh(s\varepsilon^{u})]}, \tag{32a}$$

$$p^{FM} = C\left(\delta + \frac{\eta}{a}\right)\varepsilon, \tag{33a}$$

$$p^{PTZ} = \left(\delta + \frac{\eta}{a}\right)C\varepsilon - \frac{(\alpha\delta + \eta)[\sinh(s\varepsilon)]}{(a + a\alpha\delta + \alpha\eta)s[\cosh(s\tilde{\varepsilon}^{u})]}, \tag{34a}$$

$$p^{FF} = \left(\delta + \frac{\eta}{a}\right)C\varepsilon. \tag{35a}$$

In view of the fact that y^{NTZ}, y^{PTZ}, p^{NTZ}, and p^{PTZ} involve nonlinear forms, it is impossible to compare them without precise knowledge of the economy's parameters. Consequently, given the model's complexity, it is easier to address the relative stabilization between price and nominal income target zones via numerical simulations. The parameters we utilize are adopted from Klein's (1990) analysis, which are α=0.3, a=2, δ=0.2, η=5, $\varepsilon^{u}=-\varepsilon^{l}$=2.5, σ^2=2.5.[20] Given the definition $\kappa=1/[(\eta/a)+\delta]$, it is immediately inferred from the specific parameters that $\kappa=1/2.7<1$. The simulated results associated with the assigned numerical parameters are depicted in Fig. 4, where panel (a) describes the dynamic locus of y and panel (b) describes the dynamic locus of p under all regimes.

Several interesting observations follow from Fig. 4. First, as indicated in panel (a), the y^{NTZ} locus is steeper than the y^{FM} locus and the y^{PTZ} locus is steeper than the y^{FF} locus. This outcome implies that, in response to a change in random shocks, the output variability under a nominal income target zone is greater than that under a floating nominal income regime, and the output variability under a price target zone is greater than that under a floating price regime. Second, based on a similar inference, the result exhibited in panel (b) allows us to conclude that the price variability under a nominal income target zone is less than that under a floating nominal income regime, and the price variability under a price target zone is less than that under a floating price regime. Both results are consistent with those in Section 3 and 4.

[20] To make the comparison be meaningful, we specify that both nominal income and price target zones have the same upper boundary for a random shock, i.e., $\tilde{\varepsilon}^{u}=\varepsilon^{u}$.

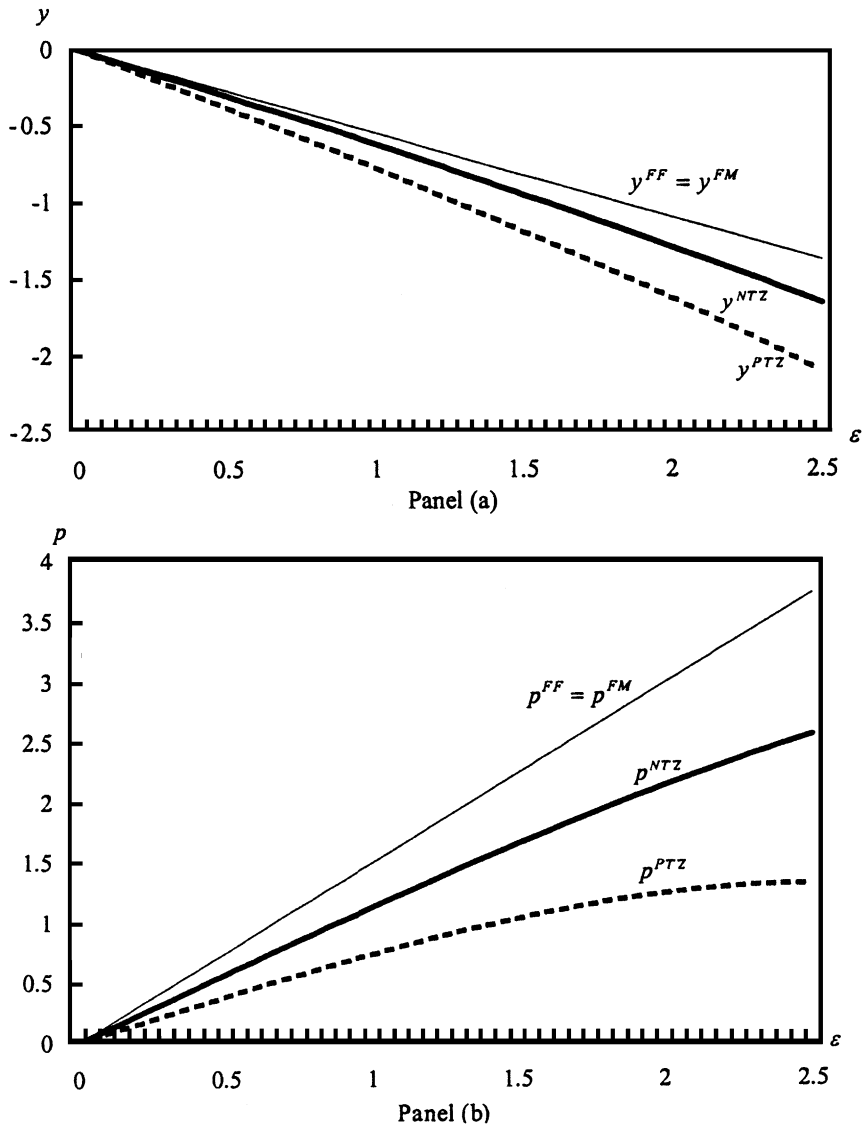

Fig. 4. Simulation results ($\kappa<1$).

Third, it is clear in panel (a) that the y^{PTZ} schedule is steeper than y^{NTZ}, implying that a nominal income target zone is superior to a price target zone when the monetary authorities seek to stabilize output. At the same time, panel (b) indicates that the p^{NTZ} schedule is steeper than p^{PTZ}, meaning that a price target zone is superior to a nominal income target zone when the monetary authorities seek to stabilize prices.

Using Klein's (1990) numerical parameters, the previous simulation results restrict $\kappa=1/2.7<1$. Recall that in the preceding discussion the elasticity of aggregate demand to real money balances κ is the crucial factor for the desirability of nominal income targeting. In

order to gain some insight concerning the role of aggregate demand's elasticity to real money balances, we thus specify that the semi-log interest elasticity of money demand $\eta=5$ changes to $\eta=0.5$ and other numerical parameters remain intact. With this adjustment, we have $\kappa=1/0.45>1$. The simulated results associated with the modified numerical parameters are exhibited in Fig. 5, where panel (a) describes the dynamic locus of y and panel (b) describes the dynamic locus of p under all regimes.

Some interesting observations with $\kappa>1$ are found in Fig. 5. First, as indicated in panel (a), the y^{FM} locus is steeper than the y^{NTZ} locus and the y^{PTZ} locus is steeper than the y^{FF} locus. This result implies that, in response to a change in supply shocks, the output variability under

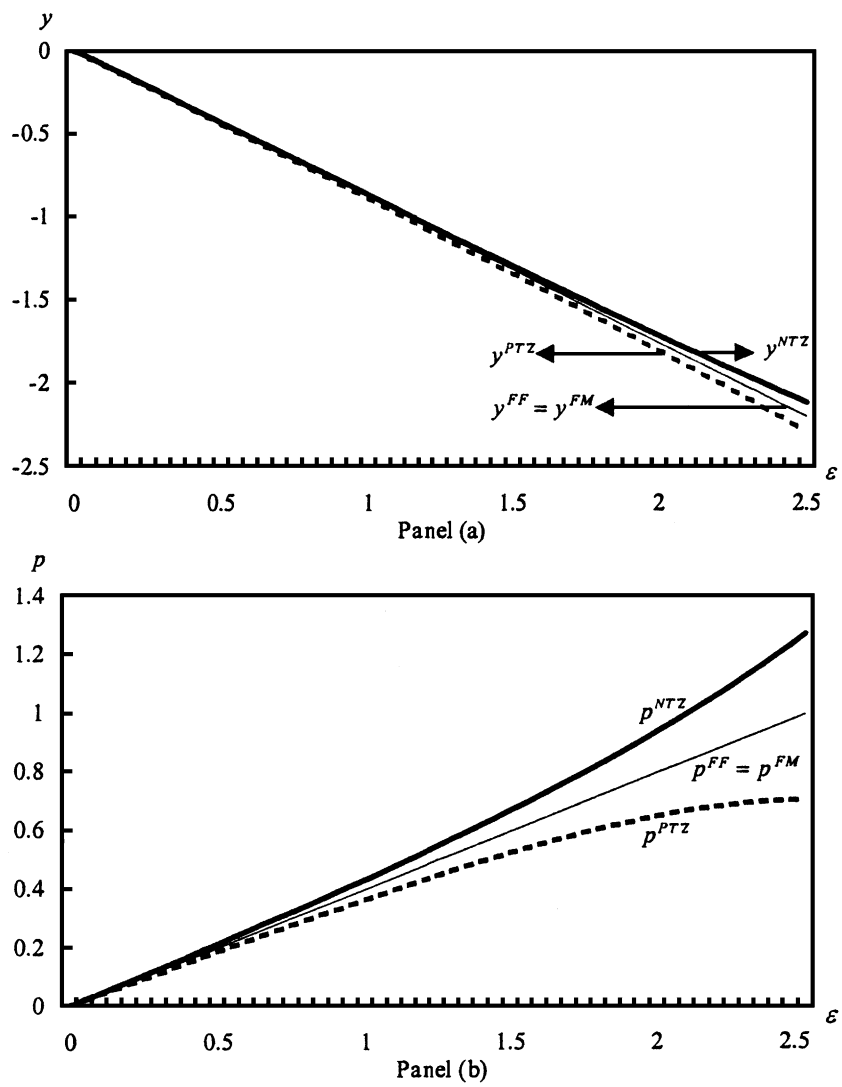

Fig. 5. Simulation results ($\kappa>1$).

a nominal income target zone is less than that under a floating nominal income regime, but the output variability under a floating price regime is less than that under a price target zone. Similarly, panel (b) shows that the price variability under a nominal income target zone is greater than that under a floating nominal income regime, but the price variability under a price target zone is less than that under a floating price regime. Both results are consistent with the discussions in Sections 3 and 4. Third, in panel (a) the y^{PTZ} curve is steeper than y^{NTZ}, implying a nominal income target zone is superior to a price target zone when the monetary authorities seek to stabilize output. At the same time, panel (b) indicates that the p^{NTZ} curve is steeper than p^{PTZ}, meaning that a price target zone is superior to a nominal income target zone when the monetary authorities seek to stabilize prices.

6. Concluding remarks

In order to evaluate the desirability of nominal income targeting, this paper sets up a stochastic macro model to illustrate the stabilizing effect of nominal income targeting. The model's salient feature is that the monetary authorities target a nominal income zone rather than a specific nominal income level. The motivation for targeting nominal income zones is that the authorities' commitment will affect the public's inflation expectations, which in turn govern the movement of relevant macro variables. When comparing the relative variety of a nominal income target zone and a fixed money supply regime, it is found that, upon the shock of a change in commodity production, the elasticity of aggregate demand to real money balances is the crucial factor for the desirability of nominal income targeting. With inelastic aggregate demand, a nominal target zone policy tends to lower the variability of commodity prices and interest rates, but raises the variability of output. However, with elastic aggregate demand, a nominal target zone policy will lead to a smaller output fluctuation at the expense of larger price and interest rate fluctuations.

This paper also addresses the stabilizing effect of price target zones in the presence of aggregate supply shocks. Based on the same model, we find that the announcement that the monetary authorities intend to defend a price target zone will reduce the variability of both domestic prices and interest rates, but raise the variability of domestic output.

Using numerical simulations, we evaluate the relative stabilization between nominal income and price target zones. With the plausible parameter values adopted from Klein (1990), two findings are observed when the economy faces a supply shock. First, a nominal income target zone is superior to a price target zone from the standpoint of output stabilization. Second, nominal income target zone is a more inferior strategy than a price target zone from the standpoint of price stabilization.

Acknowledgments

The authors are indebted to two anonymous referees for their constructive suggestions and insightful comments. In particular, we thank Chun-chien Huang for helpful

discussions and Ming-fu Shaw for numerical simulations. Any errors or shortcomings are the authors' responsibility.

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