Southeast Asian Journal of Economics 4(1), June 2016: 83-111

Optimal In lation Tolerance Band

Nath Bunditwattanawong
Faculty of Economics, Chulalongkorn University, Bangkok, Thailand
Corresponding author:nath-bundit@windowslive.com

Abstract

Recently, some inflation-targeting countries have started to use point targeting instead of tolerance band targeting, while most inflation-targeting countries still use tolerance band targeting. The main reason for the use of tolerance band targeting is to avoid serious inflation biases caused by political interference. It is considered to be an institutional arrangement; which is a subclass of an inflation contract and it modifies the central bank's preferences by imposing a constraint on the likelihood of inflation and also it is the most compromising method comparing to other institutional devices. Besides, it does not severely decrease the societys welfare.

Keywords: Monetary Policy ,CentraBanks andTheir Policies,Policy Designs and Consistency

Introduction

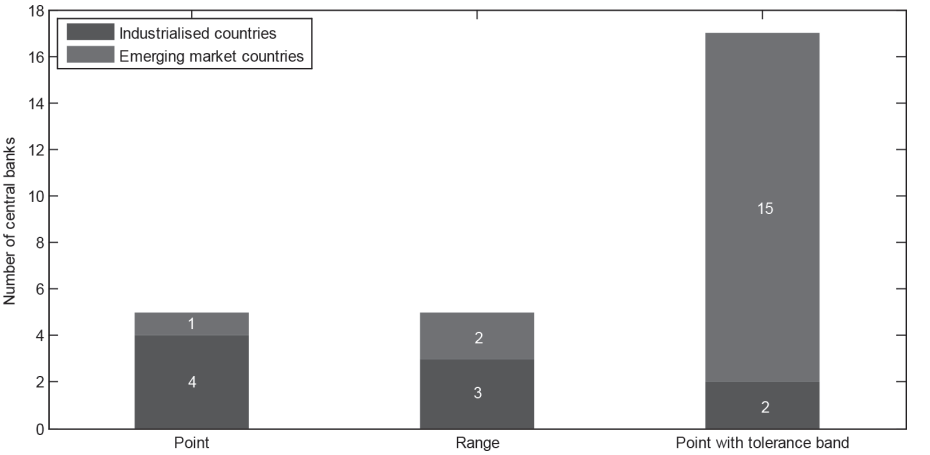
The measurement of performance and credibility is important for the central bank to get a good reputation or to enhance its future credibility. The central bank's goal is to reduce inflation bias and increase the likelihood of maintaining low and stable inflation.

Although, using a point targeting can build creditability in the long term, many of the inflation-targeting countries chose to use band targeting. Countries that choose to use band targeting or inflation range, are countries in the emerging market economy and industrial economy. Therefore, this research focuses to find reasons that support the central bank to use band targeting instead of point targeting

To understand the tolerance band of inflation, we need to understand the target variable and the characteristics of the target. Firstly, the realized inflation can be used as the target variable. However, the central bank has experienced the problem of choosing the control lags. This leads to difficulty in implementing the monetary policy as well as the difficulty in public monitoring. Therefore, central bank implements the inflation targeting as the inflation-forecast targeting. The central bank chooses not to announce inflation target but to announce the inflation forecast instead and treat the forecast as an explicit intermediate target.

Secondly, central banks in many inflation targeting countries nowadays do not only announce their point target level but also announce the explicit tolerance interval (such as ± 1 percentage point) and commit to keep the inflation inside the interval. Therefore, even though the central bank misses the target rate, they do not lose the credibility.

Figure 1. The characteristics of target



Source: Hammond (2012)

From the credibility perspective, the commitment to pursuit the point target of inflation can be superior to the commitment to keep inflation inside a range of inflation. The point target level makes it convenient to evaluate the central bank's performance. Furthermore, the tolerance band is difficult to instill the central bank's credibility. For instance, if we compare the central bank that cannot keep inflation inside a narrow band and another central bank that successfully keeps the inflation rate inside a wider band, we still cannot judge which central bank has more credibility. This ambiguousness could cause commitment mechanism to stop. Why many central banks choose to announce the tolerance band?

The literature on the design and implementation of monetary policy strategies focuses on escape clauses. According to the study of Flood and Isard (1988) and Lohmann (1992), central bank has the incentive to depart-from the point target when the side of shock is large enough. If the public expects this departure in every period, the central bank should be reformed by specifying the target range because the society can limit the departure, rather than let the central bank commit on the point target and still have whole escape clauses (Dennis (1997)). For example, Mishkin and Westelius (2008) tried to improve the discretionary equilibrium by modifying central bank's

preferences with band targeting but unfortunately they failed to determine the optimal tolerance band.

The second possible answer was from the literature of inflation forecast-targeting (Svensson (1997b) and Svensson (2003)) that states the inflation should always be equal to the target when central bank has quadratic loss function and has only the price stability as a goal. On the contrary, if the central bank has multiple goals, the deviation of inflation forecast from their point target will occur. According to the multiple goals, the central bank has to balance the price stability goal with other monetary policy goals, e.g. if the central bank has the symmetric goals between price and short-run output stability, it will keep the inflation right on the target only if the targeted output equals to the natural rate. Therefore, when the central bank puts more relative weight on other goals of monetary policy, it tends to divert more on the point targeting. This relative weight indicates the significance of stabilize other goals; therefore, the widght of the band might relate to the magnitude of relative weight on other goals.

According to the escape clauses and multiple goals of monetary policy together with inflation-forecast targeting, the central bank should announce a tolerance band with their forecast target level. However, many of the central banks announce tolerance band for the realization of inflation rather than the band for inflation forecast.

The third possible answer is from Walsh (2002), which illustrates the situation in which central bank has substantial private information on the inflation forecast that cannot be revealed to the public, therefore the central bank does not share the inflation forecast to the public. For instance, the conclusion made about the economic condition that are derived from other economic models will become the input for the policy committee's core model. These conclusions are difficult to communicate with the public. Moreover, the policy committee has some relevant information which cannot be put into the public domain for goodwill (Vickers (1999)). Therefore, if the central bank's inflation forecast cannot be observed and verified, it will make sense for the society to enforce them to retain the accountability, i.e. avoiding the inflation bias problem, by allowing it to put sanctions on the condition of realized inflation rather than sanction on the condition of inflation forecast.

Another possible answer is from the institutional variable of conducting monetary policy. These variables are not related to the incentive of the central bank, for e.g. the problem of over stating true inflation rate or the non-smooth preferences of central bank (Orphanides and Wieland, 2000. Even though these reasons cause the central bank to implement inflation band targeting, we cannot claim that it is from the central bank's incentive. Therefore, these issues do not belong to the scope of this study.

In this study, we try to explain how the central bank determines the optimal tolerance band of the realized inflation. In section 2, we explain what assumptions are used to find the optimal tolerance band of inflation. In section 3, we conduct the comparative statics analysis and the conclusions of this study are presented in section 4.

2. A Simple Framework

The framework is based on Walsh (2002, however, I modified some details as per the need of the policy in current situation. Walsh (2002 assumed that central bank had multiple goals of monetary policy, i.e. they had price stabilization goal while they also had real economy stabilization goal. The central bank had higher level of political interference when they tightened policy to stabilize inflation compared to when they eased policy to avoiding high unemployment. Thus, this assumption made central bank's objective function asymmetric in the real economy stabilization goal. Therefore, the central bank preferred to reach the target in the economic expansion than in the depression. The asymmetry of the central bank's objective function can affect the policy evaluation because this loss function is not related to the utility-based welfare function as Rotemberg and Woodford (1999 and Woodford (1998 pointed that quadratic loss function is the approximation of welfare function. Therefore, asymmetry characteristics loss function is independent from the society's welfare function.

In this study, I am considering the society's welfare as a guide to evaluate the monetary policy and I expect the appropriate policy to receive higher welfare compared to other policies. Thus, I assume that the central bank has symmetric monetary policy goals, due to the symmetry of political interfering as,

$$L_t = \frac{1}{2}(\pi_t - \pi^S)^2 + \frac{1}{2}\lambda(x_t - x^S)^2 \quad (1)$$

Where π_t is the inflation rate; x_t is the output gap; $\lambda > 0$ is the relative weight on output deviation and π^s, $x^S \geq 0$ are the exogenous inflation and output target level respectively. In addition, output target is different from social desirable level as a result from the political interferences, For example, the central bank is goal dependent.

There is a linear transmission mechanism, the inflation governed with Phillip curves and the output gap depends on the real interest rate;

$$\pi_t = \pi_t^e + ax_t + e_t \quad (2)$$

$$x_t = -b(i_t - \pi_{t+1}^e) + v_t \quad (3)$$

Where $a,b > 0$ and define $\pi_t^e \equiv E_t\pi_t$ as the public's inflation expectation based on their current information. I denoted e_t and v_t as the supply and demand shock respectively. Most of the conventional studies assumed that their transmission mechanism had character of forward-looking behavior; as a result, current economic conditions are related to the expectation of future policy. Therefore, the credibility of future policy becomes a critical issue. Despite these features are important to illustrate the role of the credibility on monetary policy, in this study; I have focused on situations where commitment on tolerance band is difficult to create the credibility in the long-run through the commitment mechanism. As I mentioned earlier, it would be difficult to measure the central bank's credibility under the band targeting regime. Thus, I excluded the forward-looking variables from my model to make it convinient.

I assume that the central bank has substantial information and they cannot reveal to the public, denoted by $e_t^f \equiv \mathrm{E}_t^{CB} e_t$ and $v_t^f \equiv \mathrm{E}_t^{CB} v_t$ as the central bank's judgment on the economic shocks.

I conclude that the political interference made the central bank set the output gap target higher than its natural rate accordingly; it has benefit to run inflation surprise. In order to alleviate this inflation bias problem, the society has to reform central banking by impose the tolerance band for the realized inflation.

2.1 The Punishment Rules

Walsh (2002) assumed that the central bank aimed to maintain price stability while stabilizing the real economy in short-run. The central bank was pressurized by the political agents when it increased the interest rate to avoid higher inflation. Instead, political pressure is less compared to when the central bank decreased interest rate to avoid higher unemployment. In order to reduce the political interference and discipline of monetary policy, society should limit the scope of central bank's policy expansion. Because the realized inflation is the policy outcome, therefore society should limit their expansionary policy by considering the realized inflation. If the actual inflation rates exceed the prescribed limit, the central banker will be freed from his duties at his office.

However, in this study, I assume that society limits the actual inflation and will not be very high and low. If the actual inflation goes outside the limit, central banker will be penalized. The missed limit situation could happen because of the lack of monetary policy discipline of the central banker. For example, one case could be if the central banker focuses too much on the price stabilization, it will lead the inflation to be lower than the limit. Another case could be when the central bank overacts on the economic stabilization, it will lead to the higher inflation rate compared to the limit.

Walsh (1995, 2002) pointed that any dismissal rule would need to be contingent on the underlying shock. However, he cited a concept of Taylor (1985) in which the state-contingent dismissal rule seems similar to the target of the nominal income. This idea is different from the recent concept in the monetary policy. In this study, I assume the society determines the tolerance limit by considering the deviation of inflation from the inflation target as it proportions to the deviation of output gap from the target, i.e. zero, thus

$$\theta_t = F(-\beta_0 - \beta_1 x_t \leq \pi_t - \pi^S \leq \beta_0 - \beta_1 x_t) \tag{4}$$

Where θ_t is the chance of central banker's reappointment in the next period and, $\beta_0, \beta_1 > 0$, represents the society's limit on economic stability goal. In order to minimize the central bank's loss function, the marginal rates of transformation and marginal rates of substitution between the forecasts of the

inflation and output gap should be equal[1]. Svensson (1997a, 1997b), Flood and Isard (1988), and Lohmann (1992) suggested that the integration between the short-run economic stabilization goal and the price stability goal may cause the central bank to lose some of their efficiency in fighting against inflation[2]. In addition, as the central bank put more weight on stabilization goal, it looses ability to establish the reputation and credibility of maintaining price stability. For instance, Mishkin and Westelius (2008) illustrated that central bank benefited when running inflation surprise because they had political interference to put more weight on their economic stabilization goal. For this reason, the society needs to put the limit on the central bank's goal in stabilizing the economy[3].

2.2 The optimal nonlinear inflation contract

If central bank sets its output gap target higher than the natural rate of the social desirable rate, the inflation bias problem will rise. There are many reasons that the central bank sets its output gap target different from the natural rate such as a situation when powerful labor union tries to prevent an employment whose target is less than natural level or who lacks precision in estimation of the natural rate, etc. Consequently, in the absence of price and wage frictions and no evidence of economic distortions and political interfering, central bank should not set the inflation different from the target level.

Central bank aims to design monetary policy to remove the inflation bias because the society will receive the maximum welfare level; the first-best equilibrium. The central bank's monetary policy can lead to three possible scenarios[4]. First, if it can commit to a monetary policy rules which alleviates

---

[1] The concept of targeting rule, see also Svensson (2007).

[2] As I mention in equation.

[3] I believe that under this central banking reformation, we cannot eliminate political interference on the relative weight of economic stabilization but we can mitigate it by impeding it to pass through the policy implementation. So, we should restrict inflation deviation at the midpoint of the band as $-(\lambda/a)x_t$ rather than. $-(\lambda/a)(x_t - x^S)$. When political pressure is on the central bank to give less importance to it price stability goal, the reformation would let it keep output gap equal only to its natural level at midpoint of the band.

[4] See also Kydland and Prescott (1997) and Barro and Gordon (1983).

inflationary bias, the society will receive the second-best equilibrium. However, this approach is not flexible enough to stabilize the economy, so it is infeasible to use. Second, if the central bank uses its discretion to determine the monetary policy with the natural rate target, $x^S = 0$, the society will receive second-best equilibrium. Third, if the central bank uses its discretion, but it cannot avoid political pressure to set the targeted higher natural rate, $x^S > 0$, the society will also receive fourth-best equilibrium.

Under this circumstance of the study, if I assume that the central bank uses their discretion in determination of monetary policy with political interfere to expand the economy, this will lead to the forth-best equilibrium. Thus, the society must play an important role to help alleviate the problem; in other words, reform the central bank.

There were two suggestions about central bank's reforms. First, Rogoff (1985) proposed a reform of the central bank by weight-conservative approach i.e. reducing the weight on stabilization goal. The weight-conservative approach could mitigate the problem of bias and it provided the third-best equilibrium. Another suggestion was from Walsh (1995). Walsh (1995) who proposed the optimal central bank linear contract approach by modifying the central bank's preferences. This study proved that it can improve the society's welfare to the second-best equilibrium.

Moreover, Mishkin and Westelius (2008) pointed that scoping the actual inflation seems similar to the approach of inflation contract whereas it formed the contract as nonlinear function.

This study differs from the previous studies in terms of using the reform of the monetary policy with the appropriate scope of inflation in a model to prevent either too high or too low inflation compared to its target level[5]. When we put constraint inflation by the nonlinear function, we can no longer apply certainty-equivalence condition. In this case the central bank needs to consider the probability distribution as a whole because it has to balanced-of-risks (Svensson (2003)), i.e. balance two side of risk of actual inflation moving outside its boundaries. Thus,

[5] Walsh (2002) assume that central bank's policy implementation was constraint by the inflation cap, as $\pi_t \leq \beta_0 - \beta_1 x_t$.

$$0 = \omega(1 - F(\pi_t - \pi^S \leq \beta_0 - \beta_1 x_t)) - (1 - \omega)F(\pi_t - \pi^S \leq -\beta_0 - \beta_1 x_t). \quad (5)$$

On the right hand side of the equation, the first and second terms in the blanked is upside risks and downside risks respectively. Where $0 < \omega < 1$ is defined as the relative weight that central banker gives to upside risks, hence $1 - \omega$ is the relative weight to downside risks. We assume that under reformation of monetary policy design, the relative weight on right tail rejection region, ω, is an exogenous factor that depends on the society's judgment about how much deviation of actual inflation should reject[6]. Mishkin and Westelius (2008) built the similar restriction but they did not take into account the central bank's need to balance its risks. Therefore, they failed to determine the optimal bandwidth.

2.3 The central bank's decision problem

I have assumed the simple transmission mechanism, therefore the monetary policy affects the economy without long and variable lags. Besides, the effect of economic shocks does not persist into the future. As a result, the central banker's decision problem is the sequence of single-period decision problems by choosing the nominal interest rate in the current period to maximize its own utility function and building the time path of the target variables[7].

---

[6] The relative weight on inflation-risk can be related to the relative weight on economic stabilization goal especially when central bank's concern about inter-temporal consistency of its band width. However political interference put them to concern more about economic stabilization and if central bank does not want to change the bandwidth from time to time oftenly, the increase in relative weight on economic stabilization goal can may require the bank to put more weight on upside risk of inflation.

[7] I assume that central bank designs its monetary policy by "discretion" because, in reality, it is difficult for a central bank to commit over the course about its future monetary policy. It is important to understand how this institutional device–inflation tolerance band–might enhance credibility in the scenario that is best approximate to reality. Moreover, under the discretion policy, it is easier to formulate optimization problem because central bank takes private sector expectations as given, therefore muli-periods decision problem can reduce the single-period decision problem.

The central banker's total benefit is including private benefit, $V > 0$, and reputation form handling economic shocks trade-off with expected return of reappointment in the future, $\mathrm{E}_t^{CB}(L_t) - \rho\overline{U}\theta_t$ where $\rho > 0$ is the time preference and $\overline{U}$ is the utility banker will get if he continues to serve in next period, thus

$$W_t = V - c(\mathrm{E}_t^{CB}(L_t) - \rho\overline{U}\theta_t) \tag{6}$$

Where $c > 0$ is the parameter that converts central banker's performance into unit comparable with the central banker private benefit. Central bank maximize (6) subject to (1), (2), (4), and (5), so

$$x_t^P = \frac{1}{\lambda + a^2}\left(a\pi^S + \lambda x^S + \rho\overline{U}\frac{\partial\theta_t}{\partial x_t^P} - a\pi_t^e - ae_t^f\right) \tag{7}$$

And

$$\pi_t^P = \frac{\lambda}{\lambda + a^2}\pi_t^e + \frac{a^2}{\lambda + a^2}\left(\pi^S + \frac{\lambda x^S}{a} + \frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P} - e_t^f\right) + e_t^f \tag{8}$$

are planned output gap and inflation respectively. Because of the rational expectation equilibrium, $\mathrm{E}_t\pi_t^P = \mathrm{E}_t\pi_t = \pi_t^e$, yields inflation expectation equals to

$$\pi_t^e = \pi^S + \frac{\lambda x^S}{a} + \mathrm{E}_t\frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P}. \tag{9}$$

Under this circumstance, if central bank uses its discretion and also considers a reappointment in the future, it will choose the interest rate, i_t^{rd}, as

$$i_t^{rd} = \pi^S + \frac{1}{b}\left(\frac{a}{\lambda + a^2}e_t^f + v_t^f\right) + \frac{\lambda x^S}{a} + \mathrm{E}_t\frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P}$$
$$- \frac{a}{b(\lambda + a^2)}\left(\frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P} - \mathrm{E}_t\frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P}\right).$$

If the central bank conducts an independent monetary policy, without political pressure, it will be able to stabilize the real economy at the natural level. It can seriously focus on establishing the reputation of inflation fighter by commiting to the optimal rules, i_t^c as

$$i_t^c = \pi^S + \frac{1}{b}\left(\frac{a}{\lambda + a^2} e_t^f + v_t^f\right).$$

The optimal inflation contract is the approach that imposes the conditions to control central bank's monetary policy, in this case society forces central banks to set the interest rate as it applies the commitment to the optimal rules, $i_t^{rd} = i_t^c$. Thus,

$$i_t^{rd} = i_t^c \text{ if and only if } \frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P} = \mathrm{E}_t\frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P} = -\frac{\lambda x^S}{a}.$$

As the result of above conditions, central bank will set the interest rate at the committed rate and control inflation inside the band.

From the model presented above, there exists an implicit assumption that the central bank has its preference to stimulate the economy and is represented from its target of $x^S > 0$ and the implementation of a discretionary policy which states that the central bank is free to re-optimize its policy tool every period (any prior policy promise does not constrain the central bank's current monetary policy). Under this path, a consequence is therefore the central bank has strong incentive to generate positive short-run inflation surprise. Ultimately, the credibility of monetary policies has been tarnished. The assumption on discretionary monetary policy underlying this model without the reforming is in line with the actual monetary policy practices from many central banks around the world.

The restrictive band of an inflation deviation is considered an innovative commitment technology to mitigate time-inconsistency problem, especially a short-run monetary policy surprise. In order to improve the society's welfare and make it close to the second-best equilibrium, the central bank needs to set the policy rate to be equal to the interest rate under the circumstance of restoring actual output to its potential counterpart (commitment to the target that $x^S = 0$). In mathematical perspective, equating both interest rates results in eliminating both

$$\frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P} - \mathrm{E}_t\frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P} \text{ and } \frac{\lambda x^S}{a} + \mathrm{E}_t\frac{\rho\overline{U}}{a}\frac{\partial\theta_t}{\partial x_t^P}$$

from the i_t^{rd} equation. Although there are many ways to achieve this process, the rationale of this conditionality is to set inflation expectation equal to the target level of inflation[8]. This means that an established institutional design mechanism leads to rational expectation equilibrium, where the central bank is no longer having an incentive to generate short-run inflation surprise. In short, biased preference of the central bank towards either expansionary or contractionary monetary policies, together with discretionary incentive to generate inflation surprise, contribute to a reduction in central bank's credibility. In order to mitigate such a problem, a social reform needs to be created that has an acceptable restrictive band on inflation deviation and would warrant that the central bank has no incentive in generating inflation surprise.

2.4 The optimal tolerance inflation band

Central bank controls the actual inflation by setting the output gap which is based on their its about the cost push shock and demand shock. The output gap depends on the planned output gap, x_t^P, and unanticipated demand shock, $v_t^f - v$, as

$$x_t = x_t^P - (v_t^f - v_t).$$

Therefore, the actual inflation equals

$$\pi_t = \pi_t^e + ax_t^P + a(v_t - v_t^f) + (e_t - e_t^f) + e_t^f.$$

If central bank wants the inflation deviation bounded by $\beta_0 - \beta_1 x_t$, it will need its unanticipated shock to be smaller than their controlled transmission. I denote inflation bias as

$$s_t \equiv (\beta_1 + a)(v_t - v_t^f) + (e_t - e_t^f)$$

therefore

$$(\beta_1 + a)(v_t - v_t^f) + (e_t - e_t^f) \leq \beta_0 + \pi^S - \pi_t^e - (\beta_1 + a)x_t^P - e_t^f,$$

[8] Substitute $(\rho\overline{U}/a)\mathrm{E}_t(\partial\theta_t/\partial x_t^P)$ in equation (9) by $-\lambda x^S/a$ and also substitute $(\rho\overline{U}/a)(\partial\theta_t/\partial x_t^P)$ by $-\lambda x^S/a$ in equation (7).

where $\bar{s}_t \equiv \beta_0 + \pi^S - \pi_t^e - (\beta_1 + a)x_t^P - e_t^f$ is upper bound of inflation bias. The central banker will be fired if the bank's anticipated shock becomes larger than the upper bound. At the same time, if central bank wants the inflation bounded by $-\beta_0 - \beta_1 x_t$, it will need its unanticipated shock to be greater than its controlled transmission, as

$$-\beta_0 + \pi^S - \pi_t^e - (\beta_1 + a)x_t^P - e_t^f \leq (\beta_1 + a)(v_t - v_t^f) + (e_t - e_t^f).$$

In this case, if the central banker anticipates the shock to be smaller than it was, the central banker will be fired, where $\underline{s}_t \equiv -\beta_0 + \pi^S - \pi_t^e - (\beta_1 + a)x_t^P + \beta_1 x^S - e_t^f$ is the lower bound of the inflation bias. Since, the society imposes this boundary to limit the ability of the central bank to fight with demand shock or the ability to stabilize real economy, some errors can occur. For instance, if the central banker expects the negative shocks that are smaller than actual ones, tit will retrain even if it tightens policy too much.

In the central bank's perspective, determining the scope of inflation deviation is similar to that of unanticipated shock and uanticipated shock is a residual from monetary policy. The central bank has no ability to perfectly control inflation and output gap. To be more specific, determining the boundry for unanticipated shock can be adjusted in the policy. By being able to do so, it allows the central bank to implement a monetary policy, which balances both stabilizing price and providing scope for central bank to employ their discretion when shocks occur. According to the inflation deviation bound from the equation, a center of inflation deviation equals to $-\beta_1 x_t$, while bandwidth equals to β_0. This shows that the inflation deviation is controlled under the bound, $-\beta_0 - \beta_1 x_t \leq \pi_t - \pi^S \leq \beta_0 - \beta_1 x_t$. From the central bank perspective, it is also considered as a bound determination of unanticipated shock under the following condition by having a center equal to $\pi^S - \pi_t^e - (\beta_1 + a)x_t^P - e_t^f$ with similar bandwidth, β_0. The bound represents the central bank's degree of flexibility in policy implementation.

As mentioned above, an ability to reform a monetary policy to have flexibility in dealing with economic shock by providing room for the central bank to maintain both economic stability and their credibility, helps mitigating

the political pressure by constraining it from passing through to the policy implementation excessively. The reason is that the appropriate bound of unanticipated shock must be under the following condition $E_t(\partial\theta_t/\partial x_t^P) = \partial\theta_t/\partial x_t^P = -\lambda x^S/\rho\overline{U}$ if and only if

$$f(\bar{s}_t) - f(\underline{s}_t) = \frac{\lambda x^S}{(\beta_1 + a)\rho\overline{U}}, \text{ where } \frac{\partial \underline{s}_t}{\partial x_t^P} = \frac{\partial \bar{s}_t}{\partial x_t^P} = -(\beta_1 + a).$$

If the government wants to stimulate economy, it would pressurize the central bank to set positive output target[9], $x^S > 0$. If the central banker is a rational agent, he will be willing to take a position as long as he feels satisfied by taking the position in the long term, $\overline{U} > 0$. In this case, $f(\bar{s}_t) > f(\underline{s}_t)$ which means that $\bar{s}_t$ would be closer to mode comparing to $\underline{s}_t$. Regarding these conditions, it means that the central bank has opportunities in implementing monetary policy to boost up the economy strongly than to shrink down economy because a reject region around the right tail is relatively lower than that around the left tail.

Besides, when the central bank has no interference from the government, bank sets the output level different from the potential output, $x^S = 0$, $f(\bar{s}_t) = f(\underline{s}_t)$ by $\bar{s}_t = -\underline{s}_t$ given that the density function of unanticipated shock is symmetry. If the situation is under these conditions, the central bank would have an opportunity to equally push forward both economy-boost up and economic contraction monetary policy.

However, when the government would like to slow down the economy by letting the unemployment rate higher than a natural rate, i.e. pressurizing the central bank to set the negative output target, $x^S < 0$, $f(\bar{s}_t) < f(\underline{s}_t)$ by $\bar{s}_t$ will distance from mode to the right side comparing to $\underline{s}_t$. This case meas that the opportunityto pursue the monetary policy that boost up economy are higher than to pursue ones that slow down economy.

---

[9] The Monetary Policy Committee (MPC) is an agent of government from the constrained discretion viewpoint. This implies that government has to take into account the reactions of the MPC when setting fiscal policy. However, the MPC simply aims to hit the inflation target given the government's fiscal stance (Mcvittie and Swales (2007)).

In other words, when central banker is willing to accept the control by society, it means that he/she admits to be scoped in policy implementation by the society. The control that prevents a loosen monetary policy implementation will get more severed when the political pressure is more intense and vice versa.

The reforming of monetary policy consists of three parts; the chance of reappointment, the benefit of reappointment, and the private benefit. These three parts are interrelated to each other. Loosely speaking, if the central bank determines the chance of reappointment to be too high or too low, it will be lack of monetary policy discipline. However, if the benefit of reappointment is too low, it will induce the central bank to stabilize the real economy in the current period, whether the chance of reappointment is appropriate or not[10]. Irrespective of the optimal chance-of-reappointment and the optimal benefit-of-reappointment, if the central banker's private benefit does not represent its performance, it will not follow the reform.

Thus, the reforms are sustainable in the long term if the optimal chance of reappointment gives enough benefit of reappointment and relates to the private benefit. To illustrate the process of determination of these three parts in this model, I will divide into three stages.

For the first stage, I will determine the chance of reappointment by gathering all the restrictions about the probability to reappointment in next period, i.e. the conditions

$$-\frac{\omega}{1-\omega}f(\bar{s}_t) = f(\underline{s}_t)$$

and

$$f(\bar{s}_t) = \frac{(1-\omega)\lambda x^S}{(\beta_1 + a)\rho\overline{U}}$$

Since, the society forced central bank to choose its interest rate as $i_t^{rd} = i_t^c$ therefore, the expected inflation was at its target level, $\pi_t^e = \pi^S$, and planned output gap was $-ae_t^f/(\lambda + a^2)$. Moreover, this boundary will be independent from the central bank's judgments, therefore the coefficient of

[10] See also equation (6).

cost push shock judgment will be zero, or

$$\beta_1 = \frac{\lambda}{a}.$$

The central bank will trade off its output gap deviation with inflation deviation. This condition is similar to the targeting rule under discretion. In consequence of this condition, I can conclude that,

$$\theta_t = \frac{F(\beta_0) - \omega}{1 - \omega} \tag{10}$$

where $F(\beta_0) > \omega$ and

$$f(\beta_0) = \frac{(1 - \omega)a\lambda x^S}{(\lambda + a^2)\rho\overline{U}} \tag{11}$$

For the second stage, I will determine the benefit of reappointment. This reform will sustain if the benefit of reappointment that central banker should receive in return for such work is high enough to drop the incentives which raise the problem of principles-agent again. Thus, I determine the benefit of reappointment from the central banker's utility from holding office without bearing the social welfare cost or

$$U_t = V + \rho\theta_t \frac{\overline{U}}{c}$$

At steady-state U_t equals to $\overline{U}$, therefore

$$\overline{U} = \frac{V}{1 - \frac{\rho}{c}\left(\frac{F(\beta_0) - \omega}{1 - \omega}\right)} \tag{12}$$

where $F(\beta_0) < c(1 - \omega)/\rho + \omega$. Third stage, I will determine the central banker's private benefit. The private benefit depends on the character of distribution function. Thus, I assume our distribution function as follows $f(s)$ is continuous, i.e. $f'(s) > 0$ for $s < 0$ and $f'(s) < 0$ for $s > 0$ and also symmetric at $s = 0$, i.e. $f'(s) = 0$ when $s = 0$ and $f(s) = f(-s)$. After substitution (12) into (11) we get the condition that tell about β_0, as

$$f(\beta_0) = \frac{(1 - \omega)a\lambda x^S}{(\lambda + a^2)\rho V}\left(1 - \frac{\rho}{c}\left(\frac{F(\beta_0) - \omega}{1 - \omega}\right)\right) \tag{13}$$

When β_0 is zero (or the commitment equilibrium) and $f(s)$ is normally distributed with zero mean and σ^2 variance, the private benefit are

$$V \geq \frac{(1-\omega)a\lambda x^S}{(\lambda + a^2)\rho f(0)}\left(1 - \frac{\rho}{2c}\left(\frac{1-2\omega}{1-\omega}\right)\right)$$

$$= \frac{(1-\omega)a\lambda x^S \sigma\sqrt{2\Pi}}{(\lambda + a^2)\rho}\left(1 - \frac{\rho}{2c}\left(\frac{1-2\omega}{1-\omega}\right)\right). \quad (14)$$

where $1/2 < c(1-\omega)/\rho + \omega$. Condition (13 and (14 tell us about the widening of tolerance band and the incentive of central bank in the steady-state respectively. Moreover, ω is greater than 1/2 means the density function is asymmetric, i.e. variance of upside risks is greater than the one on downside risks.

To conclude this section, I assume that the central bank has a quadratic loss function so our model does not loose its generality when compared with other literatures. The controlling of inflation inside certain range is based on the idea of controlling inflation deviation reasonably with the output deviation. This intuition can refer to the commitment on general targeting rules when central bank lacks a commitment mechanism. As a result of the balanced-of-risks condition, we can determine two sides of the inflation boundaries i.e. one for preventing the upward bias and another for preventing the downward bias. Moreover, central bank can excise its judgment to balance the risks and therefore the probability of upward bias and downward bias are not exactly equal. For example, the most likely outcome (mode is to always remain inside the band even if the central bank concerns more about either one side of the risks than another or not.

3. The Tolerance Band Mechanism

In this part, I will do the comparative static analysis to understand how inflation contract responds to a change of the environment in the central bank's decision problem. In the base case I, variables I am interested are the relative weight on economic stabilization goal, $\lambda = 0.5$, the output target level, $x^S = 0.1$, discount rate equals 0.01 implies $\rho = 0.99$, variance of forecast error, $\sigma = 5$, the accountability cost is unity, and the central bank's judgment about

inflation risks, $\omega = 0.75$. I want to know affect of these factors on the band mechanism in two parts; private benefit, and the widening of band. Thus, I changed these parameters case by case to see how it affects the private benefit and the size of bandwidth.

3.1 The Central Banker's Private Benefit

Under the reform, a private benefit will create an incentive for a central banker to remain disciplined in implementing the monetary policy. The discipline in implementing the monetary policy means an action to control an inflation deviation to be in the scope given by the society. Thus, if these are any changes in the implementation's conditions that will weaken the discipline then central bank has an incentive to create inflation deviation larger than the society's acceptable range. In order to solve the problem, the private benefit needs to increased. As a result, it will motivate the central banker to be disciplined in implementing the monetary policy once again.

Furthermore, the central banker's monetary discipline depends on the factors that have an impact on making monetary policy decision. However, in this research, I divide the factors into two groups i.e. factors that are negatively correlated with the monetary discipline and the factors that are positively correlated with monetary discipline.

Concretely, when there is an increase in the negative correlated factor, it will impact the central bank to create more severed inflation deviation than that is scoped. Therefore, the private benefit will surge up to encourage the central bank to be discipline in policy implementation. The factors that included in this group are:

- Central bank's preferences in stabilizing prices and economy (as referred by λ); when λ increases, the central bank will lessen the importance of maintaining the stability (figure 2 panel (a)).
- Political pressure (as referred by $x^S > 0$); when x^S rise, the central bank will face with the pressure to create more average inflation bias (figure 2 panel (b)).
- Central bank policy transmission mechanism (as referred by a or a marginal rate of transformation of economic expansion or

depression to inflation); as long as a has a smaller size than λ, the increase in a will not have such a great impact on stabilizing the price. Accordingly, the central bank is not rigorous to discipline in policy implementation (figure 2 panel (c)).

- Precision of forecasting inflation (as referred by σ^2 or a volatility of inflation forecast error); When the correction in forecasting the inflation declines, there will be more opportunities for the central bank to misbehave (figure 2 panel (d)). However, under the case, the surge in private benefit is brought up by a society's request for more accountability, which will be further described in the next following part.

On the other hand, when the factors that are positively correlated to monetary discipline increase, they will induce the central bank to be carefully implementing an indirect policy. Thus, the society will respond to it by decreasing the private benefit. The factors in this group are:

- Relative weight on upside risk (as referred by ω); in the case when the central bank indicates output target to exceed the natural rate, an increased opportunity to reject expansionary policy will force the central bank to implement the policy carefully. (figure 2 panel (e)). However, the study assumes that an increased opportunity to reject expansionary policy is tradeoff with a decreased acceptance. The compensation will not deter the monetary discipline much, so the private benefit does decrease much.
- Accountability cost (as referred by $c < 0$ (; An increase in this cost alleviates principle-agent problem by the central bank (principle) will conduct the policy which is more related to a society (agent) (figure 2 panel (f)).
- Time preferences (as referred by ρ); when the factor increases, the central bank will be concerned on the bad results in the future if it neglects the monetary discipline. The recent monetary policy will be highly relevant to future utility, or will be more crucial on limiting inflation deviation within the band (figure 2 panel (g)).

3.2 The widening of band

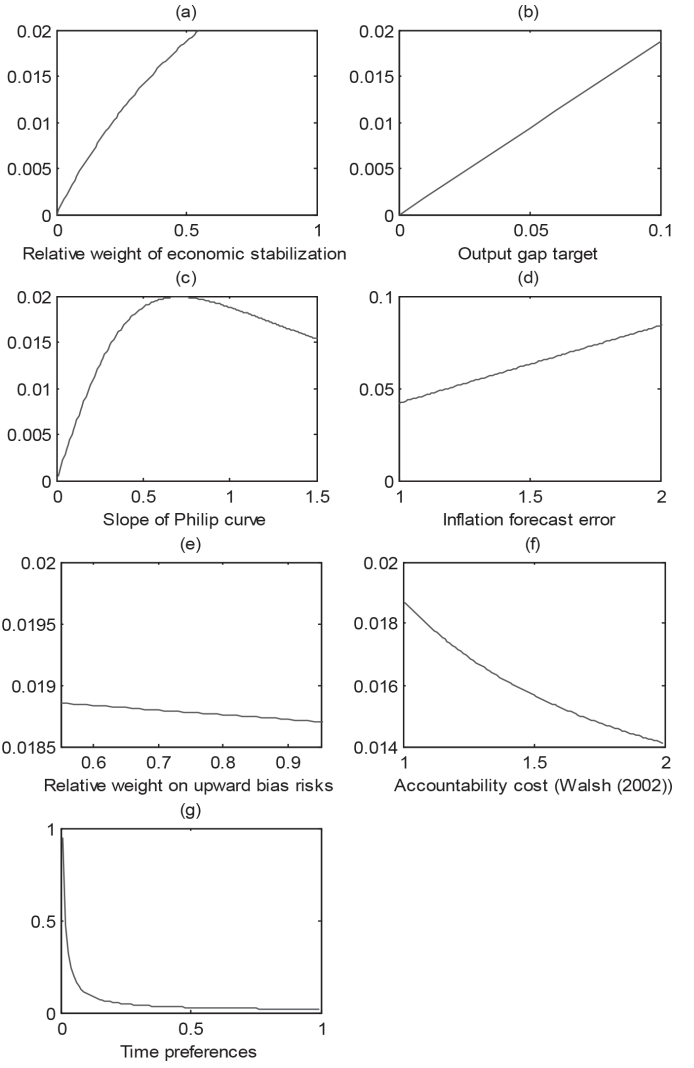
The result from comparative static analysis can be concluded into two main points. Firstly, a size of bandwidth does not indicate the central bank's creditability in implementing monetary policies as mentioned above. Secondly, using tolerance band targeting is considered as a kind of institutional arrangement that can be used to improve equilibrium in order to alleviate a problem of using discretionary policy and having output target higher than natural rate.

Specifically, the central bank's creditability cannot be specified by the bandwidth size because I have found an evidence showing that an increase in bandwidth size is caused by at least two conflict reasons used to explain the central bank creditability. For instance, if the slope of Philip curve raises, the boosting up economy affects an increase in inflation level and the size of bandwidth is expanding to response to the situation (figure 3 panel (c)). As mentioned earlier, it shows that there is more incentive to create inflation surprise, and the size of bandwidth is adjusted to the same direction.

On the other hand, the alleviated issue of principle agent makes the society to accept the central bank's expanding size of bandwidth. For instance, when the accountability cost and time preference increases, automatically the issue of principle-agent declines. In addition, the central bank's disciplinary on implementing monetary policy increases, while the size of bandwidth adjusts to the same direction (figure 3 panel (f) and (g)). Besides, the central bank is able to compromise with the government in increases, the size of bandwidth decreases but is still positive (figure 3 panel (b)) meaning the compromise remains but level should decrease as well. Furthermore, raising the size of bandwidth reflects the compromise between the governments who would like to encourage economic expansion and the society who has high concerns over a long term effect from excessively boosting up economy; where the central bank is the intermediary of negotiation between these two parties. To be more specific, it can be also explained that the central can neither use economic expansion policy boundlessly nor adhere to maintaining output to the natural rate.

Consequently, it can be concluded that we cannot use the size of bandwidth to imply the central bank's creditability.

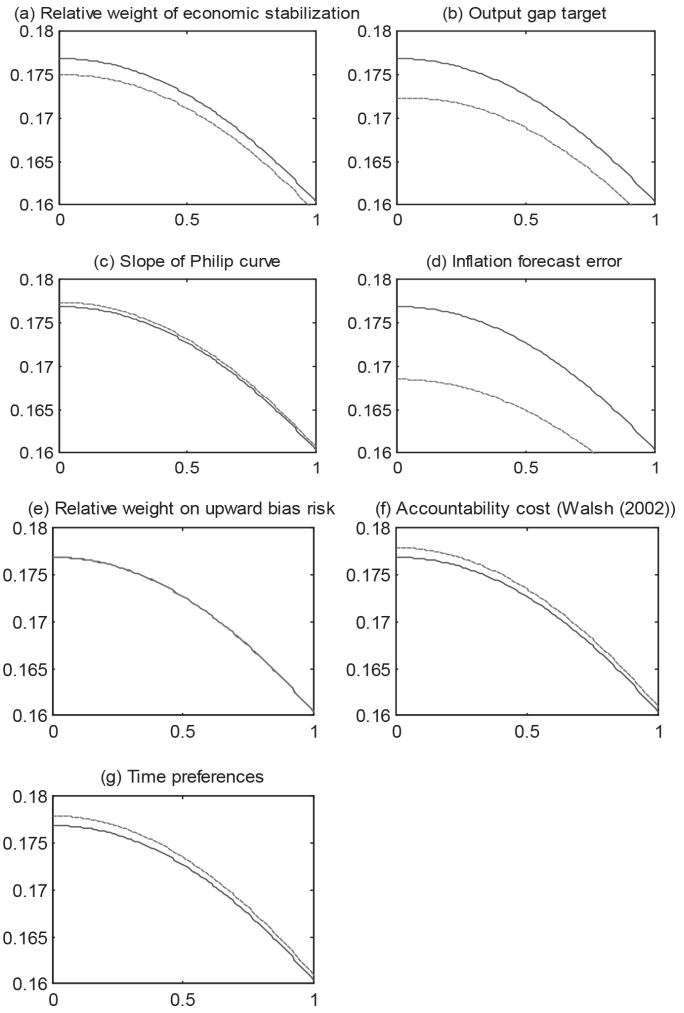
Figure 2. Central banker's private benefit



Then, I will illustrate more on the point that tolerance band targeting can improve equilibrium. When we want to conduct inflation to get nearer to a target, it will in turn affect the higher level of inflation's disturbance. Such situation is called stabilization bias which is caused by an attempt to ease inflation bias by controlling output gap to natural level. The control further

results in an increased volatility. In this model, the occurrence of inflation bias is assumedly caused by political interference in dictating central bank to make output gap exceed the natural level, while having society pushing output gap towards natural level which can be noticed by the tradeoff between inflation deviation and output gap around band's midpoint, and can cause a rise in inflation volatility. Thus, the damage in the precision of inflation forecast could lead the society to decrease the size of bandwidth.

Figure 3. The widening of band



Besides, when there is an increase in relative weight on output stabilization (λ increases), which seems like it deviates the central bank to control the output gap towards target ($x^S > 0$), output variability will decrease. However, there will in turn be more inflation bias if it is an institutional arrangement. Although, it normally will cause a society third-best equilibrium, in this case where there is a penalty for the central banker to be out of the position when inflation deviation exceeds the scope and this makes the size of bandwidth decline to a point quite close to when doing inflation contract (figure 3 panel (a)). Nevertheless, the illustrated method is not able to eliminate bias successfully. Therefore, making tolerance band targeting would bring about an equilibrium which is in between the third-best and second-best equilibrium.

Still, controlling the inflation deviation by using tolerance band target has some limitations. For example, an increase in ratio of rejecting expansionary policy has similar effects to an increase in ratio of accepting contractionary policy. As the effect can be settled off, it will make the size of bandwidth stable. (figure 3 panel (e)).

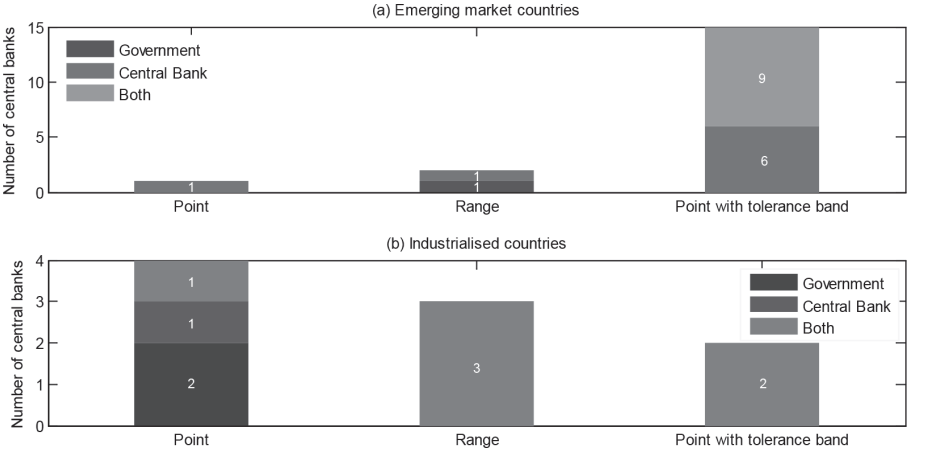
3.3 Tolerance band targeting versus point targeting

When comparing band targeting with point targeting in the aspect of credibility-enhancing, it is found that band targeting creatse the dysfunction of commitment mechanism since the decreased size of bandwidth does not mean that the central bank will seriously maintain the target. However, in the point target, the closer the actual inflation is to the target, the better the central bank performs.

In the flexibility aspect, it is discovered that band targeting has more flexibility than economic stabilization. It means that the central bank using the point targeting when preferring the flexibility will be able to differentiate the inflation from the target. Nonetheless, it needs to comply with the targeting rule (the trade-off between inflation deviation and output gap from the first-order condition). In contrast, the central bank that uses band targeting is able to implement other policies out of the targeting rule. As the targeting rule is the midpoint of the band, the central bank still adjusts the inflation to be either higher or lower by putting it within the edge of band.

Lastly, in Welfare Improvement aspect, it is found that without the political interference, using the point targeting will help gain the higher welfare than when using the band targeting. Conversely, when the monetary policy is disturbed by political interference, using the band targeting would decrease inflation bias more. Specifically, comparing between emerging economy countries and industrialized economy countries that use inflation targeting, I have found that almost every emerging economy country uses band targeting, while many of the industrialized economy countries use point targeting[11]. According to the finding, it is possible that emerging economy countries have faced with more political interference than industrialized economy countries. Moreover, the the emerging countries concerns more on economic expansion than price stability which is vice versa with that of industrialized economy countries.

Figure 4. The type of target and target dependent



Source: Hammond (2012)

[11] This statistics is based on Hammond (2012) who tells a lot about taget type adopted by full-fledge inflation targeting countries. Unfortunately, the sample size of industrialsed country is not large enough but from my knowledge and understanding, no other recent literatures has lagrer sample size than Hammond (2012).

It is better for the economy−in terms of gaining higher welfare−to adoping point targeting rather than band targeting. In order to transform from band targeting to point targeting, we need to improve the market mechanism together with an increase in the central bank's freedom to choose its policy that will help to diminish the causes of making the output target higher than natural rate. The comfirmation of this economic environment is the industrialized economy, which is likely to have better market mechanism and the central bank's freedom−the balance between government and society regarding the monetary policy cycle−might help wipe out the incentive in boosting up economy to the level that exceeds natural rate. If the need to excessively push the economy growth over the natural level is eliminated, it is no reason for central bank to adopt band targeting instead of point targeting.

4. Conclusion

In this study, I tried to determine the optimal tolerance band of inflation. I developed a model form Walsh (2002 while I assumed the central bank has quadratic loss function and commits to the general targeting rule. The inflation band targeting is subclass of inflation contract because it modifies central bank's preference by imposing the nonlinear constraint. I did not use the certainty equivalent condition. Thus, central bank needs to consider the whole distribution function to balance its risks. I assume the balanced-of-risks condition and assume that central bank can decide on which side of risks should be concerned more than another (based on soceity's judgment.

I found that, central bank can determine the optimal tolerance band, as long as it considers the balanced-of-risks. The band can mitigate the inflation bias problem. To be more specific, if the central bank is forced to appoint the output target to exceed the natural rate which can lead to an inflation bias, while a society gets to control a policy implementation by scoping the inflation deviation, this would not be the way to completely solve the inflation bias, but only to alleviate the problem−it still have room for policy athurity to boost economic growth. In another word, it cannot wipe out a political interference by doing so. Therefore, there is a high possibility for it to be chosen. Moreover, it is the way to compromise with the government more than using other institutional arrangements such as conservative weight

and linear inflation contract. Therefore, there is a high possibility for it to be chosen.

The trasformation from band targeting to point targeting would occur, if the society can eliminate the need of output target to be different from the natural rate which can be done by two ways. Firstly, it can be done by granting a freedom for the central bank to make goals by themself, although, this might build a principal-agent problem between the government and central bank. Secondly, an inspection and a balance between society and government can be used as well. Under this way, it is an attempt to prevent the government from creating monetary policy cycle which causes from indicating output target distinct from the natural level.

Acknowledgements

I have benefited from comments by Associate Professor Pongsa Pornchaiwiseskul, Ph.D., Pongsak Luangaram, Ph.D., Associate Professor Somprawin Manprasert, Ph.D., Surach Tanboon, Ph.D., San Sampattavanija, Ph.D., Panutat Satchachai, Ph.D., and Tosapol Apaitan. I owe special thanks to Pongsant Pongbangly, Chutipa Klungjaturavet, Nuchanat Karawake, Praopan Pratoomchat, Siwapong Dheera-aumpon, Somlak Kosakarn, Pongsakorn Suwanpong, and Arpakorn Noparattayaporn whom provided me with valuable suggestions. Remaining errors and obscurities are my own.

References

Barro, R. J., & Gordon, D. B. (1983. A Positive Theory of Monetary Policy in a Natural Rate Model. *Journal of Political Economy*, University of Chicago Press, vol. 91(4, pages 589-610, August.

Dennis, R. (1997. Bandwidth, bandlength, and inflation targeting: some observations. *Reserve Bank of New Zealand Bulletin*, *60*.

Mcvittie, E., & Kim Swales, J. (2007. 'Constrained discretion' in UK monetary and regional policy. *Regional Studies*, *41*(2, 267-280.

Flood, R., & Isard, P. (1988. Monetary policy strategies.

Hammond, G. (2012. State of the art of inflation targeting. *Handbooks*.

Kydland, F. E., & Prescott, E. C. (1977). Rules rather than discretion: The inconsistency of optimal plans. *The journal of political Economy*, 473-491.

Lohmann, S. (1992). Optimal commitment in monetary policy: credibility versus flexibility. *The American Economic Review*, *82*(1), 273-286.

Westelius, N. J., & Mishkin, F. S. (2006). *Inflation Band Targeting and Optimal Inflation Contracts* (No. 416). Hunter College Department of Economics.

Orphanides, A., & Wieland, V. (2000). Inflation zone targeting. *European Economic Review*, *44*(7), 1351-1387.

Rogoff, K. (1985). The optimal degree of commitment to an intermediate monetary target. *The quarterly journal of economics*, 1169-1189.

Rotemberg, J., & Woodford, M. (1997). An optimization-based econometric framework for the evaluation of monetary policy. In *NBER Macroeconomics Annual 1997, Volume 12* (pp. 297-361). MIT Press.

Svensson, L.E.O. (1997a). Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts. *American Economic Review*, *87*(1), 98-114.

Svensson, L. E. (1997). Inflation forecast targeting: Implementing and monitoring inflation targets. *European Economic Review*, *41*(6), 1111-1146.

Svensson, L. E. (2003). *What is wrong with Taylor rules? Using judgment in monetary policy through targeting rules* (No. w9421). National Bureau of Economic Research.

Svensson, L. E. (2007). Optimization under Commitment and Discretion, the Recursive Saddlepoint Method, and Targeting Rules and Instrument Rules: Lecture Notes.

Taylor, J. B. (1985, December). What would nominal GNP targetting do to the business cycle?. In *Carnegie-Rochester conference series on public policy* (Vol. 22, pp. 61-84). North-Holland.

Vickers, J. (1999). *Inflation targeting in practice: the UK experience* (No. 1999/02). CFS Working Paper.

Walsh, C. E. (1995). Optimal contracts for central bankers. *The American Economic Review*, 150-167.

Walsh, C. E. (1995). Is New Zealand's Reserve Bank Act of 1989 an optimal central bank contract?. *Journal of Money, Credit and Banking*, *27*(4), 1179-1191.

Walsh, C. E. (2002). When should central bankers be fired?. *Economics of Governance*, *3*(1), 1-21.