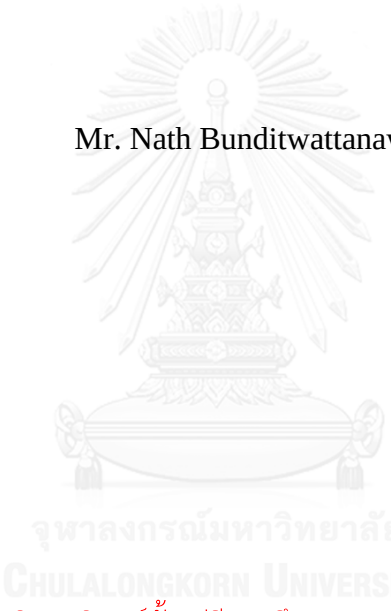
Monetary Policy of Inflation Band Targeting under Uncertatinty

Mr. Nath Bunditwattanawong



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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาเศรษฐศาสตรดุษฎีบัณฑิต
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นโยบายการเงินในปัจจุบันมุ่งเน้นบทบาทของความคาดหมายของตัวแทนทางเศรษฐกิจต่อเศรษฐกิจมหภาค และดูเหมือนเป็นความเห็นพ้องโดยทั่วกันว่า ผลกระทบของนโยบายการเงินขึ้นอยู่กับการเปลี่ยนแปลงการคาดการณ์แนวอัตราดอกเบี้ยแท้จริงในอนาคตอย่างมีนัยสำคัญ เพราะฉะนั้นธนาคารกลางหลายแห่งจึงเพิ่มการสื่อสารของตน ในทางที่จะสามารถกำหนดการคาดการณ์ของสาธารณะชนเพื่อเพิ่มประสิทธิภาพของนโยบายการเงิน

ในทางปฏิบัติธนาคารกลางที่ดำเนินกลยุทธ์การตั้งเป้าหมายอัตราเงินเฟ้อได้ออก “เกณฑ์เป้าหมาย”(target criterion) ซึ่งมีที่มาจากเงื่อนไขในการกำหนดนโยบายการเงินที่เหมาะสม อย่างไรก็ตาม ธนาคารกลางอาจกำหนดนโยบายการเงินที่ลำเอียง เพราะเผชิญ ปัญหาระบบการตัดสินใจลำเอียง (systematic biased problem) ซึ่งเป็นผลให้เป้าหมายช่องว่างผลผลิต (output gap) ไม่สอดคล้องกับระดับช่องว่าผลผลิตที่เหมาะสม จึงเป็นเหตุให้ธนาคารกลางควบคุมความแม่นยำของนโยบายการเงินให้เพียงพอที่จะขจัดความลำเอียงที่มาจากเป้าหมายช่องว่างผลผลิตที่คลาดเคลื่อน

การศึกษานี้กำหนดให้ธนาคารกลางที่ประสบปัญหาระบบการตัดสินใจลำเอียงพยายามที่จะลดความผันผวนของอัตราเงินเฟ้อและเศรษฐกิจในระยะสั้นให้ต่ำที่สุดภายใต้มุมมองกลไกการส่งผ่านนโยบายการเงิน และให้คำมั่นสัญญาที่จะควบคุมความแม่นยำของเกณฑ์เป้าหมายให้อยู่ในระดับที่น่าเชื่อถือ อีกทั้งกำหนดให้ธนาคารกลางกำหนดขอบเขต (band) ที่เหมาะสมในการควบคุมความแม่นยำของเกณฑ์เป้าหมาย ทั้งนี้เพื่อที่จะอธิบายกระบวนการกำหนดนโยบายการเงินดังกล่าวในรูปแบบจำลองตามทฤษฎีนโยบายการเงิน การศึกษานี้ได้นำแนวคิด “สัญญาอัตราเงินเฟ้อที่เหมาะสม”(optimal inflation contract) และการเบี่ยงเบนของเงินเฟ้อ (ขนาดความแตกต่างระหว่างอัตราเงินเฟ้อและอัตราเงินเฟ้อเป้าหมาย) ต้องขึ้นอยู่กับสถานการณ์เศรษฐกิจ หากขอบเขตของการเบี่ยงเบนของเงินเฟ้อลดลงมากเท่าไร ยิ่งหมายความว่าการเบี่ยงเบนของเงินเฟ้อลดลงมากขึ้นเท่านั้น และยิ่งมีแนวโน้มที่การเบี่ยงเบนของเงินเฟ้อลดลงมากเท่าไร ก็ยิ่งมีแนวโน้มที่อัตราเงินเฟ้อจะตอบสนองกับการปรับตัวของช่องว่างผลผลิตมากขึ้นเท่านั้น

การศึกษานี้ พบว่า การตั้งเป้าหมายแบบช่วงของอัตราเงินเฟ้อ (inflation band targeting) แตกต่างจากวิธีการ “เน้นแนวทางอนุรักษ์นิยม” (conservative weight) หรือวิธีการ “กำหนดสัญญาอัตราเงินเฟ้อ” (inflation contract) นอกจากนี้หากดำเนินวิธีการตั้งเป้าหมายแบบช่วงของอัตราเงินเฟ้อสามารถนำพาสังคมเข้าสู่ดุลยภาพ อย่างดีที่สุด คือ ดุลยภาพระดับสอง (second-best equilibrium) (เช่นเดียวกับการมีสัญญาอัตราเงินเฟ้อ) และอย่างแย่ที่สุด คือ ดุลยภาพระดับสาม (third-best equilibrium) (เช่นเดียวกับการเน้นแนวทางอนุรักษ์นิยม) อย่างไรก็ตามกลไกการทำงานของการตั้งเป้าหมายแบบช่วงของอัตราเงินเฟ้อดูเหมือนจะมีลักษณะบางประการที่ไม่เสถียร (non-robustness) หากธนาคารกลางเปลี่ยนมุมมองต่อกลไกการส่งผ่านนโยบายการเงินไป

หากธนาคารกลางต้องการสนับสนุนให้กลไกการตั้งเป้าหมายแบบช่วงของอัตราเงินเฟ้อมีความเสถียรยิ่งขึ้น ธนาคารกลางอาจใช้มาตรการดังนี้ มาตรการที่หนึ่ง การเพิ่มจำนวนคณะกรรมการนโยบายการเงินที่ใส่ใจอย่างมาก ต่อการสูญเสียความน่าเชื่อถือของนโยบายการเงิน มาตรการที่สอง การสร้างมาตรการการกำหนดนโยบายการเงิน ซึ่งให้ความสำคัญต่อการสร้างความน่าเชื่อถือของนโยบายการเงิน ยกตัวอย่างเช่น พระราชบัญญัติธนาคารกลางประเทศนิวซีแลนด์ ปี ค.ศ. 1989 และมาตรการสุดท้าย การเพิ่มระดับความโปร่งใสต่อการดำเนินนโยบายการเงิน โดยธนาคารกลางสื่อสารเหตุผลเบื้องหลังในการตัดสินใจกำหนดนโยบายการเงินอย่างชัดเจน กล่าวคือ การประกาศเกณฑ์เป้าหมาย แต่เนื่องด้วยเหตุการณ์ทางเศรษฐกิจในอนาคตมีโอกาสเป็นไปได้หลายลักษณะ และธนาคารกลางอาจต้องประเมินเหตุการณ์ทางเศรษฐกิจใหม่ๆ ที่เพิ่มขึ้นจากเคยที่คาดคะเนไว้ก่อนหน้าอยู่บ่อยครั้ง เพราะฉะนั้น เกณฑ์เป้าหมายที่นำมาใช้ต้องมีลักษณะที่เป็นสูตรตายตัว และรองรับการดำเนินนโยบายที่แตกต่างกันในแต่ละเหตุการณ์ ยกตัวอย่างเช่น การประกาศเกณฑ์เป้าหมาย และระบุขอบเขตในการควบคุมความแม่นยำ

สาขาวิชา เศรษฐศาสตร์ ลายมือชื่อนิสิต .....

ปีการศึกษา 2557 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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KEYWORDS: INFLATION TARGETING / TARGET TYPE / BAND TARGETING / TARGETING RULE / MODEL UNCERTAINTY

NATH BUNDITWATTANAWONG: Monetary Policy of Inflation Band Targeting under Uncertatinty. ADVISOR: ASSOC. PROF. PONGSA PORNCHAIWISESKUL, Ph.D., 91 pp.

Monetary policy in nowadays is focused on the role of economic agents' anticipations on macroeconomic and it seems to be broad agreement that effect of monetary policy depends on the change in expected path of real interest rates significantly. Thus, many central banks increase their communication in the way that can anchor public's expectation to improving the effectiveness of monetary policy.

In practical, inflation-targeting central banks already issue "target criterion", i.e., the first-order condition from optimal monetary policy. However, they may implement biased policy due to systematic biased problem which their output gap target does not consist to the desirable output gap. As a result, central banks control their projections in the way that they can make the projections precise enough to eliminate the likely level of imprecision of output target.

This study assume that central bank that faces the problem of systematic biased will tries to minimize the quadratic loss function, subject to their views of transmission mechanism and also commit to control the precision of the target criterion within some credible limits. In addition, central bank imposes band on the target criterion in order to controlling the precision of target criterion. In order to describe this procedure in theoretical monetary policy model, this study employs the idea of "optimal inflation contract" and inflation deviation (amount of gap between inflation rate and its target value) must depend on economic conditions. Thus, if bandwidth becomes narrower, it implies that the inflation gap will expect to be smaller. The more likely smaller inflation gap is the more likely lesser response of inflation with output gap.

This study found that band-targeting is neither rigid as "conservative weight" nor costly as "inflation contract". Therefore, it can bring the second-best equilibrium to society (as inflation contract) at best, or it can bring third-best equilibrium to society (as conservative weight) at least. However, the tolerance band-targeting mechanism seems to have some non-robustness character across different central bank's views of transmission.

In order promote the robustness of tolerance band-targeting mechanism we need to: First, increase the number of member in monetary policy committee who has great distaste in losing policy credibility. Second, create institutional arrangement for policy deliberation that emphasis the value of establishing policy credibility, such as Reserve Bank of New Zealand Act of 1989. Finally, increase the degree of transparency in monetary policy which is the explicit communication about the reasoning behind decisions, i.e., the target criterion. However, there are rich number of future economic events and central bank need to evaluate the new event from their prior evaluation. Therefore, the target criterion needs to have some degree of explicit formula and prescribes the possible actions in any events, such as, announcing the target criterion and specify boundaries.

Field of Study: Economics Student's Signature .....

Academic Year: 2014 Advisor's Signature .....

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Chapter 1
Introduction

For many decades, it has been acknowledged that economists have developed several sets of explanations about how an inflation-point target is performed under an inflation targeting strategy of a central bank. These set of explanations are important in order to design an optimal monetary policy. Nevertheless, the inflation-point target is not the only target type that the central bank adopts, but also they have another type of target which works quite differently than the point target. According to full-fledge inflation-targeting country survey conducted in 2012, there are two alternative target types; a range target and a point target with tolerance band. These alternative target types are more favorable than the point target. Moreover, the point target with tolerance band is the most preferable adopted target type among them.

This chapter presents the rationale for why central banks might have departed from inflation point target and examined how many inflation-targeting countries adopt each target type. The chapter will then progress towards the objectives of this study: to focus on the monetary-policy problem for central banks to set their target variables, inflation rate and output gap and to pursue price stability and short-run economic stability under discretionary policy. However, the study suggests to pursue this objective by constraining themselves not to implement excessive contraction or expansion policy by committing towards controlling the tolerances of inflation within certain band. To be specific, this study give examples of how central banks could conduct monetary policy under inflation targeting between adopting point target and tolerance band in different types of policy transmission mechanism (including; 1) statics economic model, 2) dynamics model, and 3) model uncertainty).

1.1. Rationality of departing from point target

Many literatures on conventional theory of monetary policy certainly assume that economic agents are rational and have unique desirable level of their target variables along with complete information. They also assume this information set to be perfect and symmetrical. Inflation point target thus finds itself in a favorable ground amidst such circumstance. However, adopting the inflation target does not necessarily mean that inflation always stay at its targeting level. Under inflation targeting strategy, central banks can adjust the inflation rates to immediately reach their target only when one of these circumstances happens: (1) there is no cost push inflation; or (2) central banks have concerned only a price stability, i.e. strict targeting (Clarida, Galí, & Gertler, 1999). Unfortunately, these are unrealistic because of two reasons. Firstly, many nonmonetary factors have roles in economic fluctuation, such as the effect of excess demand on marginal cost or even demand shock (from government spending). One of these factors is the cost push shock that captures everything else that might affect the marginal cost. So, it overstates that the cost push does not exist when the economy is described in the short-run. Secondly, the monetary policy significantly influences the real economy in short-run that makes central banks to have borne the responsibility for fluctuation occurring in any business

activity. The price stability is thus pursued with some degree of concern for economic stabilization, i.e. flexible targeting.

In addition to the cost push shock, an inflation rate deviating from its target level is likely to be caused as long as the shocks do not disappear. The faster the cost push shocks decay, the closer is the distance between inflation rates and its target level. However, the distance between inflation rate and its target (along the convergent path) and the rate of convergent depends on how central banks design their monetary policy.

The flexible targeting means that central banks have multiple goals. If the policies are optimally designed, then the aim would be to balance every goal rather than focusing on any goals in particular. For instance, the central banks prefer to pursue both price stability and short-run economic stability. Under the optimal policy, the inflation rate is adjusted right on the target only if the output gap equals to its target. In addition, the more an economic stability is preferred, the higher gap between inflation and its target (Svensson, 1997 and Svensson, 2003).

The appearances of cost push shock and flexible targeting cause inflation to temporarily depart from its target level but the target that is dependent on corporate with discretionary policy can cause inflation persistently depart from its target. To be specific, it is possible for government to assign their target to central bank, creating further possibility for the government to set the target of political popularity, e.g. by assigning the output target higher than natural rate. However, only pushing output gap above natural rate does not cause inflation persistently above target. It also depends on how monetary policies are designed by the central banks. For example, if monetary policies are designed on the basis of discretion, the persistent inflation gap is likely to occur. On the other hand, if the policies are designed on the basis of rule, inflation gap cannot persist. Unfortunately, even if the problem of persistent inflation gap can be avoided by the method of rule, however central banks cannot creditably commit to design their monetary policy by the same. According to the study of Flood & Isard (1989) and Lohmann (1992), it is explained that central banks have incentive to deviate from rule to discretionary policy only when the chance of shock occurring is large enough[1], i.e., escape clauses[2].

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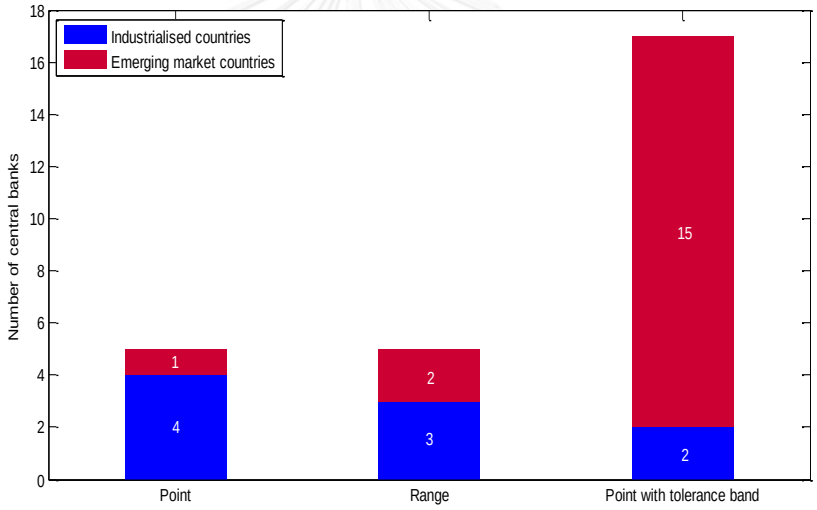
[1] In study of Flood & Isard (1989), they assume that the shock is nonnegative value and the change of occurring is positively relate to the value of its. Thus, some research papers might conclude that central banks rigid to the rule for minor shock while they follow their discretion for major shock.

[2] This conclusion is under the assumption that central banks have two strategies to handle with economic shock, one is discretionary policy another is rule. When central banks face with uncertainty to choose their strategies, they optimally respond to the uncertainty by choosing discretionary policy if possibility of shock occurring is high enough and they choose rule If possibility of shock occurring is low. Therefore, central bank might not take the rule seriously (Flood & Isard, 1989). Moreover, when central banks have to choose over intently focus on price stability or allow themselves have some degree on considering economic stability, their reaction function show that they can partially be the conservative central bankers (Lohmann, 1992).

1.2. Adopting inflation target type

Even using the point targeting can build credibility in the long term[3], but many inflation-targeting countries choose to announce other type of target, such as range target or even point target with tolerance band. To be more specific, inflation range target is fixed edge, i.e., level of inflation at the edges is constant. For example central banks have promised to keep inflation within the margin of 1%-3%. But inflation point target with tolerance band is fixed bandwidth and flexible inflation level at the edges and the level of inflation at the edges is proportional to its point target, i.e., midpoint level. For example central banks have announced their target at $3\% \pm 1$ percentage point, therefore, 3% is midpoint level and ± 1 percentage point is its tolerance level. According to the 2012 statistics (in figure 1.1), the inflation point target with tolerance band is the most preferred target type for full-fledge inflation-targeting country (Hammond, 2012).

Figure 1.1: Target type and stages of economic development



Source: Hammond (2012)

As figure 1.1, most of the countries that have adopted inflation target with tolerance band targeting are emerging and developing countries, however, there is 22% of industrialized countries (2 in 9) that have adopted this regime. Comparing the number of countries that adopts this regime to the other, it is evident that the number of countries that adopt inflation point targeting with tolerance band is more than number of countries that adopt inflation range targeting and inflation point targeting together. Many literatures on monetary policy theory do not give the specific reason

[3] We can evaluate the central bank's performance and its credibility which are important for the central bank to get a good reputation or enhance future credibility.

why central banks use the range of point target with tolerance band. However, in common, both of them explain that central banks cannot control inflation perfectly.

Nevertheless, some literatures have identified information as problem rather than assuming the information set of those economic agents as perfect and complete. In such circumstance, instead of "point target", an alternative target type might have been adopted by the central banks. Specific inflation point target is announced by the Central banks in order to anchor public's inflation expectation, which is created by the commitment mechanism. The target facilitates public to focus directly on monetary policy; it provides a yardstick for measuring the central bank's performance by comparing the realized inflation with the target rate along with providing credibility measurement, i.e., distance between expected inflation and the target. A higher credibility is achieved by central banks when the expected inflation gets closer to it. These measurements are important in order to create good reputation further enabling them to enhance future credibility. From the standpoint of credibility enhancement, the commitment to pursue the point target of inflation can be superior to the commitment to keep inflation within certain scope, i.e., either the range or the tolerance band. The scope of inflation is difficult to instill the credibility of central bank because any level of inflation within the specified scope is credible. In other words, the level of inflation within the specified scope that is close to its midpoint is credible as the level that is close to the edge. Therefore, public might get confused in evaluating the central banks' performance when inflation rates are within the scope. Hence, these reasons are considered to be the push factors that force central banks to adopt the alternative target type rather than using the point target.

Many literatures based on the alternative target types have claimed that central banks cannot perfectly control the inflation rate, for which they need to adopt other kinds of target type in order to facilitate the public's monitoring and preserve some degree of policy credibility. However, these literatures can be categorized by the type of inflation target; range target type and point target with tolerance band target type. On one hand, the range target literatures state that the central bankers have had priority to react to the inflation when it becomes a problem but they have concentrated on the short-run economic solution: opportunistic approach, when it is under control (Orphanides & Wieland, 2000). With this approach, they want to achieve the target with the least cost in terms of incremental output reduction (Orphanides & Wilcox, 2002). A group of literates supporting this view has assumed central bank's preference as quadratic preferences but it is non-smooth preferences or zone-quadratic. On the other hand, the literatures on point target with tolerance band assume that government interfere in the monetary policy by assigning the output target to central bank (Walsh, 1995b) or by pressurizing the central bank to pursue an excessively expansionary policy[4] (Mishkin & Westelius, 2008). Such political interference disrupts economy by creating persistence inflation without any gain in output. In addition to alleviate inflation bias problem, the provision of institutional

[4] Pressuring central banks to peruse excessively expansionary policy is to divert their attention from pursuit price stability (Westelius, 2008) or increase their attention to pursuit economic stability (Mishkin & Westelius, 2008).

arrangement has been set up to limit the expansion of monetary policy. Specifically, the point target level is announced by the central banks. In addition, the explicit tolerance interval (such as midpoint $\pm$ 1 percentage point) is also specified with a commitment to keep the inflation within the interval. At times, the point target could even be missed by the central bank but they do not lose the credibility as long as inflation rate remains still within the band.

Moreover, the difference between inflation range target and inflation tolerance band except fix level of inflation at the edge, is the midpoint. The range target can also help central banks to limit expansion of monetary as band target. The reason for announcing their point target with such tolerance band can be explained by the study from Walsh (1995) and Walsh (2002). The study had illustrated the situation in which central banks have substantial private information on the inflation forecast which cannot be revealed to the public, for which it is concealed from the public. For instance, there might have been difficulties to communicate their judgments about economic condition (which was derived from other economic models and became the input for the policy committee's core model). On the other hand, the policy committee might have some relevant information that couldn't have been placed into the public domain to protect their goodwill (Vickers, 1999). Nevertheless, the central banks have their flexibility of exercising their judgment; it is necessary for them to preserve policy credibility by announcing specific inflation target, i.e., the midpoint level. This means central banks have chosen the monetary policy to aim for long-run price stability but they have also allowed some degree of responsibility for fluctuations of economy as long as they do not lose their policy credibility.

1.3. Objective of study

The study is focused on the monetary-policy problem for central banks to pursue long-run price stability. It also focuses on its degree of responsibility concerned with short-run economic stability using discretionary policy while also preserving their credibility of policy. It is not concerned with either discretionary monetary policy or rules. In addition, this type of monetary-policy problem is precise with constraint discretion framework which helps central banks to establish policy credibility, through transparency and accountability, along with flexibility in response to short-run economic fluctuation.

Pervious literatures give some explanations about why the inflation point target with tolerance band is significantly favorite target type for the full-fledge inflation-targeting country. Since the tolerance band provides some degree of flexibility for central banks in response to short-run economic fluctuations, while committing itself to set tolerance of inflation within credible band, it helps them to preserve credibility of the policy. Moreover, this tolerance band can work alongside with the point targets, which provide a yardstick for the public to monitor their performance.

Thus, this study aim to illustrate set of explanation about how central banks determine the credible tolerance band of inflation and how the tolerance band target type works under inflation targeting strategy. For concreteness, three examples of

strand models for transmission mechanism will be used for each objective of the study, including;

First, the optimal monetary policy with tolerance band target type under "statics model with additive and non-persistent shocks" will be characterized followed by an analysis of how bandwidth responds when the economics factors change.

Second, the optimal monetary policy with tolerance band under "forward-looking model with additive and persistent shocks" will be characterized. Focusing on the effect of commitment-mechanism incorporated with tolerance band effect upon the effectiveness-of-monetary policy. This will be followed with an analysis on how bandwidth responds to the rate-of-convergence of inflation rate.

Third, the optimal monetary policy with tolerance band under "backward-looking model with additive and multiplicative shocks" will be characterized followed by an analysis of the effect of model uncertainty on effectiveness of inflation targeting monetary policy with tolerance band target type.

Chapter 2 lays out the monetary policy problem under inflation-targeting strategy, namely, to stabilize inflation around the target and stabilize real economy at sensible degree (the weight on stabilizing output gap). The central banks' objective is stated as the maximized quadratic loss function subject to the judgment on economic shock and transmission mechanism. The central banks derive their monetary policy in absence of commitment. In other words, they do not make commitment over the future course of their monetary policy. However, if central banks encounter political interference that pressurizes them to push the output above its natural level, then inflation may rise persistently, i.e., inflation bias. Therefore, society will impose additional constraints into the central banks' objective, namely, central banks can adjust their policy freely within credible limits (any policy that beyond this limits will be rejected by society).

This chapter indicates that when central banks design monetary policy in absence of commitment, political pressure can cause the problem of inflation bias. Nevertheless, adopting inflation tolerance band which is considered to be one of institutional arrangements can alleviate this problem.

It is a known fact that central banks have the ability to build up their own constrain so as to maintain their credibility. Thus, in the following part, the process of determination of tolerance band will be explained with an assumption that the central banks have no incentive to implement excessively contraction or expansion policy.

Chapter 3 turns to the case with forward-looking transmission mechanism. It presents the situation that current price setting depends on expectations of the future. Two simple examples of inflation tolerance constraint have been examined. First, a static constraint which has midpoint look alike the optimality condition in absence of commitment (this is, no history dependent variables). Second, a dynamic constraint which has midpoint resembles optimality condition when central banks credible commitment to fight inflation in the future (so, it has history dependent variables).

Comparing these two examples, it is demonstrated that central banks that adopt point targeting with inflation tolerance band cannot improve the current output/inflation trade-off by committing to fight inflation in the future.

Chapter 4 considers the practical problems including: imperfect information and lags, and model uncertainty. The analysis makes clear why central banks should impose band constraint on intermediate target. The degree of unclear transmission can affect the intermediate target's bandwidth.

Chapter 5 shifts from theory to practice by considering number of propositions on inflation-forecast targeting strategy in aspect of inflation tolerance band target type, this is, the intertemporally consistent properties (Woodford, 2007a) including; dual mandate of the target criterion, sequential of target criterion that corresponds to a sequence of optimality conditions, and robust principle of optimal policy

Chapter 2
Optimal Inflation Tolerance Band

In the previous chapter, the literature illustrate that tolerance band targeting is preferable. And in practice, Central banks use concept of targeting rule to find optimality conditions that can control inflation and output gap in optimal path. However, Bernanke stated that central bankers often cannot stay in the optimal path.

In theory, the reason why central banks cannot keep optimal path is that the information is not symmetric between banker and public. This chapter will set up a model to give explanation. For simplicity, the model in this chapter is static model which means the model do not have (1) forward or backward-looking expectations and (2) persistence shocks. But the model still has two essential characteristics that can capture the real world which is (1) central banks implement the policy with discretion and have credibility by using one type of inflation contract that has both punishments and rewards in central banker's utility function. It is because of the belief that credibility from implementing policy at present should give policy makers some benefits in both future and present. (2) Central banks apply balance of risks.

This chapter looks forward to use this model to specify tolerance band of inflation both in upper and lower band in situation where central banks use discretion and commit on targeting rule. Moreover, this chapter is expected to explain how tolerance-band targeting works with strategy inflation targeting.

2.1. Introduction

In this study, the policy implementation is interpreted by constraint discretion which is the recent contributions to monetary policy. This monetary policy regime is middle-grounded and based on anchoring inflation expectations over the long-run, however possessing enough flexibility to be responsible towards short-run economic fluctuation. It is assumed that the central banks set the monetary policy by the discretion. Still, the policy credibility has to be taken into account (Bernanke & Mishkin, 1997). As a result, the control mechanism of policy implementation will not to be overly aggressive.

Despite of the fact that the central banks aim to minimize the welfare loss subject to their views of transmission mechanism falls within the scope of determining monetary policy, however it cannot reflect the idea of using tolerance band target. Fortunately, some literatures attempt to explain the use of inflation target type as "band targeting". These literatures employ the idea of "inflation contract" with the situation. Briefly, the inflation contract is an idea of making binding commitment or making institutional adjustment to prevent the inflation bias problem. This study applies the inflation contract ideas. However, it can be assumed that inflation contract is used to preserve the credibility of monetary policy. If the central banks can keep the inflation rate within the band, the central banks will be benefitted.

Besides, the study attempts to point out that the general central banks that cannot function as stated above need to have a control from the society. As a

consequence, in the following chapter, it is determined that the central banks need to take into account the issues and thus establish a management procedure, i.e., procedure of preserve the credibility of monetary policy, within the organization.

2.2. A Simple Framework

The model used in the study is based on Walsh (2002). However, some details have been modified to explain the policy in the present time. Walsh (2002) assumes that central banks have multiple goals of monetary policy, i.e. they have price stabilization goal while they also have real economy stabilization goal. The central banks have higher level of political interference when they tighten policy to stabilizing inflation compare to when they ease policy to avoiding high unemployment (Walsh, 2002). Thus, this assumption made central bank's objective function asymmetric in the real economy stabilization goal. Therefore, the central banks prefer to reach the target in the economic expansion than in the depression. The asymmetry of the central banks' objective function can affect the policy evaluation because this loss function is not related to utility-based welfare function as Rotemberg & Woodford (1997) and woodfoard (2007) pointed that quadratic loss function is the approximation of welfare function[5]. Therefore, the asymmetry characteristics of loss function does not link the society's welfare function.

In this study, the society's welfare has been used as a guide to evaluate the monetary policy and the appropriate policy should receive higher welfare compared to other policies. Thus, it is assumed that the central bank has symmetric monetary policy goals, due to the symmetry of political interfering as,

$$L_t = \frac{1}{2}\left(\pi_t - \pi^S\right)^2 + \frac{1}{2}\lambda\left(x_t - x^S\right)^2 \tag{1.1}$$

Where π_t is inflation rate, x_t is output gap, $\lambda > 0$ is relative weight on output deviation and $\pi^S, x^S > 0$ 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, i.e., goal dependence.

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

$$\pi_t = \pi_t^e + ax_t + e_t \tag{1.2}$$

$$x_t = -b\left(i_t - \pi_{t+1}^e\right) + v_t \tag{1.3}$$

[5] The quadratic loss function is second-order approximation of representative agent's the utility function (Rotemberg & Woodford, 1997; Woodford, 1999c).

Where $a,b>0$ and define $\pi_t^e \equiv \mathrm{E}_t \pi_t$ as the public's inflation expectation based on their current information. e_t and v_t are denoted as the supply and demand shock respectively. Most of the conventional literatures assume their transmission mechanism has characteristics of forward-looking behavior; as a result, current economic conditions relate to the expectation of future policy. Therefore, the credibility of future policy becomes a critical issue. Despite the fact that these features are important to illustrate the role of the credibility on monetary policy, this chapter focuses on the situations where current monetary policy cannot create the credibility in the long-run through the commitment mechanism so, the forward-looking variables are excluded from the model to keep it simple.

It is assumed that the central bank has substantial information and that cannot be revealed to the public, notation: $e_t^f \equiv \mathrm{E}_t^{CB} e_t$ and $v_t^f \equiv \mathrm{E}_t^{CB} v_t$ as the central bank's judgment on the economic shocks.

It is therefore concluded that the political interference made the central bank set the output gap target higher than its natural rate accordingly; they have benefit to run inflation surprise. In order to alleviate this inflation bias problem, the society imposes the tolerance band for the forecast inflation.

2.2.1. The inflation tolerance constraint

Walsh (2002) assumes that the central banks aim to maintain price stability while stabilizing real economy in short-run. The central bank was pressurized by the political agents when they increased interest rate to avoid higher inflation. Instead, political pressure is less compared to when the central bank decrease interest rate to avoid higher unemployment. On account of reducing 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, society should limit their expansionary policy by considering the realized inflation. If the actual inflation rates exceed the prescribed limits, the central banker will be fired from the office.

However, in this study, it is assumed that society should limit the actual inflation neither too high nor too low. If the actual inflation moves beyond the limit, central banker will be penalized. The missed limit situation may happen because the central bank lacks of discipline regarding the monetary policy. For example, in the case that the central banker focuses too much on the price stabilization as a goal, it will lead the inflation to be lower than the limit. In other case when the central bank overacts on the economic stabilization goal, it will lead to the higher inflation rate compared to the limit.

Walsh (1995, 2002) pointed that any dismissal rule need to be contingent on the underlying shock. However, he cited this concept of Taylor, (1985) in which the state-contingent dismissal rules seem similar to target of the nominal income (Taylor, 1985). This idea differs from the recent concept in the monetary policy. In this study, it is assumed that the society determines the tolerance limit by considering the

deviation of inflation from the inflation target as the proportions to the deviation of output gap from the target, i.e. zero, thus

$$\theta_t = F\left(-\beta_0 - \beta_1 x_t \le \pi_t - \pi^S \le \beta_0 - \beta_1 x_t\right) \tag{1.4}$$

Where θ_t is the chance of central banker's reappointment in the next period and $\beta_0, \beta_1 > 0$, represent 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[6]. Previous literatures 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[7] (Flood & Isard, 1989; Lohmann, 1992; Lars E. O. Svensson, 1997a, 2003). In addition, as the central bank put more weight on stabilization goal, they lose ability to establish the reputation and credibility of maintaining price stability. For instance, Mishkin and Westelius (2008) illustrated that central bank benefited to run inflation surprise because they have 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[8].

2.2.2. The optimal nonlinear inflation contract

If central bank sets their 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 their output gap target different from the natural rate. To cite a few examples, powerful labor union try to prevent an employment target to be less than natural level or the lack of 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, the central bank have no reason to set the inflation different from 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 the three possible scenarios[9]. Firstly, if they can commit to a monetary policy rules which alleviate inflationary bias, the

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

[7] As I mention in equation (1.1).

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

[9] See also Kydland and Prescott (1997) and Barro & Gordon, (1983)

society will receive the second-best equilibrium. However, this approach is not flexible enough to stabilize the economy, so it is infeasible to use. Secondly, if the central bank uses their discretion to determine the monetary policy with the natural rate target, $x^S = 0$, the society will receive second-best equilibrium. Finally, if the central bank uses their discretion, but they cannot avoid political pressure to set the targeted higher natural rate, $x^S > 0$, the society will also receive fourth-best equilibrium (Barro & Gordon, 1983; Kydland & Prescott, 1977; Lars E. O. Svensson, 1997b).

Under this circumstance of the study, if it is assumed that the central bank uses their discretion in determination of monetary policy with political interference to expand the economy, it 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 banking reforms. First suggestion, Rogoff (1985) proposed a reform of the central bank by weight-conservative or reducing the weight on stabilization goal (Rogoff, 1985). The weight-conservative approach could mitigate the problem of bias and it offered the third-best equilibrium. Another suggestion was from Walsh (1995). Walsh (1995) proposed the optimal central bank linear contract approach by modifying the central bank's preferences. His 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 seem 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 the model to prevent either too high or too low inflation compared to its target level[10]. 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 they have to balanced-of-risks (Lars E. O. Svensson, 2003), i.e. balance two side of risk of actual inflation moving outside its boundaries. Thus,

$$0 = \omega\left(1 - F\left(\pi_t - \pi^S \le \beta_0 - \beta_1 x_t\right)\right) - (1-\omega) F\left(\pi_t - \pi^S \le -\beta_0 - \beta_1 x_t\right) \qquad (1.5)$$

On the right hand side of the equation, the first and second terms in the blanked is upside risks and downside risks respectively. Where $0 < \omega < 1$ define 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 which depends on the society' judgment about how much deviation of actual inflation should

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

reject. Mishkin and Westelius (2008) built the similar restriction but they did not take into account that the central bank needs to balance her risks. Therefore, they failed to determine the optimal bandwidth.

2.2.3. The central bank's decision problem

In this study, it is assumed that the simple transmission mechanism thus, monetary policy affect 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.

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, $\mathrm{E}_t^{CB}(L_t) - \rho\bar{U}\theta_t$ where $\rho > 0$ is the time preference and $\bar{U}$ is the utility he will get if he stay at the office in next period, thus

$$W_t = V - c\left(\mathrm{E}_t^{CB}(L_t) - \rho\bar{U}\theta_t\right) \tag{1.6}$$

where $c > 0$ is parameter that coverts central banker's performance into unit comparable with the central banker private benefit. Central bank maximize (1.6) subject to (1.1), (1.2), (1.4), and (1.5), so

$$x_t^P = \frac{1}{\lambda + a^2}\left(a\pi^S + \lambda x^S + \rho\bar{U}\frac{\partial\theta_t}{\partial x_t^P} - a\pi_t^e - ae_t^f\right) \tag{1.7}$$

and

$$\pi_t^P = \frac{\lambda}{\lambda + a^2}\pi_t^e + \frac{a^2}{\lambda + a^2}\left(\pi^S + \frac{\lambda x^S}{a} + \frac{\rho\bar{U}}{a}\frac{\partial\theta_t}{\partial x_t^P} - e_t^f\right) + e_t^f \tag{1.8}$$

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

$$\pi_t^e = \pi^S + \frac{\lambda x^S}{a} + \mathrm{E}_t\frac{\rho\bar{U}}{a}\frac{\partial\theta_t}{\partial x_t^P}. \tag{1.9}$$

Under this circumstance, if central banks use their discretion and also consider in reappointment in the future, they choose the interest rate, i_t^{rd}, as

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

If the central banks conduct an independent monetary policy, without political pressure, they can stabilize the real economy at the natural level and seriously focus on establishing the reputation of inflation fighter by commitment 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 they apply the commitment to the optimal rules, $i_t^{rd} = i_t^c$. Thus,

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

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

From the model presented above, there exists an implicit assumption that the central bank has its preference to stimulate the economy, which represents from its target of $x^S > 0$ and the implementation of a discretionary policy, which is the central bank is free to re-optimize their 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 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

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

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[11]. This means that an established institutional design mechanism leads to

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

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 contraction monetary policies, together with discretionary incentive to generate inflation surprise, contribute to a reduction in central bank's credibility. In order to mitigate such problem, a social reform to the central bank by creating an acceptable restrictive band on inflation deviation would warrant that the central bank has no incentive in generating inflation surprise.

2.2.4 The optimal tolerance inflation band

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

$$x_t = x_t^P - \left(v_t^f - v_t\right).$$

Therefore, the actual inflation equals

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

If central bank wants the inflation deviation bounded by $\beta_0 - \beta_1 x_t$, they will need their unanticipated shock to be smaller than their controlled transmission. Inflation bias is denoted as

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

therefore

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

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

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

In this case, if the central banker anticipated the shocks to be smaller than it was, the central banker will be fired, where $\underline{s}_t \equiv -\beta_0 + \pi^S - \pi_t^e - \left(\beta_1 + a\right)x_t^P + \beta_1 x^S - e_t^f$ is

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$\left(\rho\bar{U}/a\right)\left(\partial\theta_t/\partial x_t^P\right)$ by $-\lambda x^S/a$ in equation (1.7).

the lower bound of inflation bias. Since, the society imposes this boundary to limit 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 that negative shocks are smaller than the actual, they will retrain even if they tighten the policy excessively.

From the central bank's perspective, determining the scope of inflation deviation is similar to that of unanticipated shock. While the latter is a residual from monetary policy, since the central bank has no ability to perfectly control inflation and output gap. To be more specific, determining the bound for unanticipated shock can be adjusted by the policy within the proper range. By being able to do so, it allows the central bank to implement a monetary policy, bringing balance in both stabilizing price as well as providing scope for central bank to employ their discretion when shocks occur. According to inflation deviation bound from the equation, a centre of inflation deviation equals to $-\beta_0 x_t$, while bandwidth equals to β_0. This show that the inflation deviation is controlled under the bound, $-\beta_0 - \beta_1 x_t \le \pi_t - \pi^S \le \beta_0 - \beta_1 x_t$. From the central bank perspective, it is also considered as a bound determination of unanticipated shock under the following condition by having a centre 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, the political pressure can be mitigated with the ability of reforming a monetary policy by preventing it to pass through excessive policy implementation. Such monetary policy is brought about to have flexibility in dealing with economic shock by providing room for the central bank to maintain both economic stability and their credibility. The reason is that the appropriate bound of unanticipated shock must be under the following condition $\mathrm{E}_t\left(\partial\theta_t / \partial x_t^P\right) = \partial\theta_t / \partial x_t^P = -\lambda x^S / \rho\bar{U}$ only if

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

If the governments want to stimulate economy, they would pressure the central bank to set positive output target[12], $x^S > 0$. When 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, $\bar{U} > 0$. 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 strongly boost up the economy rather than shrinking it down. Because a rejected region around the right tail is relatively lower than that around the left tail.

[12] From the constrained discretion viewpoint, the Monetary Policy Committee (MPC) is the agent of government. This implies that government has to take into account the reactions of the MPC when setting fiscal policy, but that the MPC simply aims to hit the inflation target, given the government's fiscal stance ((McVittie & Kim Swales, 2007))

Besides, when central bank has no interference from government to set the output level differing from 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 promote the economy expansion and economic contraction monetary policy.

However, when the government would like to slow down the economy by allowing an unemployment rate be higher than a natural rate, i.e. pressuring central bank to set the negative output target, $x^S < 0$, $f(\bar{s}_t) < f(\underline{s}_t)$ by $\bar{s}_t$ will be distant from mode to the right side comparing to $\underline{s}_t$. In this case, it is evident that the opportunities to pursue the monetary policy that boosts up the economy are more than to pursue the ones that slowers it down.

In other words, when central banker is willing to accept the control by society, it means that he/she admits to stay within the scope of policy implementation by the society. The control that prevents expansionary monetary policy implementation will get more severe when the political pressure gets more intended and vice versa.

The reformation 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. Broadly speaking, if the central bank determines the chance of reappointment to be too high or too low, they will lack 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, even if the chance of reappointment is appropriate or not[13]. Whether or not, the optimal chance-of-reappointment and the optimal benefit-of-reappointment exist, if the central banker's private benefits does not represent their performance, they 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 hence relates to the private benefit. There are three distinct stages that are discussed to illustrate the process of determination of these three parts in this model.

In the first stage, the chance of reappointment is determined by gathering all restrictions about the probability to reappointment in the next period, i.e. the conditions (1.5)

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

and

[13] See also equation (1.6).

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

Since, the society had forced central bank to choose their 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 $-a e_t^f/\left(\lambda+a^2\right)$. Moreover, this boundary will be independent of the central bank's judgments[14], therefore the coefficient of cost push shock judgment will be zero, or

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

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

$$\theta_t=\frac{F\left(\beta_0\right)-\omega}{1-\omega} \tag{1.10}$$

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

$$f\left(\beta_0\right)=\frac{\left(1-\omega\right)a\lambda x^S}{\left(\lambda+a^2\right)\rho\bar{U}} \tag{1.11}$$

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

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

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

$$\bar{U}=\frac{V}{1-\frac{\rho}{c}\left(\frac{F\left(\beta_0\right)-\omega}{1-\omega}\right)} \tag{1.12}$$

[14] Central banks have no need to specify their judgment to the public.

where $F(\beta_0) < c(1-\omega)/\rho + \omega$. In the third stage, the central banker's private benefit is determined. The private benefit depends on the characteristics of distribution function. Thus, the distribution function is assumed 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 (1.11) into (1.12) we get the condition that tells about β_0, as

$$f(\beta_0) = \frac{(1-\omega)a\lambda x^S}{(\lambda + a^2)\rho V}\left(1 - \frac{\rho}{c}\left(\frac{F(\beta_0) - \omega}{1-\omega}\right)\right) \tag{1.13}$$

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 is given as:

$$V \geq \frac{(1-\omega)a\lambda x^S}{(\lambda + a^2)\rho f(0)}\left(1 - \frac{\rho}{2c}\left(\frac{1-2\omega}{1-\omega}\right)\right) = \frac{(1-\omega)a\lambda x^S \sigma\sqrt{2\Pi}}{(\lambda + a^2)\rho}\left(1 - \frac{\rho}{2c}\left(\frac{1-2\omega}{1-\omega}\right)\right) \tag{1.14}$$

where $1/2 < c(1-\omega)/\rho + \omega$. Condition (1.13) and (1.14) provides insight upon the widening of tolerance band and the incentive of central bank in a steady-state respectively. Furthermore, ω is greater than $1/2$ means the density function is asymmetric, i.e. variance of upside risks is greater than that of downside risks.

To conclude this section, it is assumed that the central bank has the quadratic loss function, so our model does not lose its generality to compare 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, two sides of the inflation boundaries can be determined, one for preventing the upward bias and the other for preventing the downward bias. Moreover, central bank can exercise their judgment to balance the risks, thus the probability of upward bias and downward bias are not exactly equal. For example, the most likely outcome (mode) always stays within the band even if the central bank is more concerned about one side of the risks than the other.

2.3. The Tolerance Band Mechanism

In this part, a comparative static analysis will be done to understand how inflation contract responds to a change in the nature of central bank's decision problem. In the base case I, the variables of interest are expressed as; 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, $\sigma = 1$, the accountability cost is unity, the central bank's judgment about inflation risks,

$\omega = 0.75$, and all effect of output gap expansion/contraction can pass through to inflation, $a = 1$. The concern is to identify on how these factors affect the band mechanism in two parts; private benefit, and the widening of band. Thus, these parameters are altered case by case to see how they affect the private benefit and the size of bandwidth.

2.3.1 The Central Banker's Private Benefit

Under this institutional arrangement, a private benefit will create an incentive for a central banker to regulate discipline in implementing the monetary policy. It means that an action to control an inflation deviation needs to be within the scope stated by the society. Thus, if there are any changes in the implementation's conditions that will weaken the discipline, then the central bank has an incentive to create inflation deviation larger than the society's acceptable range. In order to solve this problem, there is an increasingly need of adjusting the private benefit. As a result, it will once again incentivize the central bankers to be disciplined in implementing the monetary policy.

Furthermore, the central banker's monetary discipline depends upon the factors that have an impact on making monetary policy decision. These factors can be divided into 4 groups; First, the responsive factors of political interference, such as a relative weight on short-run economic stability, λ, and assigned output target, x^S. Second, transmission mechanism related factors, namely, slope of Phillip curve, a, and inflation forecast error, σ,. The slope of Philip curve describes the effect of output expansion on inflation while the inflation forecast error describes other causes of inflation. Third, policy prudential factors including; the weight on upside/downside risks, ω, and time preference, ρ. Finally, the accountability cost, c, indicating degree of strictness in policy discipline.

In figure 2.1, it is shown that the higher relative weight on short-run economic stability can cause private benefit to increase. Normally, greater the relative weight on economic stabilization, so is the greater inflation deviation of inflation from its target. Since central banks loosen their attention in price stability goal, they react less when inflation rate misses the target. In order to restore central banks' policy discipline, the gain from establishing inflation-fighter reputation must increase (panel (a)). The private benefit response to the slackened attention in price stabilization is in the same manner as private benefit response to the increase of output target. Under discretion policy, higher positive output gap target leads to an increase in central banks' intent in creating inflation bias. Policy discipline can therefore be restored if the central bankers can achieve private benefit (from inflation-fighter reputation) to compensate their motivation in creating inflation bias (panel (b)).

Figure 2.1 Private benefit: stabilization weight and goals

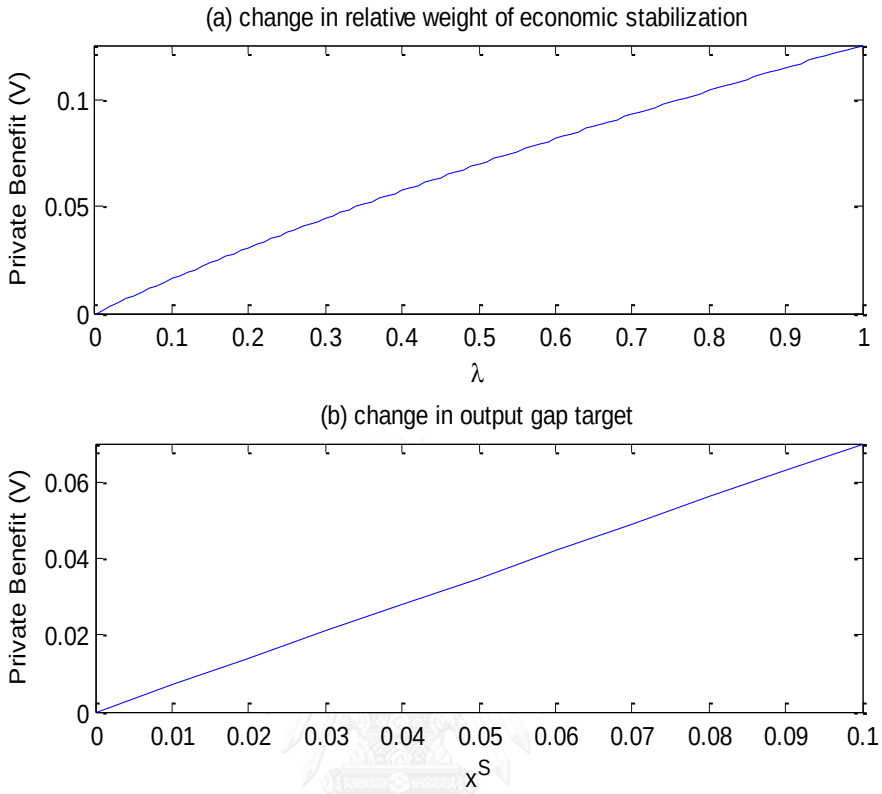


Figure 2.2 turns towards the transmission mechanism related factors including; the slope of Philip curve and inflation forecast error. The slope of Phillip curve represents rate of output gap pass through the inflation, as the central banks set $\beta_1 = \lambda/a$ in order to avoid specifying their judgment about the shocks. Thus, an increase in the pass through rate, a, for any given λ that is greater than a, then a change in output gap by one unit can cause inflation deviation to change by greater than one unit. Therefore, private benefit will increase to offset this incentive (panel (c)).

On the other hand, an increase in (additive) uncertainty in this transmission mechanism can cause the difficulty for central banks to control inflation tolerance. The private benefit must increase in order to increase central banks acceptability to confront with higher level of uncertainty (panel (d)).

Figure 2.2 Private benefit: effect of transmission and forecast error

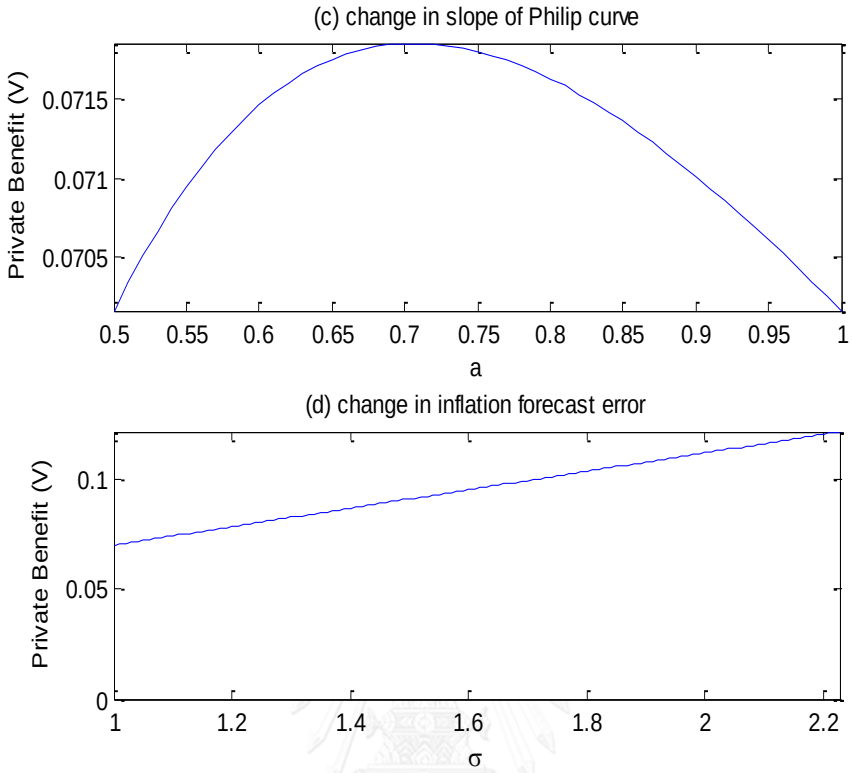
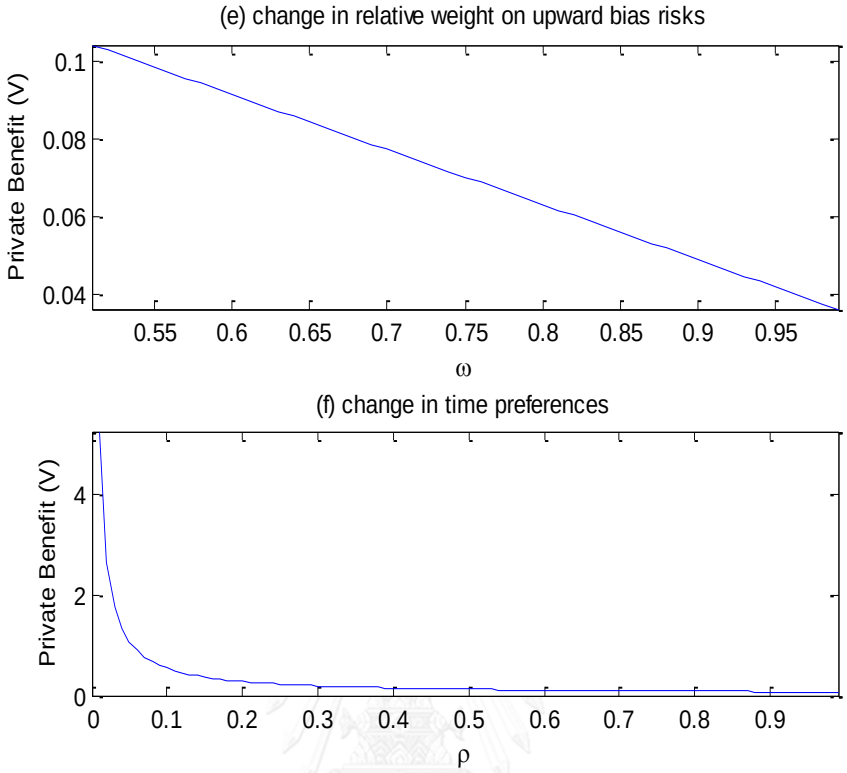


Figure 2.3, the increase in the policy prudential factors means that central banks are more concerned about their causes of monetary policy in the future. Supposing that if the society's weight on upside risk increases (society trend to reject excessively expansion policy than excessively contraction policy), then central banks have to reduce the effectiveness of monetary policy to expand the output over its potential level. If the increase in this variable can alleviate the inflation bias problem, there is not any requirement to increase private benefit either (panel (e)).

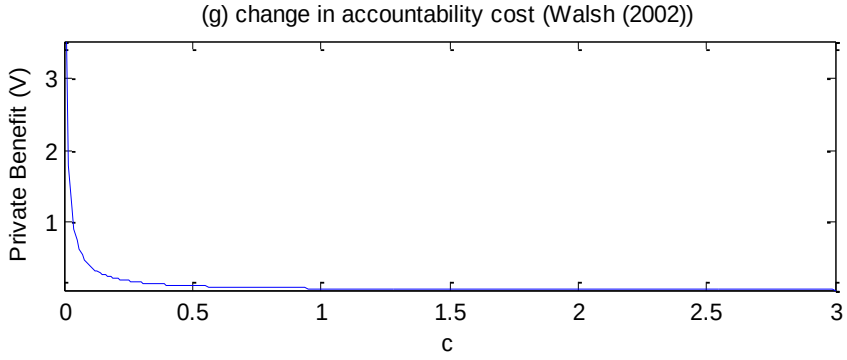
Moreover, when central banks lack foresight, they do not really concern about the future cause of the policy. Instead, they will adjust their policy in response to the current economic fluctuations. Therefore, increasing the private benefit will establish an incentive to preserve the policy credibility (panel (f)).

Figure 2.3 Private benefit: balance-of-risk and time preference



In figure 2.4, Accountability cost indicates degree of strictness in policy discipline. Thus, an increase in this costs alleviates the principle-agent problem. Such policy will hence be conducted by the central bank (the principle) that is more related to a society (the agent) (panel (g))

Figure 2.4 Private benefit: accountability cost



From this topic, we have learnt that the private benefit is a mechanism which supports the central banks' intension in stabilizing prices and distracts its interest in maintaining the economy in short run. Therefore, the private benefit would be

beneficial to the central banks in the long run, if discipline is regulated in implementing the monetary policy that is focused on the long run price stabilization. To be more specific, if a situation encourages the central bank to implement the expansion policy, the private benefit is increasing in order to distract the central banks to rather maintain the price stabilization. On the other hand, if the situation is more likely to force the central banks to stabilize the prices, the benefit in the long run would be less. Therefore, it can be predicted that the private benefit do not provide any supporting mechanism for the central banks to ultimately stabilize prices until they neglect the short run economic stabilization.

Apart from the mechanism that supports the central banks' interest in balancing policy implementations in stabilizing both prices and economy simultaneously in the long run, there is a mechanism that mandatorily controls the central banks' policy implementations in the short run. This is particularly to determine the scope for an inflation tolerance, which will be mentioned in the following part.

2.3.2 The widening of band

This part will explain the response of bandwidth to the changes in various economic factors that form database to make the monetary policy. It is noted that, the results that are shown in these figures have a marginal effect of adjusting output gap towards the monetary policy as the vertical axis. The first part is the benefit in maintaining the credibility towards monetary policy which is shown by a chance of an inflation to be in the committed band to public (Ψ_t). The second part is the cost to expand the output which is presented in the figure as the cause of creating inflation bias ($(\lambda/a)x^S$). When these two parts are settled off, the curve would intersect with the horizontal axis, representing the optimal bandwidth (β_0) or the proper scope for the central banks to manage the economic fluctuation without losing their credibility in implementing monetary policy.

Presenting the results determines the appropriate size of bandwidth accounting for 6.5 percentage shown by a point from where a thick line crosses over. Any changes will affect the bandwidth to change to the point where a dashed line intersects with the horizontal axis. It is important to note that, this study has found that the bandwidth does not respond to the changes of all economic situations that differ from the private benefit. In other words, only determining the bandwidth is not sufficient for the central banks to create the balance for policy implementation. Some economic changes require private benefit to be fixed.

Figure 2.5 shows the effect of changes in responsive factors of political interference on the size of the bandwidth. According to panel (a), it is found that when a relative weight of economic stabilization is increased from 0.5 to 0.9, the bandwidth would expand from 6.5 percentage point to 7 percentage point because of $\beta_1 = \lambda/a$. The increase of the relative weight on economic stabilization will have an impact on midpoint of the band to shift upward. When the size of the bandwidth does not change, it will make an unanticipated shock fluctuation increase. This means that the central banks gain more interests towards expansion policy, which will result in an

increase in the midpoint of inflation tolerance. The rise in turbulence of unanticipated shock is affected by an increase in upside risk. Additionally, when the turbulence increases, the central banks will no longer preserve the commitment towards the same bandwidth. Eventually, the bandwidth will rise.

According to panel (b), an increase in output gap target from 0.1 to 0.2 is responded by a decrease of the bandwidth. The increase of output gap target results in an increase in squeeze inflation tolerance band because an increase of marginal cost in creating inflation bias will be replaced by a marginal benefit caused by preserving the monetary policy credibility. Therefore, both verges of tolerance band will be shrinking towards the mode. In addition, the increase in output gap target will not affect any decisions under discretion policy. However, it will have an impact on the central banks in a way that the central banks have to be more accurate on controlling the inflation rate to be in the band.

Figure 2.5 Bandwidth: stabilization weight and goal

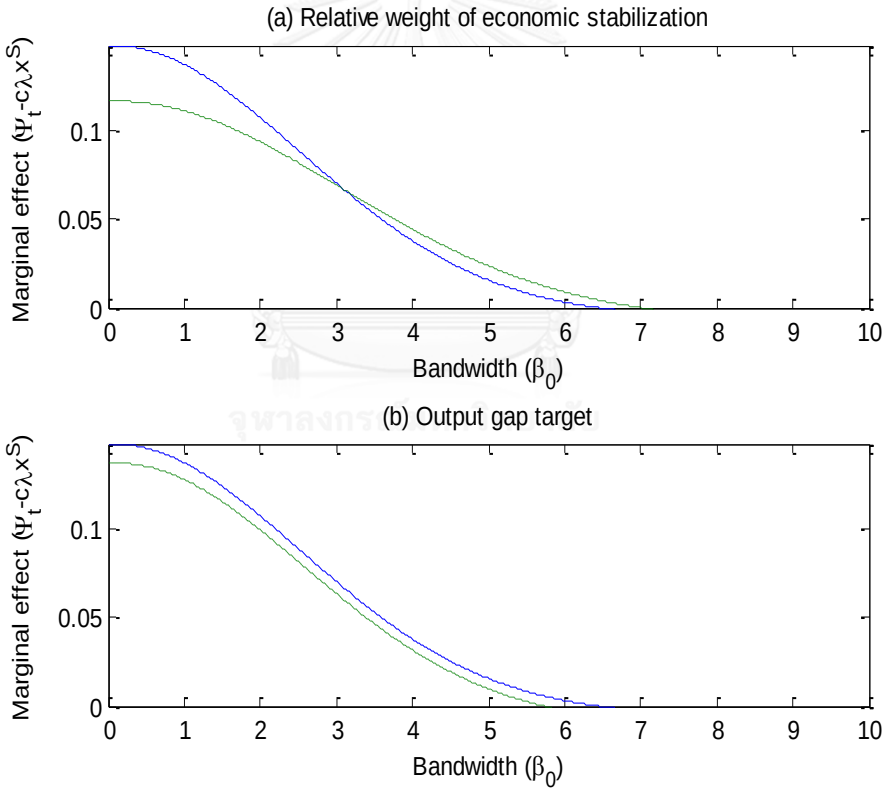


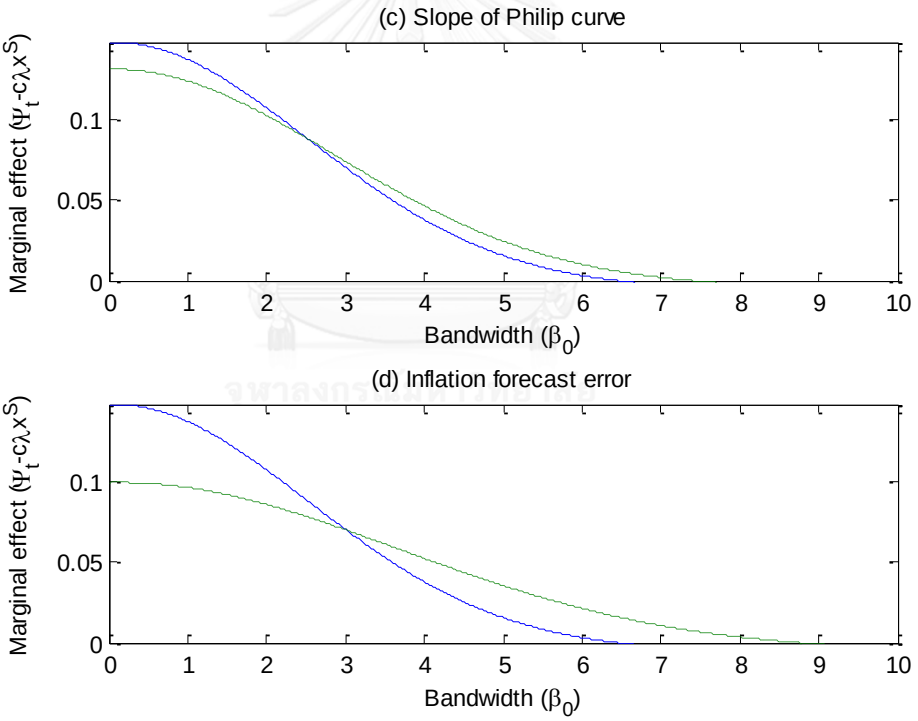
Figure 2.6 above shows that when slope of Philip curve increases from 1 to 5, it will result in a decrease of midpoint of inflation tolerance band. Meanwhile, it will result in an increase of unanticipated variance. The changes further affect the change in bandwidth to be more expanding. Also, they point out the more severe effect on a variance of unanticipated shock comparing to the effect from the changes at the midpoint. As a result, it can be concluded that in this case, the increase in a transmission of the monetary policy brings about the more efficient monetary policy

implementation to economic situation. However, if economic disruptions use the same channel to create the fluctuation in the economy, it would be harder to preserve the accurate inflation (panel (c)).

Furthermore, the panel (d) also confirms the fact that the role of changing unanticipated shock volatility is important to alter the size of bandwidth. (According to the picture, given the standard deviation of unanticipated shock increased by 1.2 times) Apart from that, it can be concluded that controlling the inflation within the band might not be able to change the variance of optimal inflation. Conversely, the change in variance of optimal inflation will affect the change of bandwidth.

Additionally, figure 2.7 shows that when the monetary policy has an immediate impact on economy, together with the decision that is period-by-period. However, the private benefit represents the long-run policy credibility, thus time preference will have effects on bandwidth (panel (f)).

Figure 2.6 Bandwidth: transmission and mechanism



Moreover, it can be seen that the factors that are not related to maintaining the balance between the marginal cost caused by an attempt to push the economic expansion out of its potential level and the marginal benefit resulted from preserving credibility of monetary policy, would not be affected by any changes of bandwidth.

In figure 2.7, when the central banks try to balance their upside risk and downside risk, they will be interested in protecting the risk of only one side. So, the

central banks have to withdraw their concern on the risk from each of these sides at the same time but maintain the constant size of bandwidth (panel (e)).

Similarly, figure 2.8 establishes that an accountability cost has no impacts on bandwidth since from the viewpoint of central banks, stabilizing the economy and preserving the credibility of monetary policy are equally important. In other words, when the interest biased towards either the responsibility on economic fluctuation or the stabilization in prices without long run issues is important, the change in accountability cost will not affect the change in bandwidth.

Figure 2.7 Bandwidth: balanced-of-risk and time preferences

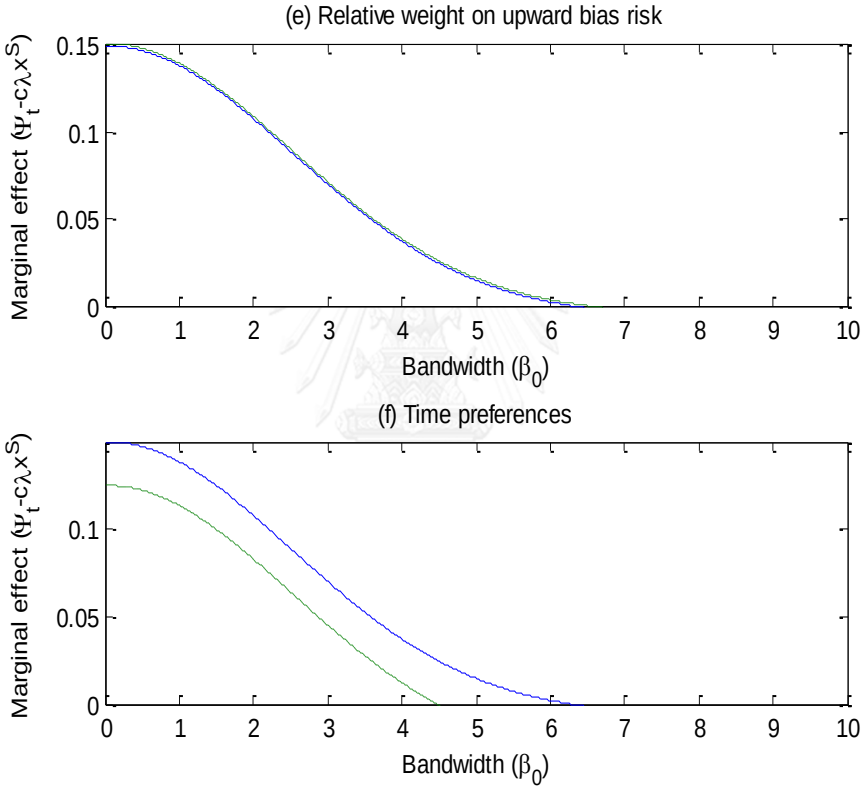
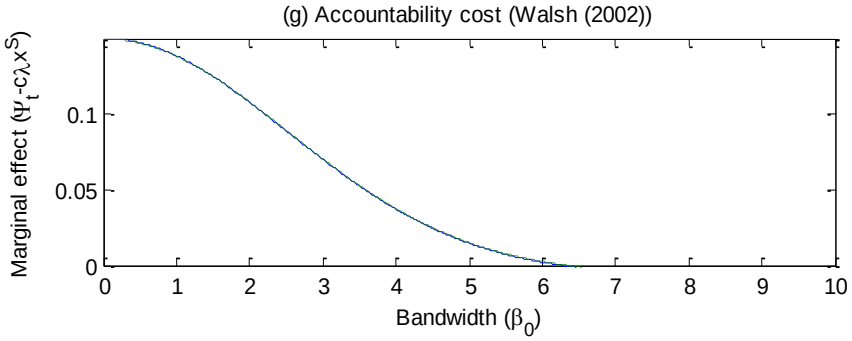


Figure 2.8 Bandwidth: accountability cost



2.4. Conclusion

In this study, an attempt has been made to determine the optimal tolerance band of inflation. A model has been developed from Walsh (2002) while it is assumed that the central bank has quadratic loss function and commits to the general targeting rule. Because the inflation band targeting is a sub class of inflation contract, this method modifies central bank's preference by imposing the nonlinear constraint. The certainty equivalent condition is no longer applied here. Central bank thus needs to be concerned about the whole distribution function in order to balance their risks. The balanced-of-risks condition is taken into consideration with an assumption regarding which side of risks should the central bank needs to prioritize (based on society's judgment).

It has also been found that central bank can determine the optimal tolerance band as long as they are concerned about the balanced-of-risks. The band can mitigate the inflation bias problem. More specifically, if the central bank is forced to set the output target to exceed the natural rate, on one hand, it can lead to an inflation bias. While, on the other hand, society gets to control a policy implementation by covering the inflation deviation under its scope. However, this would only be helpful in alleviating the problem, but not the ultimate solution to completely solve the inflation bias. In other words, it cannot wipe out a political interference by doing so. Therefore, in the case where there is political interference, using a band targeting will provide the society with more welfare than using point target. Moreover, it is a way to make a compromise with the government rather than a means of using other institutional arrangements such as conservative weight and linear inflation contract. Therefore, there is a high possibility for band targeting to be chosen.

The results present that there are two mechanisms that can help the central banks to balance the policy implementation. Firstly, it is to create the motivation to keep a balance between both the economy and the price level by depending on the adjustment of a private benefit. Secondly, it is to determine the bandwidth so as to force the central banks to keep the inflation within the announced band. However, this mechanism cannot always respond to the change of issues in making the policy. In some cases, the bandwidth will not respond to the economic changes. Besides, any changes that have an impact on the fluctuation of unanticipated shock will have an obvious effect on the changes in bandwidth.

Chapter 3
Optimal Dynamic Inflation Tolerance Band

Public's expectations play an important role in the real world. Many central bankers from different countries often try to gain good reputation to control expectations. It simply means they believe that their series of actions in each period will impact their capacities to make a policy in the future.

This chapter develops the model to be a dynamic model, which applies forward-looking expectations and persistence shocks. To be more specific, a policy implemented in this period has impact on a current economy and that in next period as well, and likewise, so do the shocks. A belief behind the model is that central bankers' performance impacts public expectations in the next period. This chapter tries to imply this idea to the model, and then see what happens next.

This chapter studies a tolerance band targeting in two different assumptions: first is that the tolerance band aims to erase a bias in an economy but cannot control public expectations and static tolerance constraints. Second is that the tolerance band aims to erase a bias in an economy and also control public expectations. To be more specific, the model has history dependent variables in an equation, or also known as dynamic tolerance constraints.

This chapter aims to give an idea about the functioning of the model of tolerance band with respect to its expectations and persistence shocks. However, in practical, it is acknowledged that the tolerance band that aims to control public expectations in this chapter does not exist, but this chapter aims to prove in theoretical mathematic model.

3.1. Introduction

In this chapter, the study assigns the central banks to adopt an inflation target type as the point with tolerance band. Also, it is determined that the transmission of the monetary policy is forward-looking meaning that the present economic situation depends on the factors, which determine the current situation and the forecast for future economic situation. Normally, under this mechanism, the central banks have two choices to make a policy- a discretion policy or a rule policy. To be more specific, in determining the discretion policy, the central banks also have choices to control inflation tolerance within the band that are static inflation tolerance constraint and dynamic inflation tolerance constraint. The static inflation tolerance constraint is to preserve an inflation tolerance in accordance with current output gap. It is likely that the central banks implement the discretion policy. The dynamic inflation tolerance constraint is to make the central banks to preserve an inflation tolerance in accordance with an output gap, which seems like the central banks conduct the rule policy.

The previous studies have found that theoretically, implementing the rule policy together with the point target is the most efficient way. Nonetheless, no central bank is able to function in this way. This study also confirms the similar fact that no central

banks can announce the inflation tolerance band target and implement rule policy simultaneously. Besides, doing so would severely affect the social welfare and the resource distribution efficiency.

3.2. Forward-looking Model

In this chapter, central banks' monetary-policy problem has been explained in term of nonlinear quadratic dynamic optimization, but the main difference is the policy transmission such as forward-looking transmission. Under the forward-looking transmission, the current inflation depends on both current and future economic conditions. Thus, an inflation and output gap not only depend on a current policy but also upon the expected future of policy (Clarida et al., 1999). The transmission mechanism is based on Clarida et al. (1999), or

$$\pi_t = ax_t + \rho \mathrm{E}_t \pi_{t+1} + e_t \tag{3.1}$$

$$x_t = -b\left(i_t - \mathrm{E}_t \pi_{t+1}\right) + \mathrm{E}_t x_{t+1} + v_t . \tag{3.2}$$

In the previous chapter, economic disturbances, i.e., cost push shock, e_t, and demand shock, v_t, have instantaneously effect on the economy, so they disappear at the end of period. However, in this chapter, when the economic disturbances are realized at the beginning of period, they do not disappear in the end of period, but slowly decay into the future. Therefore, the economic disturbances are serially correlated with their previous conditions, while they are independent of each other, or

$$e_t = \phi_e e_{t-1} + \varepsilon_t \tag{3.3}$$

$$v_t = \phi_v v_{t-1} + \xi_t \tag{3.4}$$

Where $0 \le \phi_e, \phi_v \le 1$ and both ε_t and ξ_t are i.i.d. random variables with zero mean (in the viewpoint of the public and external observers) and variances σ_ε^2 and σ_ξ^2 respectively. Within this kind of environment, the credibility of future policy intentions becomes a critical factor for determining inflation tolerance band.

In general, the dynamic behavior of economic model can cause problem in central bank's decision to change from a single-stage decision problem to multi-stages decision problem. Therefore, in this case, central banker's objective function is represented as the series of the discounted net benefit from staying in office (instead of a single period net benefit as we have seen in the chapter 2). It is assumed that central bankers have formal and informal private benefit in return for their preserving policy credibility. Preserving policy credibility means maintaining inflation tolerance within the band, as

$$U_t = V + \rho\theta_t U_{t+1} = V + \rho\theta_t V + \rho^2\theta_{t+1}\theta_t V + \cdots \tag{3.5}$$

Private benefit is denoted as $V>0$, ρ is a time-preference, and $\prod_{i=0}^{k}\theta_{t+i}$ for $k>0$ is a chance for maintaining inflation tolerance inside the band from period t to period $t+k$. It is important to note that $\pi_t-\pi^S$ is the inflation tolerance from a target level, i.e., π^S is the target level of inflation, and $\underline{T}^*,\overline{T}^*$ are an upper and lower bound of inflation tolerance respectively. The chance of preserving policy credibility in period t is

$$\theta_t = F\left(\pi_t-\pi^S\le\overline{T}^*\right)-F\left(\pi_t-\pi^S\le\underline{T}^*\right). \tag{3.6}$$

where $F(\square)$ is a cumulative density function. This assumption implies that central bankers prefer to establish good reputations of strict in monetary policy discipline. However, the central bankers are also concerned about their performance appraisal, i.e., the intertemporal discounted welfare loss, as much as their own benefit; therefore, their net benefit is their own benefit net of the performance appraisal, or

$$W_t=\left\{1+\rho\theta_t+\rho^2\theta_{t+1}\theta_t+\cdots\right\}V-c\,\mathrm{E}_t^{CB}\sum_{i=0}^{\infty}\left(c\rho\right)^i L_{t+i} \tag{3.7}$$

where W_t is the net benefit. Parameter $c>0$ is an accountability cost, i.e., convert the welfare loss to central banker's benefit. Furthermore, as mentioned in chapter I that the optimal policy is guided by the maximum welfare level, thus the loss function is quadratics, or

$$L_t=\frac{1}{2}\left(\left(\pi_t-\pi^S\right)^2+\lambda\left(x_t-x^S\right)^2\right) \tag{3.8}$$

where $\lambda>0$ is a relative weight on economic stabilization, and $\pi^S>0$ is a socially desirable inflation target, whereas the output target, $x^S>0$, is greater than the potential output because the political intervene to force central banks creates inflation surprise. Nevertheless, the private benefit has a role to alleviate this problem.

The monetary-policy problem for the central banks is to maximize (3.7) subject to period loss function, (3.8), inflation's law of motion, (3.1), and to limit the inflation surprise by constraining the inflation tolerance. Since inflation tolerance constraint described in (3.6) is nonlinear constrained with two boundaries. As a result, this setting needs additional information about how they balance the risk caused by excessively implementing contraction policy or expansion policy. Balancing the risk of excessive policy means balancing a chance-of-rejection in too high or too low inflation tolerance level reject region of extreme value of inflation tolerance. The balance-of-risk condition[15] is assumed as:

[15] In addition, the balance-of-risk condition relate to significant level of policy credibility. The balance-of-risk condition tell us about how central banks trade-off the rejection region between each side of probability

$$0=\omega\left(1-F\left(\pi_t-\pi^S\le\bar{T}^*\right)\right)-(1-\omega)F\left(\pi_t-\pi^S\le\underline{T}^*\right), \tag{3.9}$$

Where $\omega\in[0,1]$ depends on central banks' judgment in rejecting an excessive monetary policy. According to (3.9), it is implicitly assumed that central banks have the knowledge about the density of economic shocks. This assumption has an implication for implementing monetary policy for alleviating the political interference. For central bankers, who are aware about the density of economic shocks and are tempted to alleviate the political interference (which forces them to create inflation surprise), intenseness degree of rejecting the excessive expansion policy is by far greater than intenseness degree of rejecting the excessive contraction policy. For example, when the density is symmetric and $x^S>0$, the central banker who is not tempted to implement the excessive expansion policy might judge $\omega>0.5$. Thus, central banker has comparatively a higher rate of rejection in expansion policy than in contraction policy. Besides, equation (3.6) and (3.9) can be concluded as

$$\theta_t=\frac{F\left(\bar{T}^*\right)-\omega}{1-\omega}. \tag{3.10}$$

It is also assumed that central banks design their monetary policy by discretion, so they exclude the forward-looking variables and aim to balance inflation forecast, π_t^P, and output gap forecast, x_t^P, as

$$\pi_t^P-\pi^S=-\frac{\lambda}{a}\left(x_t^P-x^S\right)+\frac{1}{ca}\Psi_t. \tag{3.11}$$

Controlling tolerance inflation within the band can preserve credibility of policy in a way that marginal effect of output gap on policy credibility, Ψ_t, offsets the cause of inflation bias, i.e., $(\lambda/a)x^S$. Therefore, the optimal discretion monetary policy with scoping inflation tolerance inside the band should set bandwidth as

$$\frac{1}{ca}\Psi_t=-\frac{\lambda}{a}x^S. \tag{3.12}$$

Where the incremental cost of output expansion on the policy credibility, Ψ_t, depends on tolerance inflation constraint[16]. Moreover, under the condition (3.12), the inflation forecast and output gap forecast equals to

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density's tails but the significant level is sum of rejection regions, or

$$1-\theta_t\equiv 1-F\left(\pi_t-\pi^S\le\bar{T}^*\right)+F\left(\pi_t-\pi^S\le\underline{T}^*\right).$$

[16] The optimality condition of monetary-policy problem depends on how central banks design their policy, i.e., rule or discretion, and inflation tolerance constraint. If the central banks design the policy by discretion and have inflation tolerance constraint with statics character, i.e., at the midpoint of the band, inflation tolerances

$$\pi_t^P = \frac{a^2}{\lambda(1-\rho)+a^2}\pi^S + \frac{\lambda}{\lambda(1-\rho\phi_\varepsilon)+a^2}\varepsilon_t^f , \tag{3.13}$$

$$x_t^P = \frac{a(1-\rho)}{\lambda(1-\rho)+a^2}\pi^S - \frac{a}{\lambda(1-\rho\phi_\varepsilon)+a^2}\varepsilon_t^f . \tag{3.14}$$

It should be noted that ε_t^f is central banks' judgment about cost-push shock. In equation (3.13), the inflation forecast will converge to the point that is lower than π^S, if the central banks do have any judgment on shocks. To sum up, central banks design the monetary policy by discretion and constraint inflation tolerance inside the band in order to preserve the credibility of their policy. In other words, the optimal inflation tolerance band should be set in a way that the marginal effect of output gap on policy credibility (Ψ_t/c) offsets the cause of inflation bias ($-\lambda x^S/a$).

The next section will examine the procedure of determining optimal inflation tolerance band with a simple static inflation tolerance band, i.e., the inflation tolerance band, which has the midpoint and resembles the targeting rule under discretionary policy.

3.3. A simple static inflation tolerance constraint

This example of static tolerance inflation constraint looks alike targeting rule from discretionary policy that incorporates a forward-looking model, or

$$\pi_t - \pi^S = -\beta_1 x_t \pm \beta_0 \text{ ,where } \beta_0, \beta_1 > 0 . \tag{3.15}$$

In this example, central banks design policy by discretion, while controlling the inflation tolerance, $\pi_t - \pi^S$, in line with output gap, $-\beta_1 x_t$, but not mechanically, i.e., the inflation tolerance can depart from $-\beta_1 x_t$ while the size of departure is limits within β_0. Since central banks design their policy by discretion, if they commit to scope the inflation tolerance inside the static tolerance constraint, the best level of welfare that a society can get is the level as that in the second-best equilibrium (Kydland & Prescott, 1977). In addition, this kind of band cannot affect the target variables' speed-of-adjustment (Clarida et al., 1999), but it might affect the long-run

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depend on the current economic conditions only, then the multi-stages decision problem in (3.7) can reduce to the single-stages decision problem, as in chapter 1. In addition, if inflation tolerance constraint has dynamic character, then adjusting current output gap can affect the policy credibility form now on, or

$$\Psi_t \equiv \frac{\partial}{\partial x_t^P}\left\{1 + \rho\theta_t + \rho^2\theta_t\theta_{t+1} + \cdots\right\}V$$

.

Fortunately, in this setting I can simplify monetary-policy problem from the multi-stages decision problem to the single-stage decision problem by apply the stationary condition. I mention this topic later.

level of target variable, i.e., the level towards which the target variables will converge. To be more specific, balancing inflation tolerance in line with output gap affects the convergent path of inflation and output gap. Therefore, if we apply the inflation tolerance constraint,(3.15), with inflation motion, (3.1), it would turn out to be the output gap band,

$$x_t = -\frac{\alpha}{1-\alpha\rho\beta_1\phi_\varepsilon}e_t + \frac{\alpha(1-\rho)}{1-\alpha\rho\beta_1}\left(\pi^S \pm \beta_0\right), \tag{3.16}$$

and the inflation rate band,

$$\pi_t = \frac{\alpha\beta_1}{1-\alpha\rho\beta_1\phi_\varepsilon}e_t + \frac{1-\alpha\beta_1}{1-\alpha\rho\beta_1}\left(\pi^S \pm \beta_0\right), \tag{3.17}$$

Where $\alpha \equiv 1/\beta_1 + a$. Equation (3.16) and (3.17) are described as the midpoint and band of inflation and output gap. Equation (3.17) describes the stationary solution of the midpoint inflation rate and each side of edge. It is important to note that these stationary solutions may or may not equal to the stationary solution of inflation that the central banks implement (it depends on how central banks choose the parameters, this is, β_1, β_2, of the band). From the viewpoint of outside observers, who do not have any additional information about economic shock, the long-run inflation rate will converge inside $\left[\pi^S - \beta_0, \pi^S + \beta_0\right]$ because $\mathrm{E}_t e_t = 0$ and $1-\alpha\beta_1/1-\alpha\rho\beta_1$ is less than one. On the other hand, from the viewpoint of central banks, the long-run inflation rate may or may not converge inside $\left[\pi^S - \beta_0, \pi^S + \beta_0\right]$, it depends on the extent of their judgment on economics shock. Furthermore, the movement of these target variables' band can describe by

$$x_t = \phi_\varepsilon x_{t-1} - \frac{\alpha}{1-\alpha\rho\beta_1\phi_\varepsilon}\varepsilon_t + \frac{\alpha(1-\rho)(1-\phi_\varepsilon)}{1-\alpha\rho\beta_1}\left(\pi^S \pm \beta_0\right), \tag{3.18}$$

$$\pi_t = \phi_e \pi_{t-1} + \frac{\alpha\beta_1}{1-\alpha\rho\beta_1\phi_\varepsilon}\varepsilon_t + \frac{(1-\alpha\beta_1)(1-\phi_\varepsilon)}{1-\alpha\rho\beta_1}\left(\pi^S \pm \beta_0\right). \tag{3.19}$$

On one hand, according to (3.19), it indicates that the rate-of-convergent for output gap and inflation rate are equal to ϕ_ε that are independent of the tolerance constraint parameters, β_0, β_1. On the other hand, equation (3.17) tells that the rate-of-convergent can affect the inflation rate's band when central banks have some judgments on economic shocks. For example, when inflation rate can quickly move back to band (it has high rate-of-convergent), the minor cost push shocks may cause inflation rate to shift outside the band[17].

[17] The higher rate-of-convergent is the greater sensitiveness of the inflation rate from cost push shocks (see the coefficient in the first term in the right-hand-side of equation (3.17)).

Central banks operate their monetary policy by adjusting instrument variables, e.g., repo rate or short-term rate, in order to control the output gap and inflation rate. If they can improve the precision in controlling output gap, it means that they can improve the precision in controlling inflation rate as well. In other words, keeping inflation rate inside the band is to control inflation tolerance within acceptable limits. It should also be noted that the static inflation tolerance constraint incorporated with the inflation motion (the new Keynesian Philip curve) causes the policy constraint the output gap as (3.16). Thus, controlling inflation tolerance inside the band implies limiting the unanticipated shocks of (3.16) within an acceptable band. Equation (3.16) can be rewritten in terms of unanticipated shocks and central banks' judgment on shocks, or

$$s_t^d = -\frac{1-\alpha\rho\beta_1}{\alpha(1-\rho)}x_t^P - \frac{1-\alpha\rho\beta_1}{(1-\rho)(1-\alpha\rho\beta_1\phi_\varepsilon)}\varepsilon_t^f + \pi^S \pm \beta_0 \tag{3.20}$$

where

$$s_t^d \equiv \frac{1-\alpha\rho\beta_1}{\alpha(1-\rho)}(\xi_t - \xi_t^f) + \frac{(1-\alpha\rho\beta_1)}{(1-\rho)(1-\alpha\rho\beta_1\phi_\varepsilon)}(\varepsilon_t - \varepsilon_t^f)$$

And planned output gap is denoted as x_t^P, $\varepsilon_t - \varepsilon_t^f$ and $\xi_t - \xi_t^f$ is unanticipated cost-push shock and unanticipated demand shock respectively. Note that equation (3.20) indicates a higher planned output gap in current period (x_t^P) that causes a decrease in the chance of preserving policy credibility (θ_t)[18]. Moreover, the boundaries in this equation depend on current economic conditions only, so the function in (3.5) can be simplified by $U_t = V + c\rho\theta_t\bar{U}$ where $\bar{U} \equiv U_{t+1}/c$, so

$$\Psi_t \equiv -c\rho\frac{f(\bar{S}^d)}{1-\omega}\bar{U}\frac{1-\alpha\rho\beta_1}{\alpha(1-\rho)}.$$

In addition, the boundaries can be determined as constant values when we apply x_t^P from (3.14) and set β_1 as

$$\beta_1 = \frac{\lambda}{a}. \tag{3.21}$$

This equation has an implication about efficiency of monetary policy because setting $\beta_1 = \lambda/a$ implies that the central banks try trade-off inflation and output gap as in targeting rule under discretionary policy. However, they adjust the inflation rate and output gap in response to their judgment on shock, thus they cannot strictly adjust

[18] $\partial\theta_t/\partial x_t^P = -\left(f(\bar{S}^d) - f(\underline{S}^d)\right)$ where $\bar{S}^d, \underline{S}^d$ is upper and lower bound of the unanticipated shocks when central banks apply a simple static inflation tolerance constraint.

the inflation rate and output gap level in line with the targeting rule. Therefore, society can achieve the welfare as in the second-best equilibrium when the inflation tolerance is at the midpoint level.

Controlling the unanticipated shocks within acceptable limits is to determine the value of β_0 in a way that the marginal effect of output gap on policy credibility can offset the cause of inflation bias[19] (as in (3.12)) or

$$f(\beta_0) = \frac{a(1-\rho)(1-\omega)\lambda x^S}{\rho\left(\lambda(1-\rho)+a^2\right)V}\left(1-\frac{\rho}{c}\left(\frac{F(\beta_0)-\omega}{1-\omega}\right)\right), \tag{3.22}$$

where

$$V \geq \frac{a(1-\rho)(1-\omega)\lambda x^S \sigma_s^d \sqrt{2\Pi}}{\rho\left(\lambda(1-\rho)+a^2\right)}\left(1-\frac{\rho}{2c}\left(\frac{1-2\omega}{1-\omega}\right)\right). \tag{3.23}$$

Besides, under a circumstance that a is low but ρ is high, e.g., large proportion of firms cannot adjust its price and economic agents are foresighted, the bandwidth may be smaller than the committed level.

To conclude this example of a simple static inflation tolerance band, central banks may control the level of inflation tolerance inside the band, which is narrower than announced band if price is rigid and economic agents are foresighted. Moreover, the static inflation tolerance band cannot affect the target variables' rate-of-convergent however the vice versa is not true. The higher the rate-of-convergent is, the higher would be the sensitiveness of inflation on economic shocks. Thus, it is possible that minor shock can cause inflation rate go outside the band. However, this kind of band has advantage in implementing an efficient monetary policy because the trade-off between inflation tolerance and output gap at the midpoint of the band resembles the targeting rule under discretionary policy (which is based on the marginal principle (Lars E.O. Svensson, 2010), i.e., the marginal rate of transformation equals to the marginal rate of substitution). Thus, the best level of welfare that society can achieve is not more than the welfare level in second-best equilibrium.

3.4. A simple static tolerance band mechanism

In this chapter, the transmission mechanism is assumed as forward-looking transmission, which implies the current economic conditions depend on future cause of policy. Nevertheless, central banks design monetary policy on their current information and future expectation are taken from future economic conditions such as discretion policy. As a result, the private benefit will strongly adjust to compensate any cause of incentive to implement the indiscipline policy. In addition, central banks

[19] See also chapter 2.

in this circumstance will control the inflation tolerance within the bandwidth that are larger than the bandwidth in static transmission mechanism (as seen in chapter 2).

3.4.1. Private Benefit

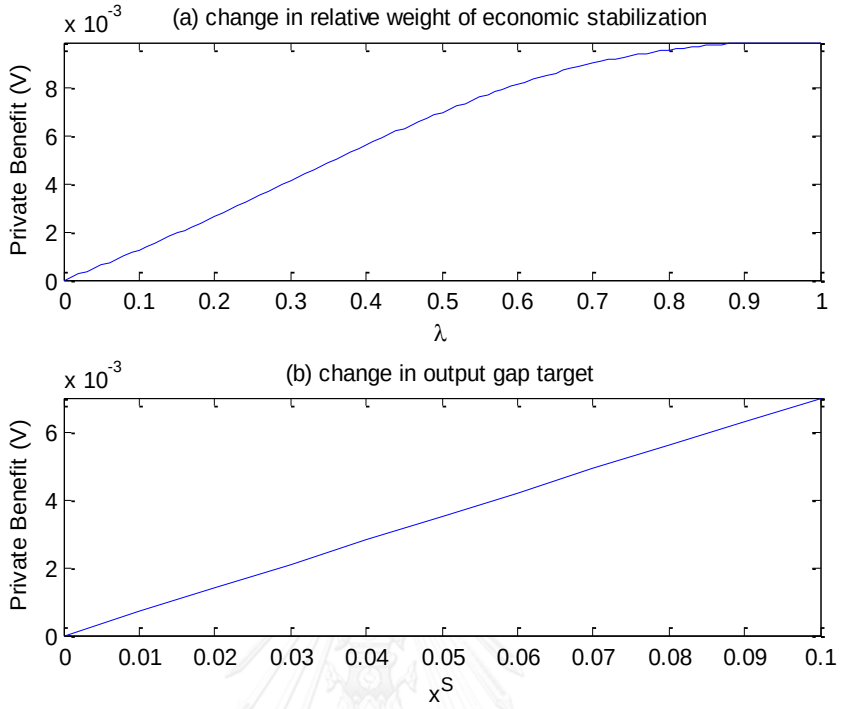
Figure 3.1 indicates how private benefit reacts with the responsive factors of political interference. Generally, private benefit increases with the increase of these factors. However, the responsibility of private benefit in the forward-looking mechanism is stronger than the static mechanism (see in panel (a) and (b)). Once, the additional inflation deviation is created, this deviation will persist into the future. This is because any economic conditions in the future can affect not only current expectation but also the current economic conditions. Hence, if the forward-looking feedback enlarges the effect of inflation deviation on policy credibility, then the private benefit must response immediately in order to restores the policy disciplinary. For example, if the relative weight on economic stabilization goal increases, central banks will set the gap between inflation and its target (along the convergent path) higher and also increase the cause of inflation bias[20]. The first effect is the possibility that inflation will converge outside the band ((3.17)) for any given $\beta_1 = \lambda/a$. In other words, increasing the possibility of inflation to join outside the band means an increase in the risk of unanticipated shock. The greater the uncertainty they confront, the greater private benefit is compensated. The second effect of an increase in relative weight on economic stabilization is an increase in cause of inflation bias. As a result, this increases the private benefit in order to offset these motivations (panel (a)). However, increasing in output gap target can affect only the cause of inflation bias, $\lambda x^S/a$, which can be compensated by an increase of private benefit (panel (b)).

[20] According to the optimal policy under discretion, central banks aim to set the inflation gap and output gap as

$$\pi_t - \pi^S = -(\lambda/a)x_t + (\lambda/a)x^S,$$

thus the first term on the right-hand-side indicates how central banks set the inflation gap in response of economic shock and the second term indicate the cause of inflation bias. When the relative weight on economic stabilization goal increase, midpoint of the band will shift up and cause of inflation bias will be higher.

Figure 3.1 Private benefit under static constraint: stabilization weight and goal



The figure 3.2 gives some explanations about the transmission mechanism related factors as follows. Firstly, the rate of output gap pass through to the inflation represent by the slope of Philip curve. Secondly, the inflation forecast error. Under the dynamic mechanism, if the slope of Philip curve, a, is higher than the relative weight of economic stabilization goal, λ, central banks will reduce the inflation tolerance. Moreover, increasing the rate of pass through can help inflation to be less sensitive with economic shock[21]. Therefore, private benefit will increase to offset this incentive (panel (c)). However, when the uncertainty of transmission mechanism (the additive uncertainty) increases, it causes the difficulty for central banks to control inflation tolerance. To increase central banks acceptability to confront with higher level of uncertainty, then private benefit must increase too (panel (d)).

[21] According to the stationary of inflation,

$$\pi_t = \frac{a^2}{\lambda(1-\rho)+a^2}\pi^S + \frac{\lambda}{\lambda(1-\rho\phi_\varepsilon)+a^2}e_t,$$

The higher pass through rate is the lesser sensitivity of inflation on shock, i.e., the lower of coefficient on shock.

Figure 3.2 Private benefit under static constraint: transmission mechanism and forecast error

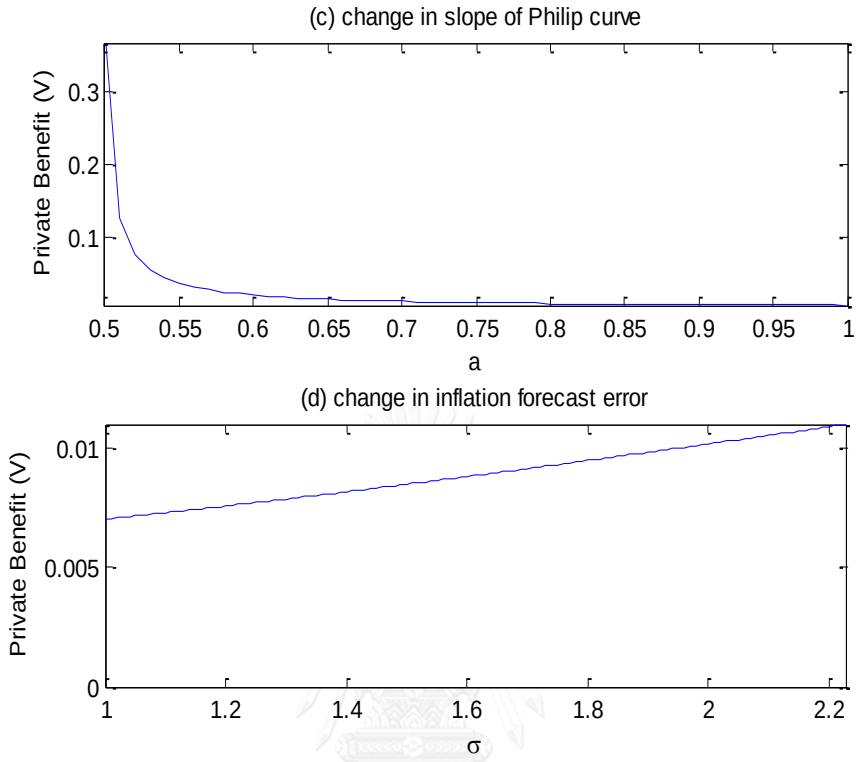
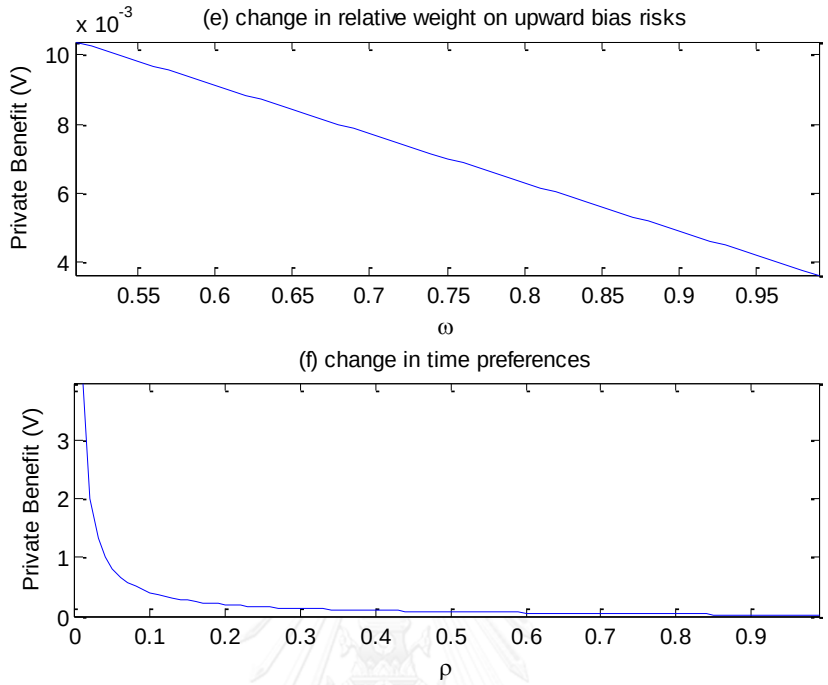


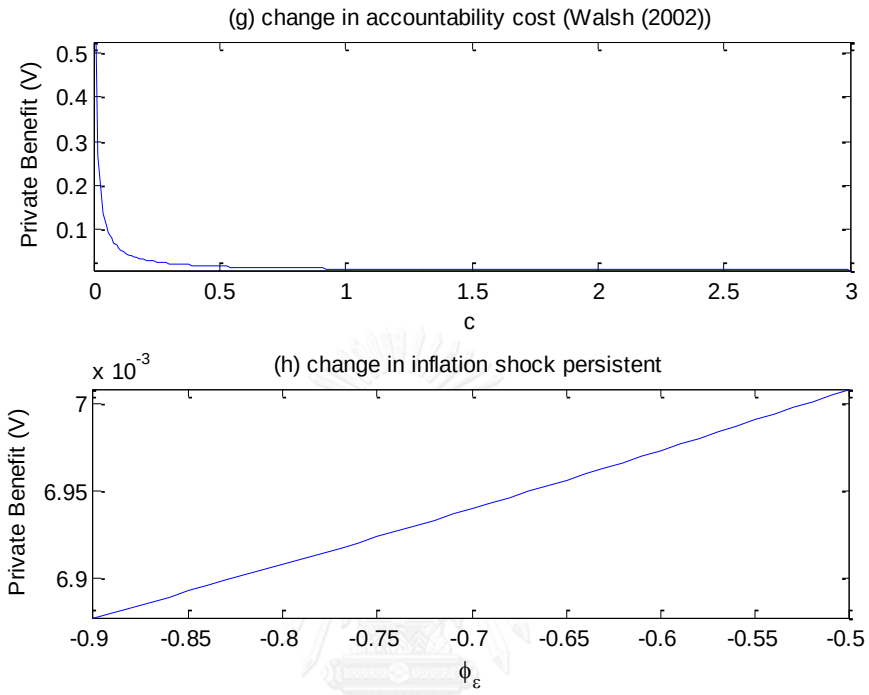
Figure 3.3, shows the increasing policy prudential factors including the society's weight on upside risk and the level of foresight. It means that central banks are more concerned about their cause of monetary policy in the future. Therefore, central banks will focus more on price stability goal when these factors increases. The private benefit should decrease in order to balancing central banks' attention on economic stability goal and price stability goal (panel (e) and panel (f)).

Figure 3.3 Private benefit under static constraint: balance-of-risk and time preference



In figure 3.4, the accountability cost indicates a degree of strictness in policy discipline. This shows an increasing the accountability costs will induce central banks to put more attention into their long-run policy performance (panel (g)). In addition to this, this model assumes that the effect of shock can persist into the future, at the rate of ϕ_{ε} in each period. Increasing the persistent of shock can lead to the increase inflation's rate-of-convergent and sensitivity of monetary policy on shock. However, this model assumes that the central banks concern in the long-run economic performance, i.e. they try to control long-run inflation tolerance within the credible band. Thus, central banks focuses on the sensitivity of their policy on shock rather than the speed of inflation adjustment towards its target. When the economic shocks take longer period to disappear, then the private benefit will increase in order to put more central attention on preserving price stability (panel (h)).

Figure 3.4 Private benefit under static constraint: accountability cost and inflation shock persistent



In conclusion to this, the private benefit response to all factors of monetary policy-related in a way that they restore incentive of central banks to preserve policy credibility in long-run. This is the confirmation that the reward and penalty mechanism has an important role on creating the reasonable degree-of-flexibility of monetary policy under this dynamic policy environment.

3.4.2 The widening of band

In this section, it will show how the bandwidth responds to the changes in various economic factors. The results, which are shown in these figures, have a net marginal effect, i.e., the benefit in maintaining the credibility of adjusting output gap net of the cause of creating inflation bias, as the vertical axis and the horizontal represents the size of bandwidth (β_0). In addition, the cut-off point between the curve and horizontal axis indicates the optimal size of bandwidth. Moreover, the base case has the optimal bandwidth at 12 percentage point (the cut-off point between the solid line and horizontal axis). Note that under the dynamic mechanism, central banks try to control long-run inflation inside the committed band. There are many factors that are related to a character of convergent, and few other factors that lessens the effect of one economic factor.

Figure 3.5 shows the effect of changes in responsive factors of political interference on the size of the bandwidth. In panel (a), it is found that when a relative

weight on economic stabilization increases from 0.5 to 1.5 (3 times larger), the bandwidth will expand 12 percentage point to 20 percentage point (about 60 percent larger). The increase of the relative weight on economic stabilization will impact on midpoint of the band to shift upward intensely in short-run but in the long-run the intensity of this effect is depends on time preference variable. The lack of foresight economic agents will have a higher impact due to the weight of economic stabilization on bandwidth. Moreover, increasing the weight on economic stabilization can increase the volatility of unanticipated shock and which increases the bandwidth.

According to panel (b), the increase of output gap target from 0.1 to 0.2 cannot cause any change in the size of bandwidth. Its effect on bandwidth is reduced by other factors that relate to the stationary condition. In other words, changing the output target in the static model can cause central banks to change the bandwidth in order to increase the marginal effect of policy credibility to offset this cause of inflation bias immediately. However, the dynamic behavior of stationary inflation rate can cause the inflation rate convert to a limit that narrows the committed band. Thus, it has the buffers for the cause of inflation bias increase.

Figure 3.5 Bandwidth under static constraint: stabilization weight and goal

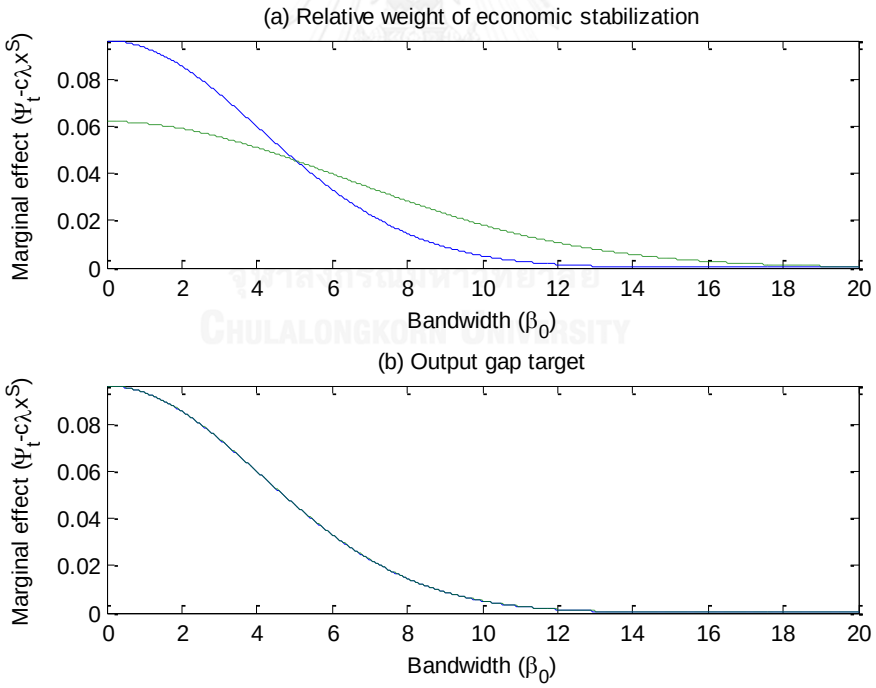


Figure 3.6 shows the fact of changing unanticipated shock volatility which is important to alter the size of bandwidth (as in previous chapter). Panel (c) and (d) indicates the change of the effect on pass through rate (the slope of Philip curve) and the change of unanticipated shocks' volatility on the size of bandwidth respectively. However, the effect of change in Philip curve's slope is not as strong as static model

(this case slope of Philip curve increases from 0.1 to 0.3which is 3 times larger and can cause bandwidth increase only 60 percent larger).

Figure 3.6 Bandwidth under static constraint: transmission mechanism and forecast error

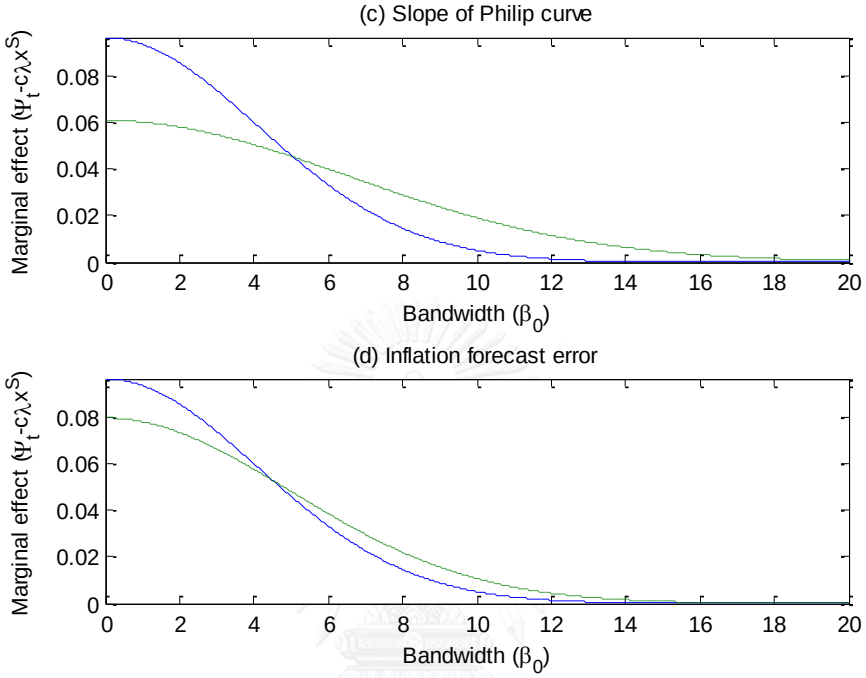
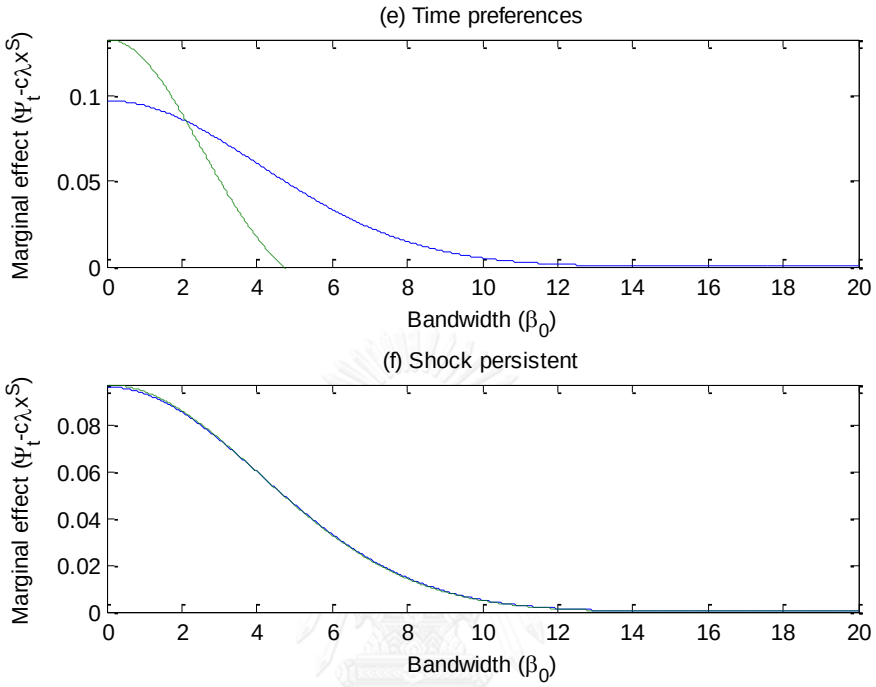


Figure 3.7 shows that when the economic agent lacks the future forecasting character it will have an impact on the size of bandwidth. When the time preference variable decrease, it reduces the impact of forward-looking, which will then the concern the central banks about the short-run policy-credibility. As a consequence, monetary policy relates to the economic shocks. In order to preserve the policy credibility, central banks need to commit on narrower band (panel (e)).

Furthermore, this model assumes the central banks concern in the long-run economic performance and the persistent of shock does not have the key role on long-run inflation rate. Therefore, changing the shock persistent rate cannot cause significant change in the size of bandwidth (panel (f)).

Figure 3.7 Bandwidth under static constraint: accountability cost and inflation shock persistent



3.5. A simple dynamic tolerance inflation constraint

In the previous section the central banks constraint inflation tolerance by a simple static tolerance band was assumed. This kind of constraint has a midpoint, which resembles the targeting rule form discretion policy. However, there is another framework in designing the monetary policy, which is the rule. This framework assumes that central banks commits to achieve the inflation target level at all cost. The usefulness of commitment is the ability to control expectation, e.g., central banks apply this framework for a long time until their actions become the focal point of public's expectations formation of future economic conditions. The fact targeting monetary policy literatures conclude that if central banks adopt the point target and price-setting depends on expectations of future economic conditions, i.e., forward-looking transmission mechanism, then the central bank that can credibly commit to a rule faces an improved short-run trade-off between inflation and output gap (Clarida et al., 1999). In this section the circumstances that central banks adjust the monetary policy by discretion but also commits to constraint their policy with inflation tolerance band is examined. However, in this section, the midpoint of this inflation tolerance constraint resembles optimality condition of the rules.

This example differs from a simple statics tolerance inflation constraint because central banks controls the tolerance inflation in line with output gap growth, $-\beta_1(x_t - x_{t-1})$, rather than output gap level, $-\beta_1 x_t$, or

$$\pi_t - \pi^S = -\beta_1(x_t - x_{t-1}) \pm \beta_0, \text{ where } \beta_0, \beta_1 > 0. \tag{3.24}$$

Moreover, the dynamics inflation tolerance constraint can affects the rate of convergence of targeted variables, as

$$x_t = \frac{\alpha'\phi_\varepsilon}{(1-\alpha'\phi_\varepsilon\beta_1\delta)(\delta-\phi_\varepsilon)}e_t + \frac{\alpha'(1-\rho)}{(1-\alpha'\beta_1\delta)(1-\delta)}(\pi^S \pm \beta_0), \tag{3.25}$$

$$\pi_t = -\frac{\alpha'\phi_\varepsilon\beta_1}{(1-\alpha'\phi_\varepsilon\beta_1\delta)(\delta-\phi_\varepsilon)}(e_t - e_{t-1}) + (\pi^S \pm \beta_0) \tag{3.26}$$

where $\alpha' \equiv 1/a + (1+\rho)\beta_1$. These equations describe the midpoint and band of target variables. For example, the motion in (3.26) indicates that inflation rate has bandwidth β_0 and midpoint at π^S. But, if cost-push shock disrupts economy, the midpoint of inflation and the edge of band may as well response to the shock (we can see this feature in the first-term on the right-hand-side of (3.26)). Note that as for stationary solutions of target variables require $\delta \equiv (0,1)$ where

$$\delta \equiv \frac{1}{2} - \frac{1}{2}\sqrt{1 - \frac{4}{\alpha'\beta_1}}.$$

In this example, the tolerance constraint parameter, β_1, relates to stationary conditions, so determining tolerance band can affect rate-of-convergent of the target variables. Moreover, the higher β_1 is the higher response of inflation tolerance, $\pi_t - \pi^S$, on economic growth, $x_t - x_{t-1}$, i.e., the larger change in output gap level is the more intense adjust inflation tolerance, can cause a decrease in rate-of-convergent of the target variables. In addition, the rate-of-convergent in this example can obviously be seen in the movement of inflation, as

$$\pi_t = \delta\pi_{t-1} + \frac{\alpha'\beta_1}{1-\alpha'\phi_\varepsilon\beta_1\delta}(e_t - e_{t-1}) + (1-\delta)(\pi^S \pm \beta_0). \tag{3.27}$$

This equation explains three components of effect that determine the inflation rate at the midpoint and at each side on the edge of band. The first component is the feedback of inflation from last period, which leaves the effect δ in this period. In addition to this, the second component is the effect of economic disturbance. The last component is the exogenous effect. In this case, it is the midpoint level (the target level) and inflation rate at the edge of the band ($\pi^S \pm \beta_0$). Once the disturbance

disrupts economy, the inflation rate departs from the midpoint level (target get level) as a size of second component effect. After that, inflation rate will move to the midpoint at the rate of convergent, δ, in each period. The higher β_1, the greater inflation tolerance at the midpoint and the slower rate inflation move back to the midpoint level.

When central banks control the precision of (3.25), then inflation will accurately move inside the band. In order to do this, central banks divide the cause of uncertainty of this equation (an unanticipated shocks) and scope it within credible limits, or

$$\tilde{s}_t = -x_t^P + \frac{\alpha'\phi_\varepsilon}{(1-\alpha'\phi_\varepsilon\beta_1\delta)(\delta-\phi_\varepsilon)}\varepsilon_t^f + \frac{\alpha'(1-\rho)}{(1-\alpha'\beta_1\delta)(1-\delta)}(\pi^S \pm \beta_0), \tag{3.28}$$

where $\tilde{s}_t \equiv \alpha'\phi_\varepsilon/(1-\alpha'\phi_\varepsilon\beta_1\delta)(\delta-\phi_\varepsilon)(\varepsilon_t-\varepsilon_t^f)+(\xi_t-\xi_t^f)$. Adjusting planed output gap has negative effect on the chance of policy credibility because planed output gap in (3.28) negative coefficient. Moreover, central banks set a planed output gap by discretion, itresponses to central banks' judgment (as (3.14)), so

$$\begin{aligned}\tilde{s}_t = &\left(\frac{a}{\lambda(1-\rho\phi_\varepsilon)+a^2} + \frac{\alpha'\phi_\varepsilon}{(1-\alpha'\phi_\varepsilon\beta_1\delta)(\delta-\phi_\varepsilon)}\right)\varepsilon_t^f + \frac{a(1-\rho)}{\lambda(1-\rho)+a^2}\pi^S \\ &+ \frac{\alpha'(1-\rho)}{(1-\alpha'\beta_1\delta)(1-\delta)}(\pi^S \pm \beta_0)\end{aligned} \tag{3.29}$$

Therefore, if central banks do not need to specify their judgment to outside observers, they should set β_1 in the way that makes coefficient of ε_t^f (in (3.29)) become zero. One possible way[22] that lets this situation happen is

[22] The coefficient of anticipated cost push shock in (3.29) can conclude as

$$\frac{a}{\lambda(1-\rho\phi_\varepsilon)+a^2}\left(\frac{\alpha'\phi_\varepsilon(\lambda(1-\rho\phi_\varepsilon)+a^2)}{(1-\alpha'\phi_\varepsilon\beta_1\delta)(\delta-\phi_\varepsilon)a}+1\right)\varepsilon_t^f .$$

Thus, this coefficient become zero when

$$(\phi_\varepsilon-\delta)\left(a^2+\frac{\beta_1}{a}(1-(\phi_\varepsilon\delta-\rho))\right) = \frac{\phi_\varepsilon}{a}(\lambda(1-\rho\phi_\varepsilon)+a^2) .$$

One possible way that make this condition become true is when

$$\frac{\phi_\varepsilon}{a} = \phi_\varepsilon - \delta \quad \text{and} \quad \lambda(1-\rho\phi_\varepsilon) = \frac{\beta_1}{a}(1-(\phi_\varepsilon\delta-\rho)) ,$$

so

$$\beta_1 = \frac{4a}{1-4(1+\rho)+\left(1-2\phi_\varepsilon\left(\frac{a+1}{a}\right)\right)^2} \neq \frac{\lambda}{a}. \tag{3.30}$$

Unfortunately, this condition implies that central banks cannot improve the short-run trade-off between inflation and output gap if they adopt tolerance band target.

$$f\left(\hat{\pi}^S + \hat{\beta}_0\right) = \frac{(1-\omega)\lambda x^S}{\rho V}\left(1-\frac{\rho}{c}\left(\frac{F\left(\hat{\pi}^S+\hat{\beta}_0\right)-\omega}{1-\omega}\right)\right) \tag{3.31}$$

where $\hat{\pi}^S \equiv \left(\frac{a(1-\rho)}{\lambda(1-\rho)+a^2}+\frac{\alpha'(1-\rho)}{(1-\alpha'\beta_1\delta)(1-\delta)}\right)\pi^S$ and $\hat{\beta}_0 \equiv \frac{\alpha'(1-\rho)}{(1-\alpha'\beta_1\delta)(1-\delta)}\beta_0$ but the benefit of preserving policy credibility is the same as (3.23).

In conclusion to this, central banks design the monetary policy by discretion, and commits to preserve the policy credibility by obligating to scope inflation tolerance inside the dynamic constraint. Under this constraint the midpoint inflation rate will convert to the its point target level but the inflation rate that implements by central banks will convert to the point that lower than its target level. Thus, this situation will impact the credibility of central bank in the long-run. Moreover, if central banks choose not to specify their judgment, then they will lose an ability to minimize the loss function. However, if they choose to specify their judgment, then they will lose the flexibility to fight with short-run economic fluctuation.

$\delta = \phi_\varepsilon\left(\frac{a+1}{a}\right)$ and $\beta_1 = a\lambda(1-\rho\phi_\varepsilon)\left(1-\left(\phi_\varepsilon^2\left(\frac{a+1}{a}\right)-\rho\right)\right)^{-1}$.

When substitute these conditions in the definition of δ, then β_1 becomes

$$\beta_1 = \frac{4a}{1-4(1+\rho)+\left(1-2\phi_\varepsilon\left(\frac{a+1}{a}\right)\right)^2}.$$

Moreover, $\beta_1 > 0$ if and only if $\left(\left(1-2\phi_\varepsilon\left(a+1/a\right)\right)^2-3\right)/4$ greater than ρ.

3.6. Conclusion

In this chapter central banks adopt inflation target type as the point with tolerance band, while the policy transmission mechanism is forward-looking, i.e., current economic conditions depend on the expected future causes of monetary policy. From the standpoint of policy designed to enhancing credibility, assumption is made that central banks have choices to control inflation tolerance within the band, which are static inflation tolerance constraint and dynamic inflation tolerance constraint. The static inflation tolerance constraint resembles the targeting rule form discretion policy, but the dynamic inflation tolerance constraint resembles the optimality condition from the rule policy.

This chapter confirms that no central banks can announce the inflation tolerance band target and implement rule policy simultaneously. Besides, doing so would severely affect the social welfare and the resource distribution efficiency.

As a result, it leads to the conclusion that if the central banks announce the inflation tolerance band target, the only possible policy is to determine the discretion policy, which results in the second-best equilibrium for social welfare at best. Moreover, the central banks are more likely to keep inflation rate within the band which is narrower than what is announced. The response of the band to the causes of inflation bias will be vanished, for the pattern of the dynamic of transmission mechanism helps alleviate the issues as well. The private benefit which supports the motivation is crucial to respond to the economic changes. Any changes that affect the fluctuation of unanticipated shock are considered as an important part of bandwidth responses.

Chapter 4
Model Uncertainty

In practice, many central bankers announce not only their inflation target but also the time to reach the target and the midpoint. The announcement of time to reach the target is the evidence that central bankers believe that there is a time lag for policy to impact to economies. Moreover, to implement the policy correctly, central bankers must predict changes that may occur along the time before policy reach the target.

This chapter will try to develop the model to capture that fact that monetary policy, which acts to economy, must take time or also called control lag. Moreover, in practical, central bankers have limit to evaluate how well the transmission of policies affect economies. To be more detailed, when the time changes and the central bankers receive new information, is aimed to find in this chapter. Also how do they take care the information in context of discretion policy with some flexible to fight with fluctuation is answered in this theoretical model. This chapter is expected to answer that tolerance band will have to handle a role of uncertainty in economic model. Therefore, the optimal tolerance band must be able to respond to the changes in information because the model is dynamic, the scope of target variable must relate with changes in model.

4.1. Introduction

In this section, the study aims to add a characteristic of transmission mechanism that the central banks need to face literally. First of all, the transmission of monetary policy takes times to achieve. In addition, the central banks hold an unclear perspective towards how the transmission is. These two characteristics controls the future inflation rate to be in a proper scope necessary. Because of the unclear of transmission mechanism and the imperfection of inflation rate control, the central banks have to use an intermediate target. Therefore, if the central bank can control an intermediate target to be within the proper scope, it would be beneficial to anticipate inflation rate, which eventually be in the most appropriate level to economic situation.

The study determines that the central banks announces a forecast of inflation tolerance band to be used as an intermediate target by expecting the limited scope of an inflation forecast to be within the band which will be able to control the uncertainty affecting the inflation forecast level to be in a proper level in the future.

The result in the theoretical perspective is found that the monetary policy implementation by the central bank affects the fluctuation of anticipated inflation rate. However, due to the imperfection of the data between the central bank and the public, the central bank cannot pursue the policy with the channel.

4.2. Model uncertainty

This section focuses on the long and variables lags problem in monetary policy transmission which incorporate with the uncertainty in this transmission. Thus,

monetary policy does not affect economy immediately but it affects the economy with lag periods. In addition, central banks know all transmission mechanism, i.e., all realizations of the parameters, up to and including period that they set its interest rate instrument, but they do not know their future transmission mechanism. In order to keep this realistic feature inside the model, while simplifying the model simple as possible, It is assumed that the central bank have the transmission mechanism as

$$\pi_{t+1} = a_{\pi}\pi_t + a_{x,t+1}x_t + e_t^f + \tilde{e}_t \tag{3.32}$$

$$x_{t+1} = -b_r\left(i_t - \mathrm{E}_t\,\pi_{t+1}\right) + b_x x_t + v_t^f + \tilde{v}_t\,, \tag{3.33}$$

It is also assumed that the entral bank have additional information about economic shocks but outside observers have not. It is defined that e_t^f and v_t^f as central banks' judgment on cost push and demand shock respectively. Since the central banks do not share their judgment with outside observers, thus $e_t = e_t^f + \tilde{e}_t$ and $v_t = v_t^f + \tilde{v}_t$ where $\tilde{e}_t$ and $\tilde{v}_t$ is unanticipated economic shocks. The shocks have autoregressive process, as

$$e_{t+1} = \phi_{\varepsilon}e_t + \varepsilon_{t+1}\text{, where } \varepsilon_{t+1} = \varepsilon_t^f + \left(\varepsilon_{t+1} - \varepsilon_t^f\right) \text{ and} \tag{3.34}$$

$$v_{t+1} = \phi_v v_t + \xi_{t+1}\text{, where } \xi_{t+1} = \xi_{t+1} + \left(\xi_{t+1} - \xi_{t+1}^f\right), \tag{3.35}$$

Since, the central banks have larger information set than outside observers, they can divide the random part of (3.34) and (3.35) into anticipated part (judgment part) and unanticipated part. According to (3.33), when central banks adjust the interest rates in current period, it can hit the output gap in next period and hit inflation rate for next two periods. Besides, the effects of policy on the output gap pass through to the inflation with uncertainty (as in (3.33)). In other words, central banks are unclear in Philip curve's slope, so

$$a_{x,t+1} = a_x + \eta_{t+1}\,. \tag{3.36}$$

The parameter is assumed to be a random variable with unconditional mean $\mathrm{E}\,a_{t+1} = a_x$, and variances σ_a^2. Moreover, this parameter and the unanticipated shocks are independent of each other.

Monetary-policy problem is to determine one-period-ahead output gap and two-period-ahead inflation rate[23] to minimize society's loss function subject to the inflation law of motion in (3.32). Under this setting, the central banks one-to-two-year inflation is

[23] Because the policy instrument (interest rate) can affect the output gap with a lag of one period, while the output gap take one more period to pass through this effect to inflation.

$$\pi_{t+2} = \mathrm{E}_t \pi_{t+1} + \left(a_{x,t+1} - \mathrm{E}_t a_{x,t+1}\right)\mathrm{E}_t x_{t+1} + e_{t+1} + \left(a_{x,t+1}v_{t+1} - \mathrm{E}_t\left(a_{x,t+1}v_{t+1}\right)\right) + e_{t+2}, \quad (3.37)$$

where

$$\mathrm{E}_t \pi^P_{t+2} = \mathrm{E}_t \pi^P_{t+2} + \left(\mathrm{E}_t a_{x,t+1}\right)\mathrm{E}_t x^P_{t+1} + \mathrm{E}_t\left(a_{x,t+1}v_{t+1}\right) + e^f_{t+2}. \quad (3.38)$$

Note that $\mathrm{E}_t\left(\mathrm{A}_{t+i}\middle|\Omega^P\right) \equiv \mathrm{E}_t \mathrm{A}^P_{t+i}$ is expected value of A_{t+i} with central banks' information set. In order to minimize the welfare loss, the output gap forecast (or intermediate target), in year t should be set as forecast of one-to-two-period inflation rate conditional upon information available in period t, such as their judgment on economic shocks and parameters estimated Philip curve's slope, concise with the targeting rule. I will explain this procedure in next section.

4.3. Discretionary policy

Suppose that central banks have typical quadratic loss function with the weight on economic stabilization as $\lambda > 0$ and positive target get level for inflation (x^S) and output gap (π^S). Central banks minimize the intertemporal loss function subject to the motion of inflation rate,

$$\pi_{t+2} = a_\pi \mathrm{E}_t \pi_{t+1} + a_{x,t+1}\mathrm{E}_t x_{t+1} + a_\pi e_{t+1} + a_{x,t+1}v_{t+1} + e_{t+2}. \quad (3.39)$$

Equation (3.39) comes from (3.37) and (3.38). Under marginal principle, central banks trade-off between the benefit from expanding output gap and cost of inflation, as

$$\lambda\left(\mathrm{E}_t x^P_{t+1} - x^S\right) - \rho\lambda\left(\mathrm{E}_t x^p_{t+2} - x^S\right) + \rho\,\mathrm{E}_t\left(\left(\pi^P_{t+2} - \pi^S\right)\frac{\partial \pi^P_{t+2}}{\partial x_{t+1}}\right) = 0, \quad (3.40)$$

Where ρ is discount rate. Since, inflation motion is (3.40), the last term on left-hand-side of above equation is

$$\rho\,\mathrm{E}_t\left\{\begin{pmatrix} a_\pi \mathrm{E}_t \pi^P_{t+1} - \pi^S + \left(a_x + \eta_{t+1}\right)\mathrm{E}_t x^P_{t+1} + \tilde{e}_{t+1} \\ +\left(a_x + \eta_{t+1}\right)\tilde{v}_{t+1} + \tilde{e}_{t+2} + e^f_{t+2} \end{pmatrix}\left(a_x + \eta_{t+1}\right)\right\}$$

or

$$\rho\,\mathrm{E}_t\left(\left(\pi^P_{t+2} - \pi^S\right)\frac{\partial \pi^P_{t+2}}{\partial x^P_{t+1}}\right) = \rho a_x a_\pi\left(\mathrm{E}_t \pi^P_{t+1} - \pi^S\right) + \rho\left(\sigma^2_a \mathrm{E}_t x^P_{t+1} + a_x e^f_{t+2} - \left(1 - a_\pi\right)\pi^S\right).$$

Therefore, the targeting rule in this kind of setting is

$$\begin{aligned} \mathrm{E}_t\,\pi_{t+1}^{P} - \pi^{S} = & -\frac{\lambda}{\rho a_x a_\pi}\left(\mathrm{E}_t\,x_{t+1}^{P} - \rho\,\mathrm{E}_t\,x_{t+2}^{P}\right) \\ & + \frac{\lambda(1-\rho)}{\rho a_x a_\pi}x^{S} - \frac{(1-a_\pi)}{a_x a_\pi}\pi^{S} - \frac{\sigma_a^2}{a_x a_\pi}\mathrm{E}_t\,x_{t+1}^{P} - \frac{1}{a_\pi}e_{t+2}^{f}. \end{aligned} \tag{3.41}$$

This targeting rule extremely differs from the case that central banks have a clear transmission mechanism. Fortunately, this targeting rule can be rewritten in simple form. With stationary solution of the output gap,[24] simplifying this targeting rule as a relation between one-period-ahead forecast of inflation tolerance and one-period-ahead output gap forecast. Using (3.39) and (3.41), the stationary motion of output gap is

$$\begin{aligned} \mathrm{E}_t\,x_{t+2}^{P} = & \,\delta\,\mathrm{E}_t\,x_{t+1}^{P} - \frac{(1-\rho)(1-a_\pi)}{\rho(1-\delta)}x^{S} \\ & - \frac{a_x a_\pi(1-a_\pi) - (1-a_\pi)^2}{\lambda(1-\delta)}\pi^{S} + \frac{a_x\phi_\varepsilon^2}{\lambda(\delta-\phi_\varepsilon)}e_{t+2}^{f} \end{aligned} \tag{3.42}$$

where

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[24] With incorporate of these equations yield the second-order difference equation, as

$$\mathrm{E}_t\,x_{t+3}^{P} - 2a_1\,\mathrm{E}_t\,x_{t+2}^{P} + b_1\,\mathrm{E}_t\,x_{t+1}^{P} = -a_0 + b_0 e_{t+2}^{f}$$

note that parameters a_1 and b_1 (in the left-hand-side) are defined as

$$2a_1 \equiv \frac{\lambda(1+\rho a_\pi) + \rho\sigma_a^2}{\lambda\rho} \quad \text{and} \quad b_1 \equiv a_\pi\frac{\lambda + \rho\sigma_a^2 - \rho a_x^2}{\lambda\rho},$$

and parameters a_0 and b_0 (in the right-hand-side) are defined as

$$a_0 \equiv \frac{(1-\rho)(1-a_\pi)}{\rho}x^{S} + \frac{a_x a_\pi(1-a_\pi) - (1-a_\pi)^2}{\lambda}\pi^{S} \quad \text{and} \quad c_0 \equiv \frac{a_x\phi_\varepsilon}{\lambda}.$$

Suppose that the coefficient $\delta \in (0,1)$ is the smaller root of characteristic equation, $L^2 - 2a_1 L + b_1 = 0$, and $\delta = a_1 - \left(a_1^2 + b_1\right)^{1/2}$. Thus, the stationary solution of output gap is

$$\mathrm{E}_t\,x_{t+2}^{P} = \delta\,\mathrm{E}_t\,x_{t+1}^{P} - \frac{a_0}{1-\delta} + \frac{b_0\phi_\varepsilon}{\delta-\phi_\varepsilon}e_{t+2}^{f}.$$

$$\delta = \frac{\lambda\left(1+\rho a_\pi\right)+\rho\sigma_a^2}{2\lambda\rho} - \left(\left(\frac{\lambda\left(1+\rho a_\pi\right)+\rho\sigma_a^2}{2\lambda\rho} \right)^2 + a_\pi \frac{\lambda+\rho\sigma_a^2-\rho a_x^2}{\lambda\rho} \right)^{1/2}.$$

This optimal path of output gap is helpful to simplifying targeting rule in (3.41), as

$$\begin{aligned} \mathrm{E}_t\, \pi_{t+1}^P - \pi^S = & -\frac{\lambda\left(1-\rho\delta\right)+\rho\sigma_a^2}{\rho a_x a_\pi} \mathrm{E}_t\, x_{t+1}^P + \frac{\phi_\varepsilon^2+\phi_\varepsilon-\delta}{a_\pi\left(\delta-\phi_\varepsilon\right)} e_{t+2}^f \\ & -\frac{\left(1-a_\pi\right)\left(a_\pi\left(1+a_x\right)-\delta\right)}{a_x a_\pi\left(1-\delta\right)} \pi^S + \frac{\lambda\left(1-\rho\right)\left(a_\pi-\delta\right)}{\rho a_x a_\pi\left(1-\delta\right)} x^S \end{aligned}. \qquad (3.43)$$

Moreover, the targeting rule in (3.43) implies how central banks adjust the intermediate target, i.e., output gap forecast, to control the gap between inflation forecast and its targets along the convergent path[25]. On the other hand, when central banks do not have the ambition to set the output to be higher than its potential level ($x^S = 0$), this targeting rule from outside observers' point of views is

$$\mathrm{E}_t\, \pi_{t+1} - \pi^S = -\frac{\lambda\left(1-\rho\delta\right)+\rho\sigma_a^2}{\rho a_x a_\pi} \mathrm{E}_t\, x_{t+1} - \frac{\left(1-a_\pi\right)\left(a_\pi\left(1+a_x\right)-\delta\right)}{a_x a_\pi\left(1-\delta\right)} \pi^S. \qquad (3.44)$$

If the central banks commit to a specific forecast-targeting rule, commitment to minimize a loss function over forecast of target variables and specific condition for the forecast target variables, are needed to choose to communicate either the targeting rule in (3.41) or targeting rule in (3.44). However, they never specify their judgment. When they commit on the targeting rule in (3.41), the outside observers have no need to find the optimal forecast and instrument plan, but they need to find the stationary solutions of target variables. However, the targeting in (3.43) contains the additional information about the stationary solutions of target variables. In other words, if the central banks commit to a specific targeting rule a like (3.43), they have to specify (3.41) together with (3.42). Moreover, when we compare the condition (3.41) with (3.43) in term of the requirement of information domain, the condition (3.41) require larger information domain than the condition (3.43). Therefore, the public can get more convenient in monitoring the monetary policy when the central banks commit on the targeting rule in (3.43) rather than (3.41).

In reality, central banks might commit to the targeting rule but it might not followe mechanically. Thus, it examines the constraint on inflation forecast tolerance which indicates room of policy flexibility in respond to the economic shocks in next section.

[25] The definition of this targeting rule is different from some recent monetary policy theory literatures. This is because of the different in method they use in finding optimal monetary policy. If they adopt Lagrangian method, then the targeting rule look alike (3.41) (Lars E. O. Svensson, 2003). However, if they examine the value function as Bellman equation, then the targeting rule resemble (3.43) (Lars E. O. Svensson, 1997a).

4.4. Forecasted Inflation tolerance constraint

This section examines how the tolerance band target type corporate with the specific forecast-targeting rule under circumstance that the central banks have the limited information in current period including the views of transmission mechanism and the judgment on economic shocks. Suppose that central banks commit to a simple forecasted inflation tolerance constraint, as

$$\mathrm{E}_t\,\pi_{t+1} - \pi^S = -\beta_1\,\mathrm{E}_t\,x_{t+1} \pm \beta_0 \tag{3.45}$$

where $\beta_0, \beta_1 > 0$. Since it is possible for central banks to commit on specific forecast-targeting rule in (3.44), thus, it is possible to constraint forecasted inflation tolerance as (3.45), which has character same as in (3.44). Central banks need to limit the output gap forecast as (3.45) in order to scope the actual inflation in next two periods and preserve their credibility of monetary policy, such as

$$\underline{T} \le \pi_{t+2} - \pi^S \le \overline{T},$$

Where $\underline{T}, \overline{T}$ is upper bond and lower bound respectively.

Therefore, the decision making process of central banks are as follows:

1. They have to make conditional forecasts on inflation and output gap,
2. they minimize the intertemporal loss function and constraint themselves to preserve policy's credibility by constraint output gap forecast as(3.45). In this regular cycle central banks aim to adjust their target variables as

$$\begin{aligned}\mathrm{E}_t\,\pi^P_{t+1} - \pi^S = &-\frac{\lambda}{\rho a_x a_\pi}\left(\mathrm{E}_t\,x^P_{t+1} - \rho\,\mathrm{E}_t\,x^P_{t+2}\right)\\ &+\frac{\lambda(1-\rho)}{\rho a_x a_\pi}x^S - \frac{(1-a_\pi)}{a_x a_\pi}\pi^S - \frac{\sigma_a^2}{a_x a_\pi}\mathrm{E}_t\,x^P_{t+1} - \frac{1}{a_\pi}e^f_{t+2} + \frac{1}{c\rho a_x a_\pi}\Psi_{t+1}\end{aligned} \tag{3.46}$$

where Ψ_t is the marginal effect of output gap forecast on policy credibility.

In addition, they can preserve the credibility if and only if this marginal effect of output gap forecasts on policy credibility can eliminate the cause of inflation bias, or

$$\frac{1}{c\rho a_x a_\pi}\Psi_{t+1} = -\frac{\lambda(1-\rho)}{\rho a_x a_\pi}x^S, \tag{3.47}$$

and output gap forecast will follows

$$\mathrm{E}_t\,x^P_{t+2} = \delta\,\mathrm{E}_t\,x^P_{t+1} - \frac{a_x a_\pi(1-a_\pi) - (1-a_\pi)^2}{\lambda(1-\delta)}\pi^S + \frac{a_x\phi_\varepsilon^2}{\lambda(\delta-\phi_\varepsilon)}e^f_{t+2}. \tag{3.48}$$

However, this motion is not possible if central banks do not have credible band of forecast inflation tolerance that can scope the public's expectation about output gap in next period as (3.45). In the next section how to scope this public expectation which is based on the setting in chapter 1 and 2 is explained.

4.5 Optimal forecasted Inflation tolerance band

In this study, it is assumed that the central bank have additional information about economic shocks, i.e., anticipated shocks, which depend on their judgment. Thus, the output gap in next period is constrained the forecast of inflation tolerance in (3.45) and central bank will receive the credibility as long as they can scope two-periods-ahead inflation tolerance in side certain band ($\pi_{t+2} - \pi^S \in \left[\underline{T}, \bar{T}\right]$). From the perspective of central bank, two-periods-ahead inflation depends on their plan about the expected target variables and other causes of uncertainty inside the transmission mechanism. Suppose that the realized inflation in next two periods is

$$\begin{aligned}\pi_{t+2} = {} & \mathrm{E}_t\, \pi^P_{t+2} + \left(a_{x,t+1} - \mathrm{E}_t\, a_{x,t+1}\right)\left(\mathrm{E}_t\, x^P_{t+1}\right) \\ & + e^f_{t+1} + \varepsilon_{t+1} + \left(a_{x,t+1}\xi_{t+1} - \mathrm{E}_t\left(a_{x,t+1}\xi_{t+1}\right)\right) + \varepsilon_{t+2}.\end{aligned}$$

Nevertheless, central bank can anticipate some of specification factors, such as

$$\mathrm{E}_t\, \pi^P_{t+2} = a_\pi\, \mathrm{E}_t\, \pi^P_{t+1} + \left(\mathrm{E}_t\, a_{x,t+1}\right)\mathrm{E}_t\, x^P_{t+1} + \mathrm{E}_t\left(a_{x,t+1}\xi_{t+1}\right) + e^f_{t+1} + e^f_{t+2},$$

Thus, the inflation in next two periods depends on some specification factors to central bank knowledge and some uncertain factors

$$\pi_{t+2} = a_\pi\, \mathrm{E}_t\, \pi^P_{t+1} + \left(a_{x,t+1}\right)\left(\mathrm{E}_t\, x^P_{t+1}\right) + \varepsilon_{t+1} + a_{x,t+1}\xi_{t+1} + \varepsilon_{t+2} + e^f_{t+2} \tag{3.49}$$

Since central banks aim to scope the tolerance of inflation in next two periods within $\left[\underline{T}, \bar{T}\right]$. In order to do that they commits to constraint the forecast on period ahead inflation tolerance as (3.45), or

$$\begin{aligned}\pi_{t+2} - \pi^S = {} & \left(a_x - a_\pi\beta_1\right)\mathrm{E}_t\, x^P_{t+1} + e^f_{t+2} - \left(1 - a_\pi\right)\pi^S \pm a_\pi\beta_0 \\ & + a_{x,t+1}\xi_{t+1} + \eta_{t+1}\,\mathrm{E}_t\, x^P_{t+1} + \varepsilon_{t+1} + \varepsilon_{t+2}\end{aligned}.$$

Therefore, keeping $\pi_{t+2} - \pi^S$ inside $\left[\underline{T}, \bar{T}\right]$ mean limiting uncertainty part of above equation, as

$$s_{t+1} = \left(a_x - a_\pi\beta_1\right)\mathrm{E}_t\, x^P_{t+1} + \phi_\varepsilon e^f_{t+1} - \left(1 - a_\pi\right)\pi^S \pm a_\pi\beta_0, \text{ and} \tag{3.50}$$

$$s_{t+1} \equiv a_{x,t+1}\xi_{t+1} + \eta_{t+1}\,\mathrm{E}_t\, x^P_{t+1} + \left(1 + \phi_\varepsilon\right)\varepsilon_{t+1}, \text{where } \varepsilon_{t+2} = \phi_\varepsilon\varepsilon_{t+1} \text{ and } e^f_{t+2} = \phi_\varepsilon e^f_{t+1}. \tag{3.51}$$

Note that s_{t+1} is the random variable draws in period $t+1$ (as in (3.51)) and its density relies on the factor in period $t+1$ (as in (3.50)). The uncertainty feature in transmission mechanism as an addictive uncertainty was described in the previous chapters (chapter 2 and 3). Thus the certainty equivalent rule can be applied in those settings. However, in this chapter, two sources of uncertainties have been assumed in the transition mechanism, i.e., additive uncertainty and multiplicative uncertainty. As a result, the certainty equivalent will no longer be applied. Moreover, the multiplicative uncertainty also affects t the assumption of independent and identically distributed random variables, such as s_{t+1} in (3.51), which relate to $\eta_{t+1}\mathrm{E}_t\, x_{t+1}^P$. Thus, changing target variables can affect the variance of this random variable and reshape the density function of s_{t+1}. Consequently, central bank in this setting will adjust the intermediate target (output gap forecast) to minimize loss function and also adjust "average marginal chance of preserving policy credibility" to offset the cause of inflation bias. Denote that the average marginal chance of preserving policy credibility is

$$\Psi_{t+1} \equiv \mathrm{E}_t\left\{\frac{\partial}{\partial \mathrm{E}_t\, x_{t+1}^P}\left(V + \rho c\theta_{t+1}\bar{U}\right)\right\}, \tag{3.52}$$

when $\theta_{t+1} \equiv F\left(\underline{T} \le \pi_{t+2} - \pi^S \le \bar{T}\right)$, $F(\square)$ is cumulative density function and I assume the central bank balanced-of-risk condition as $\omega\left(1-F\left(\bar{T}\right)\right) = (1-\omega)\left(F\left(\underline{T}\right)\right)$. It is important to note that (3.52) has been calculated by applying Liebniz integral rule, ,

$$\frac{\partial}{\partial z}\int_{-\infty}^{b(z)} f(y;z)dy = \int_{-\infty}^{b(z)} \frac{\partial f(y;z)}{\partial z}dy + f(y;z)\frac{\partial b(z)}{\partial z}.$$

The definition of θ_{t+1} together with balanced-of-risk condition implies

$$\theta_t = \frac{F\left(\bar{T}\right)-\omega}{1-\omega} \text{ where } F\left(\bar{T}\right) = F\left(s_{t+1} \le \left(a_x - a_\pi\beta_1\right)\mathrm{E}_t\, x_{t+1}^P + \phi_\varepsilon e_{t+1}^f - \left(1-a_\pi\right)\pi^S + a_\pi\beta_0\right),$$

By assuming s_{t+1} is normally distributed, thus Liebniz integral rule indicates that equation (3.52) can rewrite in the following form as,

$$\Psi_{t+1} \equiv c\,\mathrm{E}_t\left\{-\left(\frac{\partial\left(s_{t+1}^2 \big/ \mathrm{E}_t\left(s_{t+1}^2\right)\right)}{\partial x_{t+1}^P}\right)F\left(\bar{S}\right) + \left(a_x - a_\pi\beta_1\right)f\left(\bar{S}\right)\right\}\frac{\rho\bar{U}}{1-\omega}. \tag{3.53}$$

In addition, central bank do not share their judgment on economic shocks to outside observers, so they avoid specifying the information by set β_1 that make $\bar{S}$ independent of this information[26], ,

$$\beta_1 = \frac{a_x^2\phi_\varepsilon^2}{a_\pi a_x \phi_\varepsilon^2} + \frac{\lambda(\delta-\phi_\varepsilon)(1-\delta\phi_\varepsilon)}{a_\pi a_x \phi_\varepsilon^2},$$

and

$$\bar{S} = (1-a_\pi)\left(\frac{(\delta-\phi_\varepsilon)(1-\delta\phi_\varepsilon)(a_\pi(1+a_x)-1)}{a_x\phi_\varepsilon^2(1-\delta)} - 1\right)\pi^S + a_\pi\beta_0 \qquad (3.54)$$

The assumption of asymmetric information also affects (3.53), because the central bank's plan is to adjust the output gap forecast on their judgment. The shape of the density function will get affected by adjusting monetary policy since the random variable S_{t+1} and its variance depends on this forecast output. . However, the information about changing the shape is describe by,

$\frac{\partial\left(s_{t+1}^2 / \mathrm{E}_t\left(s_{t+1}^2\right)\right)}{\partial x_{t+1}^P}$, where $\mathrm{E}_t\left(s_{t+1}^2\right)$ is the variance in period $t+1$[27].

If s_{t+1} is function of central bank's judgment, then the information about the shape of density is also the function of central bank judgment. Therefore the change in scheme of uncertainty will be unexpected to the outside observer, since the judgment of the central bank is unknown. Thus, the average marginal chance of preserving policy credibility will be,

---

[26] Since, $\mathrm{E}_t\, x_{t+1}^P = \delta x_t^P - \frac{a_x a_\pi (1-a_\pi) - (1-a_\pi)^2}{\lambda(1-\delta)}\pi^S + \frac{a_x\phi_\varepsilon^2}{\lambda(\delta-\phi_\varepsilon)} e_{t+1}^f$ then

$$\mathrm{E}_t\, x_{t+1}^P = -\frac{a_x a_\pi (1-a_\pi) - (1-a_\pi)^2}{\lambda(1-\delta)^2}\pi^S + \frac{a_x\phi_\varepsilon^2}{\lambda(\delta-\phi_\varepsilon)(1-\delta\phi_\varepsilon)} e_{t+1}^f,$$

and substitute this into $\bar{S}$, the value of β_1 is satisfy

$$\frac{(a_x - a_\pi\beta_1)a_x\phi_\varepsilon^2}{\lambda(\delta-\phi_\varepsilon)(1-\delta\phi_\varepsilon)} + 1 = 0.$$

[27] Note that the term $s_{t+1}^2 / \mathrm{E}_t\left(s_{t+1}^2\right)$ is the standardize uncertainty in period $t+1$ with a zero mean.

$$\Psi_{t+1} \equiv c\left(a_x - a_\pi \beta_1\right) f\left(\bar{S}\right)\frac{\rho\bar{U}}{1-\omega} = -cf\left(\bar{S}\right)\frac{\rho\bar{U}\lambda\left(\delta-\phi_\varepsilon\right)\left(1-\delta\phi_\varepsilon\right)}{\left(1-\omega\right)a_x\phi_\varepsilon^2}. \qquad (3.55)$$

The Central bank have to set the average marginal credibility in order to offset the cause of inflation bias. In this process, central bank will choose the size of the bandwidth, β_0, in (3.54) to balance the chance between two situations. In this particular situation, the forecast of inflation-tolerance is at the upper edge ($f\left(\bar{S}\right)$) and the situation which forecast of inflation-tolerance is lower and the upper edge will be ($F\left(\bar{S}\right)$), or,

$$f\left(\bar{S}\right) = \frac{\left(1-\rho\right)\left(1-\omega\right)a_x\phi_\varepsilon^2 x^S}{\left(\delta-\phi_\varepsilon\right)\left(1-\delta\phi_\varepsilon\right)V}\left(1-\frac{\rho}{c}\left(\frac{F\left(\bar{S}\right)-\omega}{1-\omega}\right)\right), \qquad (3.56)$$

Where,

$$V \geq \frac{\left(1-\rho\right)\left(1-\omega\right)a_x\phi_\varepsilon^2 x^S\sigma\sqrt{2\Pi}}{\left(\delta-\phi_\varepsilon\right)\left(1-\delta\phi_\varepsilon\right)}\left(1-\frac{\rho}{2c}\left(\frac{1-2\omega}{1-\omega}\right)\right). \qquad (3.57)$$

Note : The condition (3.56) is the result from substituting (3.55) into (3.47) and condition (3.57) will be equal to (3.56), when $\bar{S}=0$. If the coefficient of π^S in (3.54) is higher, the size of bandwidth, β_0, will decrease, in order to keep the optimal level of $\bar{S}$ constant, in each optimal level in (4.25) . Thus, the side of bandwidth has a key role in balancing the condition in (3.56).

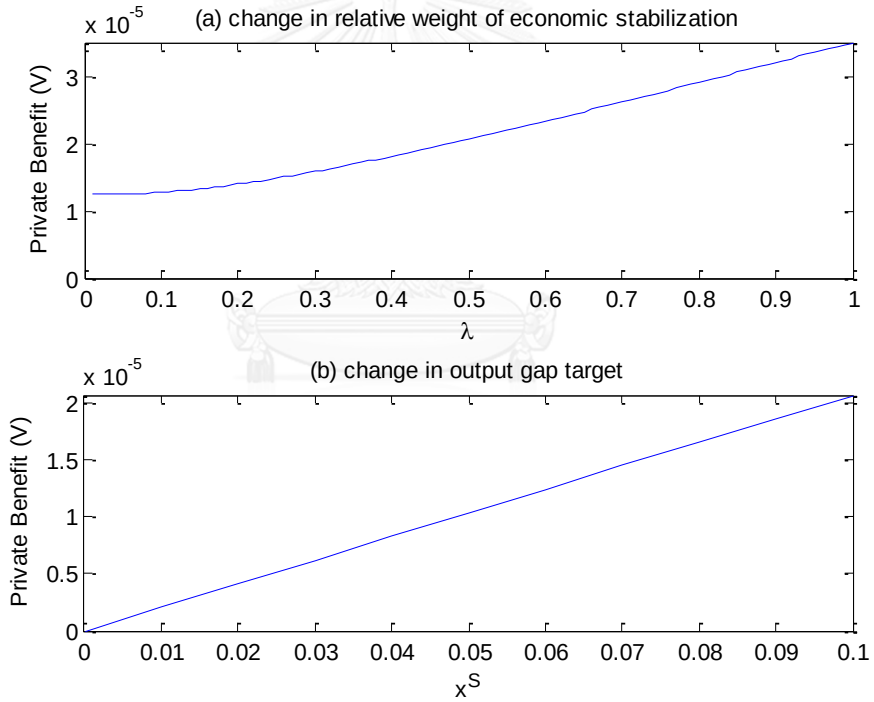
4.6. Forecasted Inflation tolerance band mechanism

The set of explanations of band mechanism will help forming a simple model that can explain the mechanism of band in a richer complicated model. The main character of the inflation tolerance band is based on the idea of how the central bank chooses the optimal policy, i.e., the trade-off between marginal substitution and marginal transformation. However, the inflation tolerance band have the credibility to commit when the inflation tolerance constraint has been replicated by the targeting rule which comes under the discretion policy. In this chapter, using of discretion has been assumed to design the central bank's policy. . However, the central bank do not understand clearly about the transmission mechanism which the bank possess. , i.e., parameter uncertainty problem. Furthermore, control lags are also a problem which the central bank contains. Monetary policy can affect the economy in two-periods-lag. Under these circumstances, the mechanism of the tolerance band will be explained in two topics; the role of private benefit in the model and how the bandwidth response to the change in economic environment.

4.6.1. Private benefit

The response of private benefit on changes in the responsive factors of political interferences are shown in figure 4.1. Normally, when the relative weight of the economic stability goal increases, it will increase the trade-off between inflation forecast, output gap forecast and the cause of inflation bias (as shown in (3.46))[28]. Nevertheless, this transmission has an unclear pass-through between output gap and inflation. Therefore, the central bank have some concerns on the uncertainty of the pass-through. As a result, the effect of change in the relative weight of economic stability goal is not as strong as in previous chapters. Therefore, the size of the private benefit compensation will be lower than the previous model (panel (a)). On the other hand, the effect of change in output gap target can cause the inflation bias similar to previous chapters. As a result, the private benefit in this particular circumstance will response to the output gap similar to the previous chapters (panel (b)).

Figure 4.1 Private benefit: stabilization weight and goal



[28] According to the targeting rule in this model

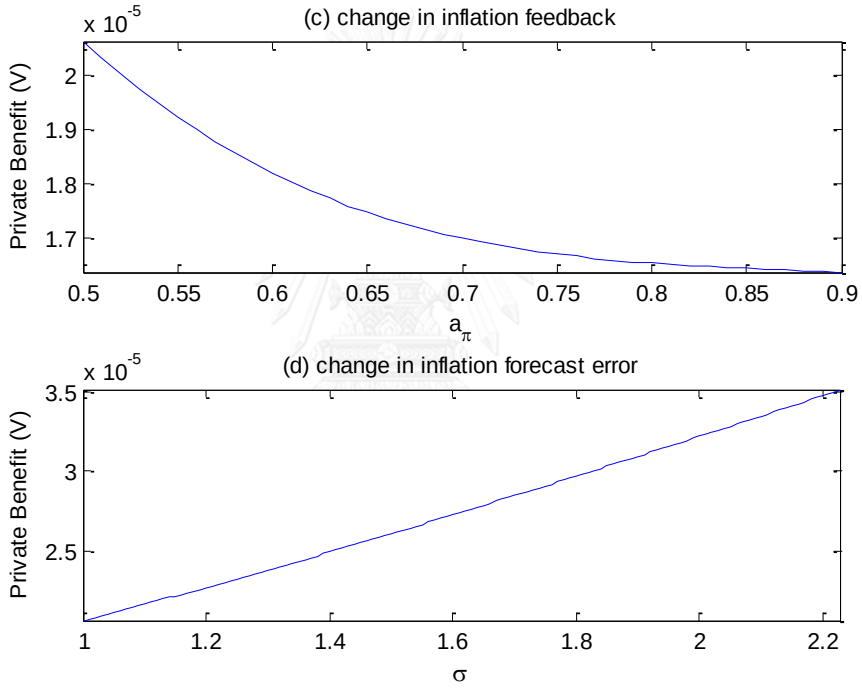
$$\mathrm{E}_t\,\pi^P_{t+1} - \pi^S = -\frac{\lambda(1-\rho\delta)+\rho\sigma_a^2}{\rho a_x a_\pi}\mathrm{E}_t\,x^P_{t+1} + \frac{\lambda(1-\rho)(a_\pi-\delta)}{\rho a_x a_\pi(1-\delta)}x^S + F_{t+1},$$

when the relative weight on economic stabilization goal changes, it will affect the first and second terms on the right-hand-side of this equation. However this effect can be stronger when central banks lack of foresight. Note that F_{t+1} capture other factors under central banks' policy consideration but independent of the relative weight on economic stabilization goal.

The backward-looking transmission mechanism has been explained in figure 4.2. If the feedback coefficient equals to one, there will be no need to set band for the period ahead inflation forecast.

Because the closer inflation feedback coefficient gets to unity, the less accurate it gets to control the inflation forecast inside the band, with constant bandwidth. As a result, if it approaches to one, the private benefit will be lower and if it approaches to zero (panel (c)), the tolerance band regime will dysfunction. However, the effect of additive uncertainty is similar to the previous chapter. When similar uncertainty increases, it causes difficulty for central bank to control inflation tolerance. Thus, the private benefit must increase (panel (d)).

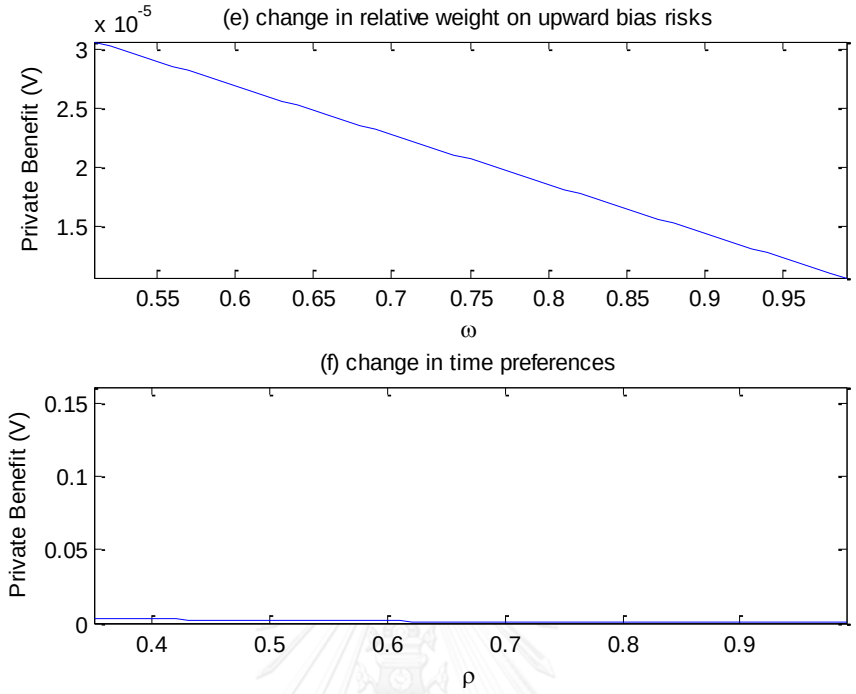
Figure 4.2 Private Benefit: transmission and forecast error



The effect of central banks anxiety on the upside risk is shown in figure 4.3, which is in panel (e). When they have too much of concern on price stability goal, the private benefit needs to decrease, in order to balance a particular goal with another which will result an output as shown in (panel (f)).

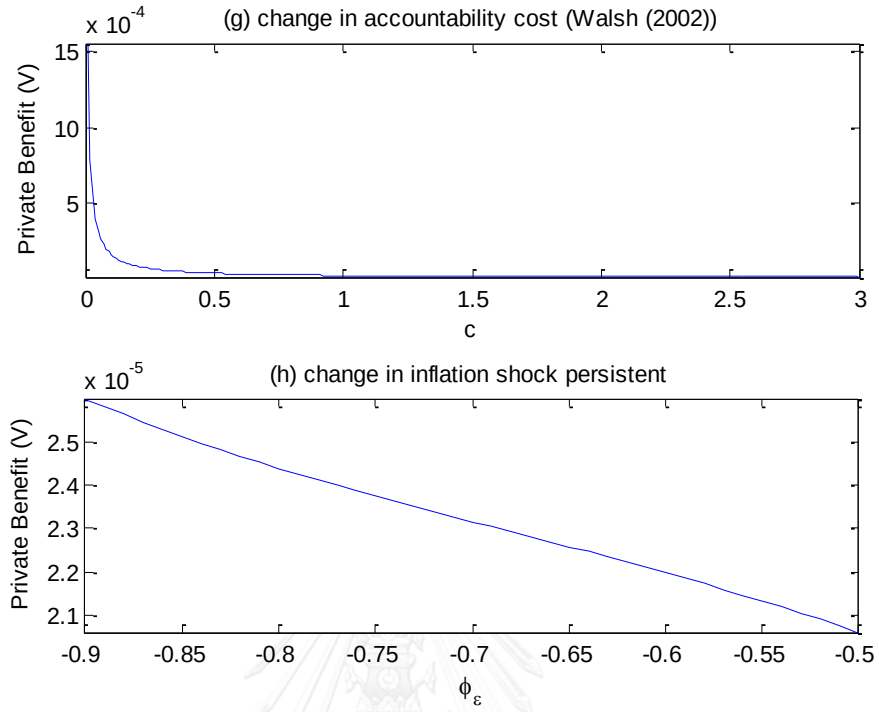
The central bank decision problem, as shown in the previous chapter, can be reduced into a single stage decision problem. However, under this transmission, the central bank has to design their policy in multi-stages decision problem. The marginal effect on policy credibility and the cause of inflation bias occurs in the same period, which indicates that the central bank set their band to restore the credibility by offsetting the future cause of inflation bias. As a consequence, there is no direct effect of time preference; therefore, changing it will have no significant effect on private benefit (panel (g)).

Figure 4.3: balance-of-risk and time preference



The effect of accountability and the persistent of inflation shock on private benefit are shown in figure 4.4, are also similar to previous chapters. When the accountability cost, i.e., the degree of strictness in policy discipline, increase, then the central bank will focus on their long-run policy performance. Thus, to create an additional incentive to preserve price stability goal as shown in (panel (g)) is not required. In addition, increasing in the rate of shock persist can lead to the increase inflation's rate-of-convergent and sensitivity of monetary policy on shock. As a result, inflation will move faster into the band. Consequently, when the rate of shock persist increases, the private benefit will be lower as shown in (panel (h)).

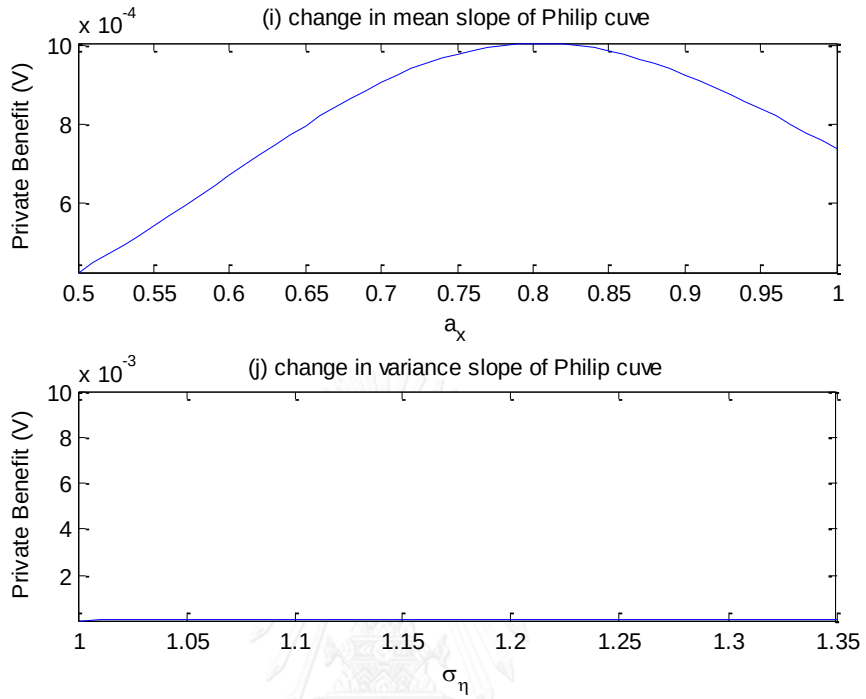
Figure 4.4: accountability cost and inflation shock persistent



A mean and variance on parameter uncertainty of transmission mechanism is shown in figure 4.4 by turning the problem of unclear views. The mean of pass through coefficient determines the midpoint level of one-period-head inflation forecast and also determines the variance of unanticipated shock. However, if transmission mechanism is uncertain, it will have many factors that are related to the variance of unanticipated shock. When the variance has many factors-related, then the effect of one of those factors will not be prominent. Therefore, change in variance of this pass through coefficient does not have significant effect on private benefit, as shown in (panel (i)).

However, when the mean of the pass through coefficient changes, it affects directly on the inflation forecast at the midpoint of the band. Thus, it can cause changes in private benefit. Furthermore, its effect on private benefit is nonlinear, namely, when it is high enough to cover other variables that also determine the midpoint, and then the midpoint will shift down (because the cost of generating temporary economics growth is too high). The private benefit will decrease in order to respond to this situation as shown in (panel (j)).

Figure 4.5 Private benefit: mean and variance of multiplicative shock



In conclusion when considering the circumstance of which the central bank is unclear about the transmission mechanism which the bank possess, , the central bank have unclear views about how much additional output gap can generate future inflation, and the mean of parameter uncertainty have stronger significant effect on private benefit than its variance.

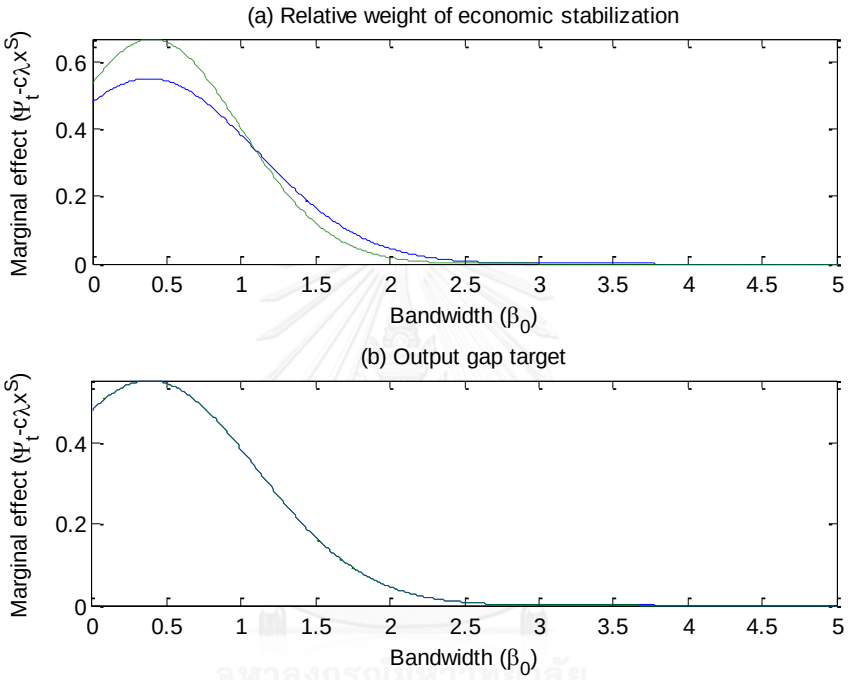
In addition, when the transmission mechanism becomes backward looking, e.g., vector of autoregressive model, the rate of shock persistent has a key role to determine a private benefit whereas the time preference has a significant effect on private benefit. Furthermore, the feedback of inflation from previous period determines the existent of tolerance band regime.

4.6.2. The widening of band

The bandwidth response to the changes in various economic factors will be shown in this particular section. As similar to the previous chapter, each figure has a net marginal effect. i.e., the benefit in maintaining the credibility of adjusting output gap net of the cause of creating inflation bias, as the vertical axis and the horizontal represents the size of bandwidth (β_0). In addition, the cut-off point between the curve and horizontal axis indicates the optimal size of bandwidth. Furthermore, the base case has the optimal bandwidth at 2.5 percentage point; this is the cut-off point between the solid line and horizontal axis.

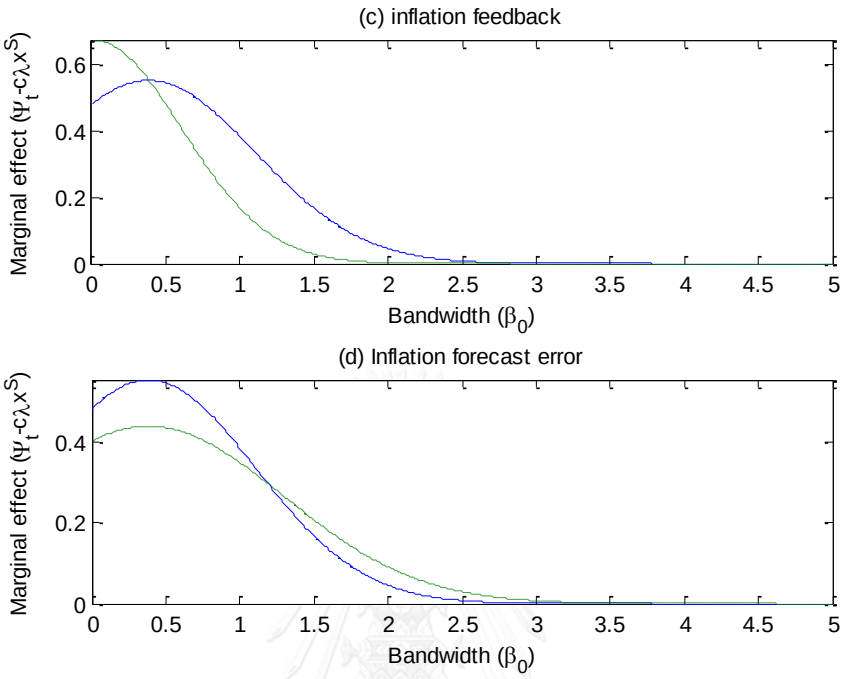
Figure 4.6 indicates that under dynamic transmission mechanism, the stationary character can deplete the effect of changing output gap target on band (panel (a)). However, the relative weight on economic stabilization goal still affects the bandwidth through changing the variance of unanticipated shock (panel (b)). Thus, are the change in relative weight on economic stabilization goal is the only responsive factors of political interference that can be affected the size of bandwidth under dynamic transmission mechanism.

Figure 4.6 Bandwidth: stabilization weight and goal



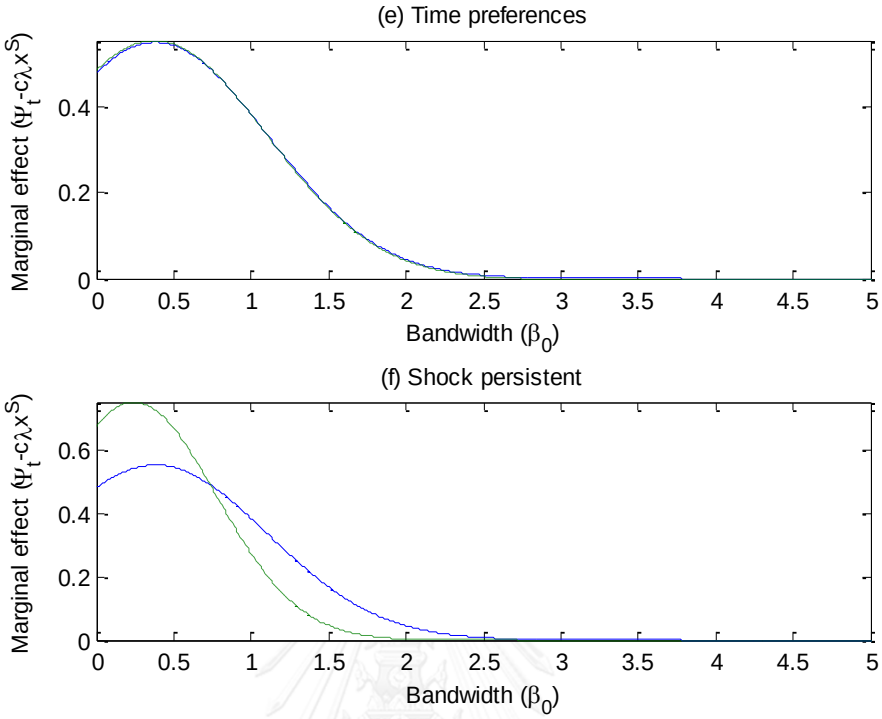
When there is an increase in the inflation feedback (from 0.5 to 0.9), the bandwidth will shrink as shown in figure 4.7. The impact of changing the feedback will decrease the speed of adjustment of inflation. Therefore in order to decrease bandwidth, the accuracy of inflation forecast (panel (c)). However, when additive uncertainty increases, it will increase the side of bandwidth as well.

Figure 4.7 Bandwidth: transmission and forecast error



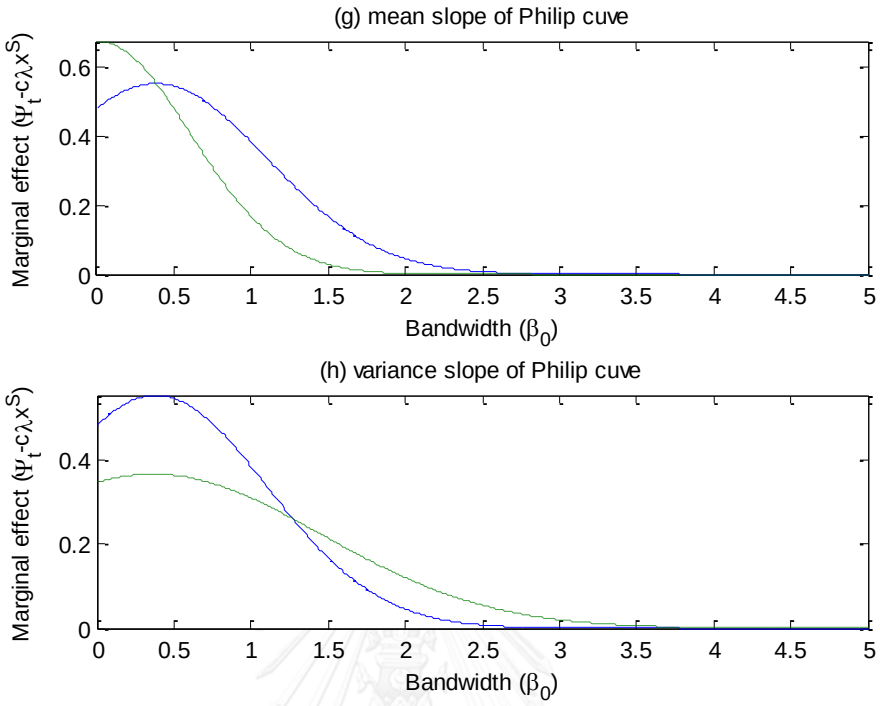
In figure 4.8, it indicates that time preference cannot cause any changes in the size of bandwidth. Because the setting assumes that changes in policy credibility will offset the future cause of inflation bias as shown in (panel (e)). However, when the size of persistent increases (from 0.5 to 0.9), it indicates that the inflation will adjust slower than before. Then, the size of bandwidth will decrease in response to this. The central bank should prudentially implement expansion policy because any minor deviations diverge the inflation forecast from its target (panel (f)).

Figure 4.8 Bandwidth: balance-of-risk and time preference



A small impact of monetary policy on forecasted inflation implies a large mean pass through coefficient as shown in figure 4.9. In the above case, the mean of the pass through coefficient increases; therefore, the central bank should decrease the size bandwidth (panel (g)). In panel (g), the change in the variance of pass through coefficient impacts curvature of density function, i.e., the scheme of shock, and then it will affect the bandwidth at last. Note that this effect is so small. The figure here is changing and the standard deviation that is 1.2 times larger can cause bandwidth 0.4 times larger.

Figure 4.9 Bandwidth: mean and variance of multiplicative shock



4.7. Conclusion

Hence, the study focuses on the circumstance where central banks do not have perfect information about their transmission mechanism, i.e., the multiplicative uncertainty and additive uncertainty. In addition, monetary policy can affect their target variables with lag periods (the backward-looking model) (Lars E. O. Svensson, 1999) with the none unity feedback of inflation from previous period. According to this realistic feature, a simple inflation tolerance band when dealing with a political interference was examined

The results which extrapolated from the theoretical perspective found to be that the monetary policy implementation by the central bank affects the fluctuation of anticipated inflation rate. However, due to the imperfection of the data between the central bank and the public, the central bank cannot pursue the policy with the channel. Besides, the unclear section of transmission mechanism deteriorates the capability of the bandwidth in respond to economy. Thus, it was left with the mechanism of a private benefit to respond to the various changes. The changes of economy results not only affect the fluctuation of unanticipated shock, but also in the mean of unanticipated shock. In addition, the knowledge of density of shock has crucial role in controlling the accuracy of predicting the future inflation rate.

Chapter 5
Conclusions

This study aims to illustrate a set of explanations about how central banks determine the credible tolerance band of inflation and how the tolerance band target type works under the inflation targeting strategy. In addition, this chapter draws the comparison between the results from previous chapters in order to find the robust explanations of how the band target work under inflation targeting strategy. Moreover, this comparison considers a number of propositions on inflation-forecast targeting strategy (Woodford, 2007a) in an aspect of the inflation tolerance band target types, including the Intertemporal consistency, dual mandate of the target criterion and sequential of target criterion that corresponds to a sequence of optimal conditions, and robust principle of optimal policy.

It is possible that a quantitative point target of inflation alone is not enough to evaluate central bank's performance under inflation targeting strategy. For example, the central banks in inflation-targeting countries not only have concern towards value of monetary unit, i.e., price stability, but also have some degree of concern in short-run real activity. This indicates the possibility of departure of inflation rate from its target value in short-run (as this study mentions in chapter 1). Therefore, it is important for central banks to give some criterion to the public about the basis of policy decision and to expect that inflation will achieve its target over suitable horizons. Moreover, the criterion should not be a rigid framework because it should allow central banks to take account of non-quantitative sources of information, i.e., central bank's judgment. This study develops the explanations that support the usefulness of inflation tolerance band targeting that central banks can receive as a new kind of target criterion. The new target criterion will be helpful for central bank's communication because it provides a certain measure of inflation be projected to converge into its target value in medium-run. Moreover, it remains consistent overtime even when central banks receive new source of relevant information to frame the economic projection.

The rest of the chapter is outlined as follows. Section 5.1 presents the monetary-policy problem in the light of transparency and communication policy that can increase the effectiveness of monetary policy. Section 5.2 discusses the usefulness of new target criterion that is based on the middle ground of monetary policy approach between commitment and discretion, i.e., constraint discretion approach. Section 5.3 explains micro-foundation of new target criterion which is helpful for central banks to error collect the systematic bias. Section 5.4 gives the baseline framework for analysis of new target criterion. The band targeting approach in this study is subclass of optimal inflation contract which incorporate the idea of balance-of-risk. Section 5.5 describes the inflation tolerance band mechanism and the robustness of mechanism. Finally, section 5.6 evaluates the suitability of tolerance band-targeting under descriptive perspective.

5.1. Monetary-policy problem

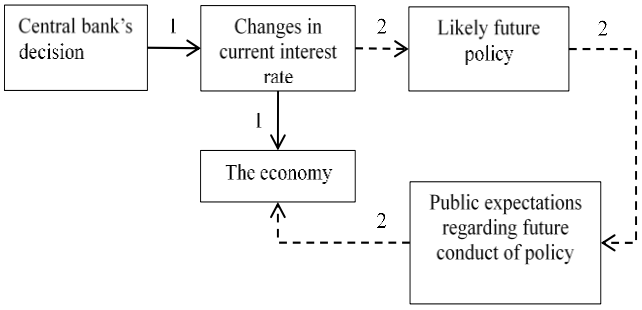
Nowadays, monetary policy is focused on the role of economic agents' anticipations on macroeconomic incidents (Phelps's augment (Phelps, 1970)), thus we can see in many recent monetary-policy literatures that uses hypothesis of rational expectation to specify agents' anticipation in economic model. The role of economic agents' anticipation leads to notable changes in central banking; many central banks have thus increased their transparency and have more actively communicated about their policy decision and intensions[29].

The question regarding why public expectation lead to a greater transparency and active communication of central bank have been always prevalent. Although, changing the policy instrument can influence the short-term course of real economy, however it is important for central banks to develop other channels that can shape public expectations about future policy. In practice, there are two ways that nominal variables can influence economy. First, changing the current level overnight interest targeted by the central bank. Second, changing the financial market prices, such as long-term interest rate, equity prices and exchange rates that rely on expected path of real interest rates over months and years. Many central banks attempt to operate their monetary policy through their policy instrument by trading in the market for overnight cash. Some of them even control the credit and regulate the flow of funds through financial markets and institutions directly. However, monetary policy that relies on changing central bank's policy instruments alone cannot generate influence on economy significantly, i.e., the effects on economic decision-making from these instruments are negligible (Woodford, 2007b). The significant effect of monetary policy depends on the change in expected path of real interest rates. Moreover, these depend on the expected path of nominal interest rate and the public expectation of future inflation that are strongly influenced by the public expectations of future monetary policy.

Fortunately, changing current nominal interest rate can indicate the likely future policy and hence influence on expected conduct of future policy (figure 5.1). Therefore, central banks have to think carefully about what current nominal interest rate signals regarding the future policy and seek to develop other channels that can shape the public expectations of the same.

[29] For example, European Central Bank holds a press conference at the time that policy decision occurs. Bank of England and Swedish Risks bank issue the Inflation Reports several times a year (to provide detailed and present the reason behind their policy decision). Federal Reserve and European Central Bank offer direct indications about future interest rate decisions inside the official statements (Woodford, 2007b).

Figure 5.1 Monetary policy channels



Note: the effect of monetary policy by changing current nominal interest rate alone display by solid line and the effect of monetary policy that indicate likely future policy display by dash line.

Inflation-targeting countries give quantitative definition of the central banks' objective stability, i.e., the quantitative inflation target, to the public and commit to achieve the target in the medium-term or even the long-term. Even though, the central banks specification on their monetary policy's goal makes it clear to the public and further making the central bank's performance valuable to them, however, it not enough to anchor the public expectation. The public have to figure out the pattern in central bank's behaviour by forecasting from what central banks had conducted in the past. The central banks need to communicate with the public about their basis of policy decision, in order to enable them to see the way in which central banks operate so as to be clear on their expectation about the achievement of their target over a suitable period. For example, once the central bank designs the policy and changes the current interest rate (the interest rate alone affects the economy through 1st channel of figure 5.1). In the meantime, central banks communicate about the likely path of future policy (2nd channel in figure 5.1), then the public can discern the pattern in which the central banks behave. Therefore, the public expectation about the future conduct of policy will change in the same manner as the central bank intends to.

The usefulness of central bank's communication to the public brings about usefulness in improving the effectiveness of monetary policy. According to the anchoring inflation expectation, when current inflation rate departs from its average rate, the public have reasons to believe that inflation will always return fairly quickly to a stable long-run rate. Thus, the departure of the current inflation rate from average rate has a little effect on expected inflation for the future. In other words, the short-run Phillip-curve trade-off is much flatter and monetary policy has larger short-run effect on real activity.

5.2. New target criterion

In order to use the communication policy, central banks require not only commitment to transparency, but also they must have the systemic approach to

deliberations of the policy as well. The central bank's statement about the likely path of future policy alone might not influence the public expectation. It might just influence the public expectation that also not for too long. In addition, if central banks do not have actual plan for actions, they cannot reveal their intentions. Therefore, in order to reveal their intensions, central banks need to formulate a plan for actions and explain their past decision in a way that helps the public to predict future decisions. In practice, many inflation-targeting central banks issue the Inflation Report several times a year. It contains the projection of economic evolutions over the next several years which are consistent with "target criterion". This kind of communication helps central bank to anchor inflation expectation in many ways. Firstly, it makes policy commitment verifiable. The public can examine the consistency between the conduct of policy and the commitment of central bank. Secondly, it allows the public to observe how the central bank processes and responds through their own projection and decision discussed in the report. Lastly, it allows the central bank's own vision of the future evolution influence upon the inflation expectation (Woodford, 2007a) which is crucially considered as the anchoring medium-run inflation expectations. How well it can anchor inflation expectation mainly depends on the lists of criterion that the acceptable projections are expected to satisfy. For example, Norges Bank issues the inflation measure, target value and particular horizons where inflation will converge towards its target. Moreover, they also specify the target criterion that explains about the acceptable near-term transition path of inflation.

The target criterion is a certain measurement of projected inflation that explains how temporary departure of projected inflation from its target will converge to its target value. In other words, the target criterion describes what the transition path should look like: it should be suitable proportion between inflation gap (the amount of inflation rate exceeds its target) and output gap (the amount of current real GDP depart from the potential level of output). More precisely, the two gaps should have opposite signs (Woodford, 2007b, 2013). Furthermore, these gaps should be projected in order to be eliminated at the same speed over time (Woodford, 2007b). The target criterion is simply the standard efficiency condition, i.e., the first-order condition from optimal monetary policy. It is the equality between the marginal rates of substitution and transformation between the target variables (such as, inflation rate and output gap) (Lars E. O. Svensson, 2005). Supposedly, it can be represent as

$$\pi_t^P - \pi^S = -\beta_1 x_t^P , \tag{4.1}$$

where β_1 is some positive value. Note that this formulation of target criterion characterizes the optimal monetary policy with no commitment. In addition, the projected inflation, π_t^P, and output gap, x_t^P, include non-quantitative source of information, i.e., central bank's judgment which may change overtime owning to unexpected circumstances. When central bank specifies target criterion, the public can now judge whether the central bank policy in on track or not. The optimal equilibrium can be solved by combining micro-founded private sector's behaviour, i.e., IS curve and Philip curve, and target criterion. This results in the optimal inflation and output gap plans and also optimal instrument rate plan, i.e., the future conduct of monetary policy. Therefore, knowing an explicit target criterion theoretically knows the

expected path of real interest rate which is a matter of concern for economic decisions.

Unfortunately, there will be different paths of projected inflation and output gap in future that will depend on the quantitative and non-quantitative information of monetary policy committee. The different paths mean that specific actions of central bank in short-run and actions in the past can no longer be affected by public expectation (Woodford, 2011). Moreover, the monetary policy committee will design the appropriate policy paths by voting upon at any meeting (Woodford, 2007a). This intertemporal consistency problem causes failure to internalize the consequences of public expectation of systematic patterns in central bank's conduct. To examine the case of new information that allows the policy committee to change paths of projected inflation and output gap, the unanticipated shock[30], s_t, has been introduced to incorporate with target criterion,

$$\pi_t^P - \pi^S = -\beta_1 x_t^P + s_t . \tag{4.2}$$

Initially, at the beginning of period t the target criterion as (4.1) is cited to apply in each of a sequence of future periods and central bank does not realize any unanticipated economic shock. At the end of this period, central bank receives new information about realized economic shock, thus the previous projections are no longer cited. The private sector instantaneously responds by adjusting their plans while central bank observe the adjusted plans and revise the projections in the next period if this shock is persists. Changing the projections lead to changing the instrument plan. Moreover, the public cannot analyse the consequences of central bank's policy action, then this action cannot influence public's expectation. Therefore, the realized new information can be problematic in shaping public expectation.

Central bank needs to constraint current policy with past actions in order to shape public expectation. Thus, the consequences of the past action can affect the public expectation. The recent monetary policy literatures focus on the analysis of monetary policy rule rather than the decisions about individual policy action, i.e., discretionary policy (Woodford, 2011). The suitable monetary policy from normative perspective might include; first, a systematic pattern of conduct, second, the desire for central banks to follow, and finally, the reliable way for the pattern of conduct to be predictable (Woodford, 2011). However, it is not necessary to assume that any central banks that conduct the monetary policy possessing these characteristics must follow the rule. For example, this study examines the middle ground between discretion policy and rule by introducing the band target criterion as,

$$\pi_t^P - \pi^S = -\beta_1 x_t^P \pm \beta_0 . \tag{4.3}$$

[30] This can be view as deviation of estimation or mistake of policy committee in judging economic evolution (McCallum & Nelson, 2004).

This kind of target criterion explains the association between medium-term inflation rate and the level of capital utilization. Moreover, this criterion gives the upper limit and lower limit of the acceptable path. Any path that relies within this contained limits is the alternative acceptable paths. In other words, the public can make use of this kind of target criterion to solve for optimal inflation and output gap plan with its upper and lower limits and also the optimal instrument rate path with its upper and lower limits.

Even though this target criterion indicates that central bank's decision approach is the sequential optimization, i.e., the discretionary policy, however it has some form of prior commitment to constraint the optimal instrument path within the limits. When the limits are chosen once and for all, it implies that central bank specifies all of the alternative optimal instrument path. In each time of decision period, central bank will choose the specific optimal instrument path. It is still possible to choose different paths at each period as per the decision taken but the optimal instrument path is chosen from the same set in each period and hence, central bank shall follow this procedure in the days ahead. This can capture the reality that the FOMC tries to bring the forecast of target variables in line with its stated objectives but it will not be mechanically followed (Bernanke, 2015).

According to the criticism on discretionary policy, the discretionary policy is based on the approach of sequential optimization that can only design the individual policy action in each period (Kydland & Prescott, 1977). Any action in certain sequence will not relate with the prior action. Therefore the policy action will fail to internalize the consequence of the public expectation. As a consequence, recent literatures of monetary policy are focused on the analysis of monetary policy rule rather than discretionary policy. Although the target criterion in (4.3) indicates that central bank adopts sequential optimal approach (because it does not contain history dependent variable), but central bank constraints the policy by choosing optimal interest rate path from the same acceptable set. Therefore, the central bank's conduct is systematically predictable at some degree. For example, if the policy committee receives new non-quantitative information or judgment, they are not required to revise the projection as long as it does not make the original projection shift outside the limit. In addition, when central bank does not specify the judgment to the public, then even the policy committee selects new instrument path (in order to respond to the new non-quantitative information) while the private sector will not adjust their plans.

5.3. Micro-foundation of the new target criterion

Nowadays, there is a board agreement that monetary policy has important consequences for aggregate economic activities. As a result, the goal of monetary policy is not only to maintain long-run price stability but also to develop some degree of concern for stabilization of real economy in short-run. Despite central bank's concern with real economy, the purpose of monetary stabilization policy is to ensure stability of money value over the medium-run to long-run. The economic disturbances disrupt private sector's inflation and output plans. Indeed, this sort of uncertainty can discourage nominal contract and affect the efficiency of financial intermediations.

Therefore, in order to ensure stability of money value, the monetary policy needs to ensure an optimal adjustment to economic disturbances.

The most effective policy to maintain the public confidence of average rate of inflation over the medium-run term is commitment policy, namely, the timeless perspective approach (Woodford, 1999a) or commitment policy. This approach does not restrict the choice of instrument to depend on contemporaneous value of the shock but allows the instrument to respond towards the entire history of shocks. Therefore, the central banks that conduct policy in this way will constraint current policy with past action. This approach has target criterion as,

$$\pi_t^P - \pi^S = -\beta_1\left(x_t^P - x_{t-1}^P\right). \tag{4.4}$$

This target criterion indicates that the optimal policy under commitment requires adjusting the change in the output gap in response to inflation. The usefulness of constraint current policy (current output gap) with past action (previous output gap) is the ability of shaping private sector's expectation, so the expected output gap can be influenced by current inflation. Therefore, the central banks can partially adjust output gap (just the change in the output gap) in response to inflationary pressures (Clarida et al., 1999). Even though, central bank can manipulate private sector expectations directly by using this approach, but there may be some practical complications in implementing commitment policy (Clarida et al., 1999) and its interest rate rule might has undesirable side effect (the indeterminacy problem (Woodford, 1999b)).

Another problem that can affect ability of anchoring expectation of monetary policy is systematic biased problem (such as, when central banks aim to reduce inflation rate but their policy might in fact generate higher inflation, if the central banks measure potential output higher that it actually occurs). The reason that why systematic bias might happen, is that it could cause political interference (as illustrate in chapter 2) or it could be measurement error in the level of potential output (for example, it difficult for central banks to do real-time estimate of productivity trends (Woodford, 2007a)). Thus, the sign of biasness can be either positive or negative sign. The systematic biased problem might lead to systematic biased policy and the target criterion will not involve the desirable output gap level. Since, the immediate effect of policy actions depends on what it can signal about the future conduct of central banks. Thus, it will be inferior to make use of information about future. For example, when central banks cannot measure the potential output precisely, then they choose the optimal policy by discretion. These central banks will have the target criterion, as

$$\pi_t^P - \pi^S = -\beta_1\left(x_t^P - x^S\right). \tag{4.5}$$

Suppose that the desirable output target is zero and the x^S represents the systematic biased problem, namely, the amount of output gap's measurement error. It could have the positive or negative sign. This situation will lead to the problem of average systematic inflationary bias. If they know that the measurement of output gap target is not precise, they will also know about the degree of likelihood of imprecision as they judge whether or not the instrument path is acceptable. The appropriate

response of these central banks is that they do not change weight on output stabilization but they should take care of the use of estimated output target when they use target criterion, i.e., they should adjust the level of estimation to for the level of certainty about it (L. E. Svensson & Woodford, 2003).

The only way to avoid this error-collection, that occurs due to the systematic biased problem, is to make commitment to correct the past target misses (to correct the overshoot/undershoot). One possible way to institutionalize the error-collection would be to make commitment to target price level not just target inflation rate (Woodford, 2007a, 2013). However, this study recommends a new way to institutionalize the error-collection which is to control the accuracy of target criterion, as

$$\pi_t^P - \pi^S = -\beta_1\left(x_t^P - x^S\right) - \frac{1}{c}\Psi_t . \tag{4.6}$$

Denote that Ψ_t/c is the marginal effect of policy on accuracy of target criterion. Notice that the accuracy of target criterion can be viewed as the credibility of monetary policy because the target criterion is in the content that central banks communicate to the public about their future conduct of policy. Any mistake in signaling about future policy will damage central bank's credibility. In general, target criterion represents how central banks optimize their policy and how the central banks normally conduct their policy in order to make the society achieve the best feasible welfare level. Therefore, it is reasonable for central banks to control their projections in a way that can make the projections precise enough to eliminate the likely level of imprecision of output target. This approach imposes the basis of social optimal to judging whether instrument path is the acceptable as,

$$\beta_1 x^S = \frac{1}{c}\Psi_t . \tag{4.7}$$

As a consequence, target criterion will now turn to be (4.1). Moreover, central banks that adopt this approach need to control the accuracy of their target criterion as (4.3), i.e., they will commit to choose the optimal instrument path from same acceptable set of instrument path which depends on (4.7). In addition, this approach does not require to set targeted rate of inflation equaling to zero as in price targeting strategy. Some degrees of variation of inflation in short-run are desirable in some economy. For example, FOMC judges that annual inflation at the rate of 2 percent (as measured by the change in the price index for personal consumption expenditures, or PCE) is consistent with the price stability goal and maximum employment. Therefore, this approach requiring commitment to error-collection by controlling the accuracy of target criterion has greater advantage than the price targeting strategy. In the cases where some degree of inflation variation is inevitable or even desirable for economy, this approach aims to improve the real-time estimation of productivity directly and allows some inflation variation as well.

5.4. The baseline framework for analysis of new target criterion

This section characterizes the formal design of monetary policy. This study assumes that central bank that faces the problem of systematic bias will triy to minimize the objective function, i.e., the quadratic loss function, subject to their views of transmission mechanism and also commit to control the accuracy of the target criterion within some credible limits. In addition, this study assumes that central bank imposes the upper limit and lower limit on the target criterion in order to control the accuracy of target criterion. Thus, these limits capture the ideology in which central banks are required to balance the upside risk and downside risk of inflation in order to constraint the inflation tolerance.

Once the above optimization problem is solved and the optimal bandwidth is determined, the central bank will make the commitment to follow the target criterion with optimal bandwidth, and follow it ever after. Therefore, central banks will announce the target type, i.e., the point target with inflation tolerance. Central banks design monetary policy by discretion with some degree of commitment to control the accuracy of target type (or constraint discretion (Bernanke & Mishkin, 1997)) and set the width of band in a way that controlling accuracy of target criterion can offset the likely degree of systematic bias on output gap target. On possible way to describe this procedure in theoretical monetary policy model is to employ the idea of optimal inflation contract (Walsh, 1995b) in which inflation deviation (amount of gap between inflation rate and its target value) must depend on economic conditions (Walsh, 1995a). In addition, assuming that central banks adopt inflation tolerance that coincides to the economic conditions is not overstated because the recent monetary policy follows the idea of "targeting rules". Central bank tries to control inflation gap in line with other target variables as the optimality condition (or approximate of its) that guarantees the efficient way to trade-off between inflation and other target variables (Lars E. O. Svensson, 2003). However, central banks that commit to targeting rule need not follow it mechanically. This indicates that they will partially commit to this rule, and have some flexibility to use in departure from it. Therefore, it is possible to represent this fact in terms of the target criterion with an upper and lower limit.

To represent this behaviour, the idea of nonlinear inflation contract, which is a sub class of inflation contract (Westelius, 2008)) has been combined with a focus on how the two sides of tolerance band are simultaneously determined (Mishkin & Westelius, 2008). However, it must, somehow, determine the bandwidth by the method optimization (Walsh, 2002). In addition, It is assumed that:

- Central banks must have the typical quadratic loss function
- Inflation tolerance band is based on ideology of targeting rule
- Central banks must balance the upside/down side risk
- Central banks cannot specify their judgment to the outside observer

The first assumption implies that the optimal monetary policy can allow society achieve the maximum welfare under the constraint of monetary policy (Rotemberg & Woodford, 1997). The second assumption captures the fact of the recent monetary

policy. The third assumption requires for central banks to not necessarily implement an inordinate policy. The last assumption describes the nature of judgment that is difficult to explain to outside observers. In addition, this study uses three examples of strand models for transmission mechanism including;

- The static transmission mechanism
- The dynamic transmission mechanism with forward-feedback and shock persistent
- The dynamic transmission mechanism with backward-feedback with additive shock persistent and multiplicative uncertainty

The first transmission mechanism often uses in the inflation targeting literatures (Lars E. O. Svensson, 1997b). The second transmission mechanism is the conventional macroeconomics literature (Clarida et al., 1999). The last transmission mechanism captures the constraint that central banks face in the real word (Brainard, 1967; Söderström, 2002; Lars E. O. Svensson, 1997a, 1999, 2003). Summarily, the character of these transmission mechanisms can be shown as,

Table 5.1 The character of transmission mechanisms

Property of transmission	Static mechanism	Dynamic mechanism Forward-looking	Dynamic mechanism Backward-looking
	Model No.1	Model No.2	Model No.3
Persistent of shock	(n.a.)	Autoregressive	Autoregressive
Feedback	(n.a.)	Forward-feedback	Backward-feedback
Uncertainty	Additive	Additive	Additive Multiplicative
Control lag	(n.a.)	(n.a.)	One-period lag

Note that: “(n.a)” is refer of that character is not avertible in the model.

Changing transmission mechanism will help clarify what the inflation tolerance band can and cannot do in order to cope with these problems. This section informs how the methodology in this study has been set up. In the next section, the results obtained from each part of the study will be compared.

5.5. Inflation tolerance band mechanism

This section aims to clarify how band targeting responds to the policy environment. For example, how central banks’ incentive in this regime changes when the factor that is responsive to political interfere changes or to what direction of the size of band changes in order to response to the increase in shock persistency etc. In addition, the band targeting has two mechanisms to determine the size of band. Firstly, the incentive mechanism is influenced by the policy credibility that helps central banks to keep a balance between their goals of monetary policy. This mechanism is based on the implicit assumption that central banks’ objective is similar

to the society goals. Then, if central banks have a good reputation as the disciplinary policy maker, they will gain the formal and/or informal benefit.

According to table 5.2, a private benefit will draw an attention of central banks to preserve policy credibility when they get political interference. For example, when governments pressure them to increase awareness in short-run economic fluctuation, this implies that central banks must increase the weight on economic stabilization goal. In this situation, private benefit, i.e., the long-run benefit of central banks from preserving policy credibility, will increase to deflect them from the attention in creating inflation bias (prevent them to please their government by generating temporary economic growth). Moreover, when government assigns the output target level to the central bank, it is possible that government may assign the target level that is higher than desirable level, e.g., full employment level, in order to gain a political popularity. Then, the private will increase to prevent the inflation bias problem.

Table 5.2 The reaction of private benefit

Factor	Model No.1		Model No.2		Model No.3	
	Relation	Character	Effect	Character	Relation	Character
Relative weight on economic stabilization goal (λ)	+	L	+	N	+	N
Output target (x^S)	+	L	+	L	+	L
Policy pass through (a)	+,-	Q	-	N	…	…
Inflation forecast error (σ)	+	L	+	N	+	N
Relative weight on upside risk (ω)	-	L	-	L	-	L
Time preference (ρ)	+	N	-	N	0	(n.a.)
Accountability cost (c)	-	N	-	N	-	N
Shock persistent (ϕ_ε)	…	…	+	N	-	N
Inflation feedback (a_π)	…	…	…	…	-	N
Mean of policy pass through (a_x)	…	…	…	…	+,-	Q
Variance of policy pass through (σ_η)	…	…	…	…	0	(n.a.)

Note that "+" define as positive relationship, "-" define as negative relationship, "0" define as no significant relationship and "N", "L" ,"Q" mean nonlinear, linear, and quadratic character respectively. "…" is none of this factor found in the model. "(n.a)" is refer of that character is not avertible in the model.

In case where policy pass-through rate (or the expected pass through rate) increases[31], central banks' private benefit will react in different ways. Still, as long as the size of policy pass-through dominates the marginal rate of substitution,[32] private benefit will increase. This effect will lessen the incentive in setting too high inflation gap which is the gap between inflation rate and its target.

Since, the private benefit represents the expected long-run gain from credibility, it can response to the change in inflation forecast error. If inflation forecast error increases (the chance that inflation will miss the band increase), private benefit will increase in return to central banks' that will be more prudentially implement their policy. This captures the idea that band targeting should relates to the variance of inflation (Erceg, 2002). Nevertheless, it is possible to say that the private benefit does not response to all types of uncertainty. This study shows that the private benefit does not significantly respond to the variance of parameter uncertainty.

The effect of inflation speed-of-adjustment on band targeting depends on transmission mechanism that central banks' faced (Dennis, 1997). Further looking at the case, the shock persistent rate represents the inflation's speed-of-adjustment, i.e., higher the persistency of shock, lower the speed-of-adjustment. Therefore, when inflation slowly adjusts to the band, private benefit will increase. On the other hand, the inflation feedback represents the inflation's speed-of-adjustment in case of backward-looking. In case of backward-looking, central banks' try to prevent the future cost of inflation bias. Therefore, when the inflation is persistent, the inflation rates in the future will not change too much. The private benefit in this case will decrease.

Moreover, private benefits can response to the degree of strict discipline of central banks; namely, the degree of strict discipline is politely related to the accountability cost. Therefore, the central bank, that naturally pays attention on their performance, does not need any incentive mechanism. However, the private benefit responds to the lack of economic agent's foresight in different ways. It considerably depends on the mechanism that central bank faces.

To sum up, the reaction of private benefit on most of economic factors are robust even if the transmission mechanism, which central bank faced, changes. Since, the private benefit is a channel of the band targeting mechanism, the robustness of this channel will encourage the robustness of the band targeting mechanism.

The size of the bandwidth itself is another channel of the band targeting mechanism. When bandwidth becomes narrower, it implies that the inflation gap[33] will be smaller. The more the smaller inflation gap, the more lesser will be the response of inflation with output gap. Therefore, the band targeting has some

[31] Suppose that may firms can adjust their optimal price of output (Calvo, 1983).

[32] This mechanism is based on marginal principle of policy design (Lars E.O. Svensson, 2010)

[33] This is the distant between inflation and its target.

characters from “conservative weight” (Barro & Gordon, 1983) and “inflation contract” (Walsh, 1995b). However, band targeting is neither rigid as “conservative weight” nor costly as “inflation contract”. Therefore, it can bring the second-best equilibrium to the society (as inflation contract) at its best, or at least it can bring the third-best equilibrium to society (as conservative weight).

Unfortunately, the react of bandwidth to the change of economic environment in each transmission mechanism is not robust. Without the problem of control lags, the bandwidth reacts with the change in economic environment under the static mechanism mostly in the same manner as it does under the forward-looking mechanism. It is noticed that the bandwidth does respond to the change in output gap target when the policy mechanism has the feedback loop.

In general, when the relative weight on real stabilization increases amount of inflation gap (the distant between inflation rate and its target) will be increases as well. Therefore, the bandwidth responds to this change by increasing its size to be wider (as see in the static model and forward-looking model). However, when central banks are unclear about their views of transmission mechanism their band width internalizes the effect of structural change by including all the structural parameters in the variation of the bandwidth. In this case, the increase in relative weight of real stabilization can lead to the decrease of bandwidth’s variation. The effect of changing in bandwidth’s variation often dominates other ways of change, so it squeezes the size of bandwidth.

The effect of output target biased (the amount of output target that deviate from natural employment level) can lead to the decrease in the size of bandwidth in the simple statics model. Unfortunately, the size of bandwidth in dynamic model (either the forward-looking or the backward-looking model) is not sensitive to the change in output target biased, i.e., bandwidth is caution change in response to the change of this variable.

When the policy pass-through rate or even its mean increases, it will make inflation rate adjust to the policy more quickly, as long as pass-through rate greater than the relative weight on real stabilization. The greater size of pass-through rate is the shorter horizons of inflation rate that will return to its target, if this rate is greater than relative weight on real stabilization. When central banks have clearly views of the transmission mechanism, increase in the rate of policy pass-through will lead to increase the size of bandwidth, namely, central banks have winder set of optimal instrument paths when their policy is more effective. If they have unclear views of transmission mechanism, they need to estimate this pass-through rate. However, when the mean of this estimation increase, it also increases the variance of projected economic evolution. Thus, the size of bandwidth in this case will decrease in order to response in the increase in estimated rate of policy pass-through. On the other hand, when central bank is more uncertain about how their policy pass-through the inflation rate, then it will not suitable to commit on narrow band. In other words, the size of bandwidth needs to increase in response to higher degree of uncertainty of pass-through rate.

This study assume that central banks' balance is either inflationary or deflationary risk by tradeoff between loosen (tighten) the upper limit of inflation and tighten (loosen) the lower limit of inflation. This tradeoff character cause the bandwidth unresponsive in either change of relative weight on upside or downside risk. For example, if the of relative weight on upside risk increases, the band of inflation will roll down with the same size of width. In addition, the characteristic of unresponsiveness of bandwidth can be found when accountability cost changes. Because of this study, we assume that central bank will control the accuracy of target criterion in the way that can solve the problem of systematic biased on output target for any given accountability cost. Therefore, the accuracy will depend on the likely degree of systematic biased on output target rather than the level of accountability cost.

In backward-looking transmission mechanism, higher feedback of inflation rate means the slower adjustment of inflation rate. The slow rate-of-adjustment of inflation rate could leads problem on the effectiveness of policy. When inflation rate temporary increase in response of economic disturbances, the public have reason to believe that inflation will not be stable on long-run rate quickly. The departure of inflation rate from average rate has large effect on expected inflation thus monetary policy have a little effect on short-run real activity. Therefore, it is incredible for central bank to commit to controlling inflation inside the narrow bandwidth. In this situation, central banks will possibly enlarge their committed bandwidth. In forward-looking transmission mechanism, the rates of the cost push shock persistency can represent the rate-of-adjustment of inflation rate. The higher rate of persistency, slower the inflation adjustment. Unfortunately, the changes in cost push shock persistency does not affect the size of bandwidth at all. It is the puzzle mechanism of this study. On other hand, changing in cost push persistency affects the variation of bandwidth in the backward-looking model and cause squeezer on the side of bandwidth.

In statics model and forward-looking model, central bank concerns in problem of systematic biased that could lead to damage on their policy credibility in the future. When these two situations, i.e., the systematic biased of output gap and the damage of policy credibility, are taking place in different period, the time preference will be included in decision making. When central bank is less foresight, they may think that the systematic biased of output target has little effects on the future policy credibility, so it is not necessary to have variety of interest rate path in the committed set. Therefore, the bandwidth will be narrower. However, in the backward-looking model, central bank will estimate the bandwidth to buffer the effect of future inflation. Thus, the systematic biased of output gap and the damage of policy credibility takes place in the same period. The time preference do not have any roles in the decision making. The bandwidth dose not respond to any changing in time preference parameter.

In conclusion, the band targeting is working through two mechanism channels; namely, the first is private benefit mechanism, which is the incentive mechanism channel. The second is bandwidth mechanism, which is mandatory mechanism. In addition, the private benefit mechanism is more robustness than the bandwidth mechanism. Thus, the robustness of this policy strategy will depend on which channel is the most influential in the economy.

Table 5.3 The reaction of bandwidth

Factor	Model No.1		Model No.2		Model No.3	
	Relation	Character	Effect	Character	Relation	Character
Relative weight on economic stabilization goal (λ)	+	R	+	R	-	R
Output target (x^S)	-	S	0	(n.a.)	0	(n.a.)
Policy pass through (a)	+	R	+	R	…	…
Inflation forecast error (σ)	+	R	+	R	-	R
Relative weight on upside risk (ω)	0	(n.a.)	0	(n.a.)	0	(n.a.)
Time preference (ρ)	+	S	+	R	0	0
Accountability cost (c)	0	(n.a.)	0	(n.a.)	0	0
Shock persistent (ϕ_ε)	…	…	0	(n.a.)	-	R
Inflation feedback (a_π)	…	…	…	…	+	R
Mean of policy pass through (a_x)	…	…	…	…	-	R
Variance of policy pass through (σ_η)	…	…	…	…	+	R

Note that "+" define as positive relationship, "-" define as negative relationship, "0" define as no significant relationship and "R", "S" mean reshape and shift of the net marginal benefit function respectively. "…" is none of this factor found in the model. "(n.a)" is refer of that character is not avertible in the model.

5.6. Suitability of inflation tolerance band-targeting

The inflation targeting nowadays implies to the inflation-forecast targeting. The forecast of future economic conditions helps the central banks to communicate with the public. The public can use the projections to justify how central bank conducts the monetary policy. For example, central banks in the inflation-targets the countries to publish their projections in the inflation report. As result of this communication, central banks can have a clear commitment about the average inflation rate (over the medium-to-long term), and it will somehow stabilize inflation expectation. On the other hand, it will increase an ability of the monetary to affect real activity in the short run and increase the possibility that the target variables will achieve its target level in the long run.

However, central banks in reality have neither the well-defined loss function nor the correct economic model. These problems can harm the credibility of central banks' projections and loosen an ability to shape the public's expectation. Moreover, even central banks can have the well-defined loss function and the correct economic model; they still have the problem of "intertemporal consistency problem". The intertemporal inconsistency problem means that central banks' change their decision overtimes, so they cannot maintain their operation as in the previous path. Besides, the new policy path will not consist of the previous projections. For example, when the monetary policy committee selects the policy path by voting, this cannot guarantee that the committee will optimize the policy correctly.

According to this problem, if the inflation tolerance band-targeting is suitable enough, then it must help central banks to correct this problem. The tolerance band targeting must have some properties so as to correct the problem. They are:

- The dual mandate of the target criterion,
- The sequential of target criterion that corresponds to a sequence of optimality conditions, and
- The robust of optimal policy.

Firstly, the dual mandate property means that the target criterion must reflect the aim of central banks to balance their goals, e.g., the targeting rule specifies how central banks systematically treats the inflation gap and output gap.

Secondly, the corresponding of sequence of target criterion and sequence of optimality conditions means the first-order condition of dynamic optimization under commitment. That specifies how to balance inflation and output gap in the near-term and also guarantee that inflation and output gap will approach its target level in long-term.

Thirdly, the robustness of optimal policy means that the projection should allow central banks to use their judgment when the economic structure changes.

Although, the inflation tolerance band targeting has some degree to solve the problem of intertemporal consistency problem, i.e., central banks that adopt this approach will commit to choose the optimal interest path rate in common set overtime, but its mechanism differs across the different views of transmission mechanism. To be specific, the private benefit channel seems to have higher robustness than the bandwidth channel. Thus, in order promote the robustness of tolerance band-targeting mechanism we need to promote the working of private benefit channel. One possible way to promote the private benefit channel is perhaps increasing the number of monetary policy committee who have great distaste in losing policy credibility. Losing policy credibility depends on how strongly the influence of cost of unexpected inflation on economy. Normally, the unexpected inflation could lead to redistribution of wealth from lenders to borrowers and it could be problematic on decision making of any individual who have fixed nominal contracts. When monetary policy committee has the many member who has great distaste of inflation in these ways will increase the concern in the cost of unexpected inflation into policy deliberation. Perhaps, the external committee who has experienced working from

financial institution may concern the effect of losing policy credibility in these perspectives.

Since, the credibility of policy is attained when the public agree that the central bank's actions are consistent with reaching the goals. We see how we internalize the credibility of policy into central bank's decision. The one possible answer is to create institutional arrangement for policy deliberation that emphasis the value of establishing policy credibility, such as Reserve Bank of New Zealand Act of 1989 (Walsh, 1995a).

Another possible way to promote band-targeting mechanism is to increase the degree of transparency in monetary policy which is the explicit communication about the reasoning behind decisions. For example, European Central Bank already gives the statement about the intermediate thresholds, i.e., the target criterion, as additional policy (Woodford, 2013). Notice that this kind of commination is relate to information of the likely forward path of short-term interest rates on regular basis. However, the number of possible states is very large and the central banks need to think about the type of situation which they have little prior though (Woodford, 2013). Therefore, the target criterion needs to have some degree of explicit formula that prescribes the possible actions in any circumstance, such as, the target criterion with its boundaries.

In this study, the inflation tolerance band target is the targeting rules that have credible limits to depart from. In addition, the midpoint of the band resembles the targeting rule under discretionary policy, so it has a dual mandate at least on the midpoint. Moreover, this band has a clear motion of inflation and output[34]. If central banks control inflation and output gap inside the band, it can specify at least the approximation range of inflation and output gap in near-term to long-term. Besides, the tolerance band target is designed for the use of judgment. Therefore, it supports the case that central banks' need to depart from their target criterion. To summarize, the inflation tolerance band targeting has the intertemporal consistency property.

[34] Clear motion of inflation rate can alleviate the problem that the band targeting inflation can leads to a symmetry between inflation target and zones for nominal exchange rate (Gerlach, 1994).

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APPENDIX

Table 1: Target type and state of development 2012

Target type	State of development	Country	Target 2012
Point	Emerging and developing economy	Hungary	3%
	Industrialized economy	Iceland	2.50%
		Norway	2.50%
		Sweden	2%
		United Kingdom	2%
Point with Tolerance	Emerging and developing economy	Armenia	4% ±1.5 pp
		Brazil	4.5% ±2 pp
		Chile	3% ±1 pp
		Czech Republic	2% ±1 pp
		Ghana	8.7% ±2 pp
		Guatemala	4.5% ±1 pp
		Indonesia	4.5% ±1 pp
		Mexico	3% ±1 pp
		Peru	2% ±1 pp
		Philippines	4.0% ±1 pp
		Romania	3% ±1 pp
		Serbia	4.0% ±1.5 pp
		Thailand	3.0% ±1.5 pp(a)
		Turkey	5.0% ±2 pp
	Industrialized economy	Canada	2% (mid-point of 1%–3%)
		Poland	2.5% ±1 pp
		South Korea	3% ±1 pp
Range	Emerging and developing economy	Colombia	2%–4%
		South Africa	3%–6%
	Industrialized economy	Australia	2%–3%
		Israel	1%–3%
		New Zealand	1%–3%

VITA

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