Essays on Inflation and Monetary Policy

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the
Graduate School of The Ohio State University

By

Junhan Kim, B.A., M.A.

* * * * *

The Ohio State University

2003

Dissertation Committee:
Stephen G. Cecchetti, Adviser
J. Huston McCulloch
Pok-sang Lam

Approved by

Adviser
Department of Economics
© Copyright by

Junhan Kim

2003
ABSTRACT

Despite the success of inflation targeting in the 1990s around the world, recognizing the weaknesses of inflation targeting, many have argued that more refinements are needed.

When output is persistent, inflation targeting tends to have high long-run inflation volatility. So price-path targeting, which promises lower inflation volatility, can be considered as an alternative. However, I argue that an optimally chosen hybrid of inflation targeting and price-path targeting gives even lower inflation volatility.

Another weakness of inflation targeting is that central bankers, when left to act under discretion, tend to create a bias toward output stabilization. Therefore, I argue that central bankers should be appropriately conservative, and the level of conservativeness depends on output persistence. Also, I show that there is a close relationship between central bankers’ conservativeness and the horizon over which price level is brought back to the desired path.

One of the important aspects of inflation targeting is that it is inherently forward-looking. So, this requires a good inflation forecast, such as trimmed mean estimators suggested here. I show several methods of finding these trimmed mean estimators of inflation, which are more efficient than headline CPI inflation.

However, these suggestions and elaborations should be implemented together with measures to earn the public’s trust, without which success cannot be guaranteed.
That is, central banks need to find the right balance between performing monetary policy optimally and earning the public’s trust.
This is dedicated to my wife Yoonjeong.
ACKNOWLEDGMENTS

I have had so much helps from many people that I cannot go on without expressing my gratitude.

First and foremost, my deepest gratitude is to my advisor, professor Stephen Cecchetti, who has provided me with crucial and invaluable suggestions in every step of my work.

I also thank Roisin O’Sullivan, Stefan Krause, and Lianfa Li, who have helped me in various ways in and out of our weekly meetings.

My family, my wife and my precious two daughters, Hena and Hesuh, deserve my deepest love and gratitude, for they’ve suffered too much by a deserting husband and father.

I owe so much to so many that I cannot list all I should acknowledge. I thank them sincerely.
VITA

July 13, 1965 .................................. Born - Seoul, Korea

1989 ........................................... B.A. Yonsei University, Seoul, Korea

1989 ........................................... Joined The Bank of Korea, Seoul, Korea

1992 ........................................... Trainee at Commerzbank, Frankfurt am Main, Germany

1994 ........................................... Trainee at Bureau of Economic Analysis, Washington D.C.

2000 ........................................... M.A. The Ohio State University

2000 - present .............................. Graduate Teaching Associate, Graduate Research Associate, The Ohio State University

FIELDS OF STUDY

Major Field: Economics

Studies in:

  Monetary Policy
  Macroeconomics
# TABLE OF CONTENTS

Abstract ........................................................................................................ ii
Dedication ........................................................................................................ iv
Acknowledgments ............................................................................................. v
Vita ...................................................................................................................... vi
List of Tables ..................................................................................................... x
List of Figures .................................................................................................... xi

Chapters:

1. Introduction ................................................................................................... 1

2. Inflation Targeting, Price-path Targeting and Output Variability .............. 6
   2.1 Introduction ............................................................................................... 6
   2.2 Hybrid Targeting ....................................................................................... 11
      2.2.1 The Central Banker’s Problem ......................................................... 11
      2.2.2 Society’s Problem ............................................................................ 15
      2.2.3 Stabilization Bias ............................................................................ 16
   2.3 Empirical Results ....................................................................................... 18
      2.3.1 Closed Economy ............................................................................. 18
      2.3.2 Open Economy ............................................................................... 23
      2.3.3 Loss Comparison ............................................................................ 26
   2.4 Conclusion ................................................................................................. 31
3. Conservative Central Bank
   and Targeting Horizon ........................................ 32
   3.1 Introduction .................................................. 32
   3.2 Optimal Conservativeness ..................................... 36
      3.2.1 Optimal Rule ............................................ 37
      3.2.2 Society’s Problem ......................................... 38
      3.2.3 Simple Rules ............................................. 41
      3.2.4 Simple Rule with Output Persistence ..................... 42
      3.2.5 Optimal Rule ............................................ 45
   3.3 Interpretation of Conservativeness ............................ 47
      3.3.1 Illustration ............................................... 48
      3.3.2 Optimal Horizon and Hybrid Targeting ................. 51
      3.3.3 Optimal Horizon and Conservativeness .................. 52
   3.4 Conclusion ..................................................... 53

4. Efficient Estimation of Inflation:
The Korean Case .................................................... 54
   4.1 Introduction .................................................. 54
   4.2 Efficient Estimators of Core Inflation ....................... 56
      4.2.1 Optimal Trim ............................................ 57
      4.2.2 Bias and Asymmetric Trimming .......................... 57
      4.2.3 Biased Trimming ......................................... 59
      4.2.4 Trimming with Changing Weights ....................... 59
   4.3 Application: Korea’s Case .................................... 61
      4.3.1 Price Change Distribution: Korea’s CPI ................ 62
      4.3.2 Symmetric Trimming .................................... 64
      4.3.3 Asymmetric Trimming ................................... 65
      4.3.4 Biased Trimming ......................................... 67
      4.3.5 Trimming with Changing Weights ....................... 68
   4.4 Conclusion ..................................................... 69

5. Conclusion .......................................................... 71

Appendices:

A. The Data Description for Chapter 2 ................................ 73
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Output Persistence: The Closed Economy Case</td>
<td>21</td>
</tr>
<tr>
<td>2.2</td>
<td>The Optimal Hybrid-Targeting Regime: The Closed Economy Case</td>
<td>22</td>
</tr>
<tr>
<td>2.3</td>
<td>Output Persistence: The Open Economy Case</td>
<td>24</td>
</tr>
<tr>
<td>2.4</td>
<td>Optimal Hybrid-Targeting Regime: The Open Economy Case</td>
<td>25</td>
</tr>
<tr>
<td>2.5</td>
<td>Loss Comparison</td>
<td>28</td>
</tr>
<tr>
<td>4.1</td>
<td>Moments of Price-change Distribution of Korean CPI</td>
<td>62</td>
</tr>
<tr>
<td>4.2</td>
<td>Efficiency(RMSE) Gain by Trimming</td>
<td>63</td>
</tr>
<tr>
<td>4.3</td>
<td>Bias of Trimmed Estimator</td>
<td>65</td>
</tr>
<tr>
<td>4.4</td>
<td>Asymmetrically Trimmed Mean Estimator</td>
<td>67</td>
</tr>
<tr>
<td>4.5</td>
<td>Estimator with Biased Asymmetrical Trimming</td>
<td>68</td>
</tr>
<tr>
<td>4.6</td>
<td>Changing Weights and Symmetrical Trimming</td>
<td>69</td>
</tr>
<tr>
<td>A.1</td>
<td>Annual Inflation Target</td>
<td>74</td>
</tr>
<tr>
<td>C.1</td>
<td>Optimal Hybrid-Targeting Regime: Closed Economy with Core CPI</td>
<td>79</td>
</tr>
<tr>
<td>C.2</td>
<td>Optimal Hybrid-Targeting Regime: Open Economy with Core CPI</td>
<td>80</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Central Bank’s λ</td>
</tr>
<tr>
<td>2.2</td>
<td>Loss comparing Targeting Regimes with Optimal Targeting</td>
</tr>
<tr>
<td>3.1</td>
<td>Inflation Gain under Optimal Hybrid Targeting</td>
</tr>
<tr>
<td>3.2</td>
<td>Conservativeness under Simple Rule with Output Persistence</td>
</tr>
<tr>
<td>3.3</td>
<td>Optimal Conservativeness under Optimal Rule with Output Persistence</td>
</tr>
<tr>
<td>3.4</td>
<td>Conservativeness under Inflation Targeting</td>
</tr>
<tr>
<td>3.5</td>
<td>Conservativeness under Price-Path Targeting</td>
</tr>
<tr>
<td>3.6</td>
<td>Conservativeness under Hybrid Targeting</td>
</tr>
<tr>
<td>4.1</td>
<td>Monthly CPI with 24 month Centered Moving Average</td>
</tr>
<tr>
<td>4.2</td>
<td>RMSE of Biased Asymmetric Trimming</td>
</tr>
<tr>
<td>4.3</td>
<td>RMSE of symmetrically trimmed estimator</td>
</tr>
<tr>
<td>4.4</td>
<td>Mean Percentile of Monthly CPI</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Maintaining low and stable inflation is believed to be the most important goal of central banks, while other goals include stabilizing output close to its potential level and stabilizing the exchange rate. Although wide adoption of inflation targeting in the 1990s has helped lowering and stabilizing inflation in many countries, including the United States, the central banks' fight against inflation is hardly over.

It is certainly not new to anyone that lowering and stabilizing inflation is central banks' main concern, even before central banks began adopting inflation targeting. However, inflation-targeting central banks can convince the public that they are really serious about lowering and stabilizing inflation by announcing an inflation target, working to achieve that target, and being held accountable when the target is missed.

Despite its success in the 1990s, inflation targeting is not without its weaknesses. First, inflation-targeting central banks tend to forgo the past misses of the inflation target, and when these uncorrected misses are added up, price volatility becomes very large, or even infinite, in the long-run.

Second, central banks tend to achieve their goals, maintaining low and stable inflation and stable output, by taking discretionary actions. This means that although

\[1\text{See Mishkin and Schmidt-Hebbel (2001).} \]
central bankers are implicitly given their goals by society, they are not given instructions for day-to-day functions. These are left to central bankers’ discretion. Although this is not specific to inflation-targeting central banks, it becomes more distinctive under inflation targeting. It is well known that discretionary central banks, doing their best at the present, may perform less than optimally in the long-run.

Recognizing these weaknesses, researchers have suggested various remedies, including price-path targeting in place of inflation targeting, and appointing central bankers who are more conservative than the general public.

While inflation-targeting central banks ignore the past shocks and misses in inflation, and only stabilizes current and future inflation, price-path targeting central banks would reverse the past shocks and misses in inflation to bring the price level back to the desired price-path.

Many researchers, including Svensson (1999), Dittmar, Gavin and Kydland (1999), Dittmar and Gavin (2000), and Parkin (2000), have shown that price-path targeting gives better long-run performance in stabilizing inflation than inflation targeting does. I go further, in this dissertation, and argue that a hybrid of inflation targeting and price-path targeting gives even better results not only compared to inflation targeting, but compared to price-path targeting as well.

Another series of suggestions concerning the problems arising from discretionary central banks is a so-called conservative central bankers argument. Rogoff (1985) and Svensson (1997) show that appointing central bankers, who are more adverse to inflation than the general public is, will achieve a lower and more stable inflation.

I not only confirm Rogoff (1985) and Svensson’s (1997) results and show that there is an optimal level of conservativeness for central bankers, but also give the
derivation of that level. Then, I go further to claim that this level of conservativeness can be alternatively viewed as the targeting horizon\(^2\) introduced by King (1999), who defines it as the time needed for the price level to get back to the desired price-path.

One of the key factors in determining an optimal hybrid of targeting regimes and optimal conservativeness is output persistence, which is defined as how long an output shock lasts.

Under high output persistence, which is common in data for many countries, the optimal hybrid targeting is closer to price-path targeting. Focusing on stabilizing current inflation, inflation-targeting central banks tend to ignore past shocks. When added over a long period, these forgone shocks would be large enough to make long-run inflation volatility very high. On the other hand, price-path targeting central banks would reverse a shock right away by creating a price surprise. Short-run inflation may become volatile as a result of this price surprise, but long-run inflation volatility will be lower than that under inflation targeting, since no shocks are to be accumulated.

However, when output is not so persistent, unreversed shocks are not accumulated, and do not have a long-run effect on inflation volatility. Reversing each shock only creates excess short-run volatility in inflation. Facing this trade-off between short-run and long-run volatility in inflation, central banks can minimize the volatility in inflation by reversing a fraction of past shocks. This is the optimal hybrid targeting.

Output persistence is also a key factor in determining the optimal conservativeness. When output is persistent, output volatility becomes very large, so central bankers, acting under discretion, tend to place too much weight on output stabilization and too little weight on inflation stabilization. This will result in too high

---

\(^2\)King (1999) called it simply the horizon, but I use the term the targeting horizon to emphasize that a central bank is targeting a price level over this horizon.
inflation volatility. Society can reduce this higher-than-optimal inflation volatility by appointing central bankers who place very high importance on inflation stabilization.

These suggestions and elaborations come with a great caveat in part because we do not have a definite understanding of the structure of the economy. But, more importantly, this is because when central banks (re)act to fluctuations in the economy, they are dealing with people rather than just a structure or institutions. Monetary policy is built on trust, not unlike money or the financial system. It is not difficult to imagine what the world would be like when people have no trust in money and the financial system, and, it is also not difficult to conceive the consequences on the economy when the central bank loses the public’s trust.

Therefore, central banks need to find the right balance between performing monetary policy optimally and earning the public’s trust. No matter how good a monetary policy may be, if it lacks transparency, it cannot gain the public’s trust. Without it, a policy is doomed to fail.

Inflation targeting, or any other targeting regime in this regard, needs to lay out a straightforward target to achieve and a mechanism through which central banks are held accountable for the outcome. Since elaborate targeting frameworks, such as the ones suggested in this dissertation, are particularly at risk of losing transparency, improving existing targeting regimes without losing a good dialogue with the general public is greatly valued.

This dissertation consists of 3 papers. The first paper discusses an optimal hybrid of inflation targeting and price-path targeting. Although inflation targeting was successful in the 1990s, it is possible to improve the central banks’ performance by adopting a hybrid targeting regime that can yield lower and more stable inflation. I
derive the optimal level of the hybrid and claim that the more persistent output is, the closer a targeting regime gets to price-path targeting.

The second paper discusses the conservativeness of central bankers. When central bankers are discretionary, then there could be a social welfare gain by appointing conservative central bankers, who are more adverse to inflation than the general public is. I derive the optimal level of conservativeness and argue that the more persistent output is, the more conservative central bankers should be. I further argue that a high (low) level of conservativeness is equivalent to have a short (long) targeting horizon, over which the price level is brought back to the desired price-path.

The third paper discusses methods of estimating better measures of inflation. Accurate measurement and forecast of inflation are crucial in achieving low and stable inflation. This is especially true for inflation targeting, since the forward-looking nature of inflation targeting requires a reliable inflation forecast, and also verifying central banks’ performance requires an accurate measurement of inflation. I show that averaging the price changes after trimming the tails of the price change distribution gives a better estimator than from simple averaging.

In the final chapter, I summarize these three papers and offer my conclusions.
CHAPTER 2

INFLATION TARGETING, PRICE-PATH TARGETING AND OUTPUT VARIABILITY

2.1 Introduction

The 1990s were amazing in many ways. Not only did the internet and cellular phones come into widespread use, but overall economic conditions improved nearly everywhere we look. Growth was higher, inflation was lower, and both were more stable. In the U.S., for example, inflation fell from 6 percent at the beginning of the decade to less than 2 percent by the end. Meanwhile real growth rose from less than 3 percent to over 4 percent. And volatility declined, too. The American case is the most dramatic of what has really been a world-wide trend. And while these improvements in economic performance could have been the consequence of the world being calmer, Cecchetti, Flores-Lagunes and Krause (2002) argue that roughly three-quarters of it can be explained by better monetary policy. That is, central bankers did a better job of stabilizing inflation at low levels while keeping growth high.

Cecchetti and Ehrmann (2002) compare the 1985 to 1989 period with 1993 to 1997 for a set of 23 industrialized and emerging market countries and find that annual inflation fell by an average of five percentage points, annual growth rose by an average of one percentage point, and both were significantly more stable.
Making better monetary policy is not just a problem of finding competent central bankers. In fact, there is a history of central bankers who tried to do their jobs, but were thwarted by politicians. Over the years we have learned that the institutional environment is at least as important as the people in insuring good policy outcomes. Without a well-designed central bank, the people in charge don’t have a chance. Today, we have a good sense of what best practice is in the design of central banks. First, it is crucial that monetary policymakers are independent of short-term political influences. Second, these independent central bankers must be held accountable through mechanisms that involve public announcement of objectives. Inflation targeting is the most common formulation of the sort of policy regime in place today.\(^4\)

The primary element of inflation targeting is a public commitment to price stability in the form of a medium-term numerical inflation target.

With the success of inflation targeting has come a discussion of potential refinements. One issue is whether the central bank should adopt a target for inflation or a target for the path of the price level. With an inflation target, the central bank simply tries to insure that period-by-period inflation remains close to the target. When inflation turns out to be above or below the target, the miss is forgotten. Bygones are bygones, so there is a form of base drift in the (log) price level. Price-path targeting, or “price-level targeting” as it is often called, is different as it implies that when the price level is above or below the target path, the objective of policy is to return it to the preset target path.\(^5\) This means that if prices move above the target path, then

---

\(^4\)For a brief synopsis of what inflation targeting entails see Mishkin (forthcoming).

\(^5\)I adopt the terminology price-path targeting rather than the traditional price-level targeting to emphasize that the target path can have a positive slope and so a period of inflation need not be countered with one of deflation.
policy will need to bring them back down. But which one is better? Should central banks be instructed to target inflation or target the price path?

Svensson (1999a) is the first person to take on this question. He starts by assuming that society actually cares about inflation. The social objective is to minimize the expected present discounted value of the weighted average of squared deviations of inflation and output from their targets. He then posits that the central bank can be bound to meet a particular objective, but not to respond to shocks in a specific way. That is, the central bank will always have discretion in adjusting its instrument, but it can be held accountable for its objective. This sort of discretion, what we might refer to as “instrument discretion,” implies that if we were to instruct central bankers to minimize the true social loss function, there would be a bias. The exact form of the bias depends on the structure of the economy, but in most cases there is a bias toward stabilizing output. One solution to this problem is to instruct the central bank to minimize a loss function that deviates from society’s. Rogoff (1985) suggested appointing central bankers who are more avid inflation hawks than the public at large.

In this context, Svensson shows that in countries where output is sufficiently persistent, performance can be improved by instructing policymakers to target the price path, even though society cares about inflation. To understand why output persistence is central to the result, note that the more persistent output is, the longer output

---

6Mervyn King (1999) argues that in practice there is little difference between inflation targeting and price-path targeting. The reason is that politicians will hold central bankers accountable for meeting inflation targets over sufficiently long horizons, that it will look like a price-path target. I will take this up in more detail below.

7For a discussion see Clark, Goodhart and Huang (1999).

8More recent papers by Dittmar and Gavin (2000), and Vestin (2000) confirm this result.
stays away from equilibrium following a disturbance. Now consider the possibility of a policy response. Monetary policy responds to shocks by inducing a price-level surprise, immediately creating a conflict between the output and inflation stability objectives. And the more persistent output is, the longer lasting the shocks and the more important it will be to aggressively respond to them. If the goal is to stabilize prices, then these aggressive responses will have to be undone quickly, which ends up lowering the volatility of inflation.

There are several issues that arise in considering this result. First, Svensson compares inflation targeting with price-path targeting in order to emphasize the contrast between the two. But there are really a continuum of intermediate possibilities that weight the two. Batini and Yates (2001) have labeled these “hybrid-targeting” regimes. I begin by showing that for a given degree of output persistence, there is an optimal hybrid-targeting policy that is a weighted average of inflation and price-path targeting. But second, and more importantly, the focus on output persistence means that the choice is an empirical one. What is the optimal regime for a given country? And beyond this, there is the question of whether it is worth trying to move to the optimal regime. Clarity is and should be highly prized in central banking.

In fact, an optimal hybrid target sacrifices simplicity for optimality. It is much difficult to explain a hybrid than it would be to explain either of the extreme alternatives. However, as King (1999) has suggested, one of the key policy choices is the horizon over which central bankers are evaluated. That is, are they asked to maintain inflation at or near the target level on average every two, three, five or even ten years? Put another way, central bankers will have an horizon over which they are expected
to bring the price level back to its desired path. Under this interpretation, hybrid-targeting becomes a statement about the optimal horizon over which the price level is brought back to the desired path, it may not be that hard to convince people that they should give the central bank some time to fight back unwanted price shocks.

Even so, the idea that central bankers should, for strategic reasons, be told to do something that explicitly deviates from what society truly cares about will trouble many people. Should we go to the trouble of explaining that we are instructing the central bank to do one thing, while we care about another because we know that they can’t be trusted? Again, this is an empirical question. How much do we lose by just telling monetary policymakers to target the thing that society cares about?

To address these issues, I examine a set of 23 countries and find that for nearly all of them some form of hybrid-targeting regime would be optimal – at least in principle. But I go on to show that adopting such an optimal regime has only very modest benefits (as measured by the percentage reduction in the social loss) when compared with strict inflation targeting. In other words, once you look at the numbers closely it is hard to see the benefit of starting to engage in what would surely be a very difficult public dialogue. My conclusion is that we should hold central bankers accountable for meeting the social loss function, not some contrived one that might incrementally improve macroeconomic performance.

The remainder of this chapter is organized as follows. First, I set out the theoretical problem and derive the optimal hybrid-targeting regime. And I show that this can be interpreted as the optimal horizon. I also show the relationship between output
persistence and the weight on price stability. And I present a set of empirical results, compare the loss between optimal targeting regime and inflation or price-paths targeting, and the final section concludes.

2.2 Hybrid Targeting

The theoretical exercise is straightforward. Society cares about a weighted average of inflation and output deviations from their target paths. If it were possible to bind policymakers to react to shocks in a particular way, then it would be optimal to give them society’s objective and then hold them accountable for adjusting their policy instrument in the way prescribed by the reaction function that minimizes this social objective. But such commitment is impossible (and may not even be desirable). Instead, the central bank can be held accountable for minimizing a loss function under discretion. What should that loss function be?

To answer this question, I proceed in two steps. First, we derive the central bank’s policy reaction function, or instrument rule, under discretion for a family of loss functions that admits a wide variety of targeting regimes. Second, given the solution I find the targeting regime that minimizes the social loss. This is the optimal hybrid.

2.2.1 The Central Banker’s Problem

The policymaker solves a standard optimal control problem, choosing the path of the price level that minimizes a quadratic loss function subject to the constraints imposed by the linear structure of the economy. I assume that the central bank
minimizes

\[ L^{CB} = E\{\sum \beta^t [\lambda (p_t - p^*_t)^2 + (1 - \lambda) (y_t - y^*_t)^2] \} \tag{2.1} \]

where \( p_t \) is the (log)actual price level, \( p^*_t \) is the desired price level, \( y_t \) is the (log)actual output, \( y^*_t \) is desired (or potential) output level, \( \lambda \) is the degree to which the central bank prefers price stability to output stability, and \( \beta \) is the time discount factor. Equation (2.1) is sufficiently general to admit inflation targeting, price-path targeting, and everything in between. Targeting regimes differ depending on how the target, \( p^*_t \), is defined. The simplest cases are inflation targeting, where

\[ p^*_t (IT) = p_{t-1} + \pi^* \tag{2.2} \]

and price-path targeting, where

\[ p^*_t (PPT) = p^*_{t-1} + \pi^*. \tag{2.3} \]

In both cases the “inflation target” is \( \pi^* \). But under inflation targeting, given by (2.2), the target is an increment over the past period’s realized price level, whatever it turned out to be. By contrast, under price-path targeting, the current target is an increment over the past period’s target.

Hybrid targeting is a weighted average of inflation and price-path targeting. That is,

\[ p^*_t (Hybrid) = \eta (p_{t-1} + \pi^*) + (1 - \eta) p^*_{t-1} + \pi^* \]

\[ = \eta p_{t-1} + (1 - \eta) p^*_{t-1} + \pi^*, \tag{2.4} \]

where \( \eta \) is the weight on inflation targeting. Notice that \( \eta = 1 \) and \( \eta = 0 \) are the special cases of inflation and price-path targeting. Substituting (2.4) into the loss
function (2.1), and normalizing various constants and initial conditions to zero, we get

\[ L^{CB} = E\{ \sum \beta [\lambda (p_t - \eta p_{t-1})^2 + (1 - \lambda) y_t^2] \}. \]  

(2.5)

Normalization implies that \( y \) is now the output gap, and that the price path is now measured as the deviation from the inflation objective \( \pi^* \).

Following Svensson (1999a) and others, I assume that the dynamics of the economy are adequately described by a Neo-Classical Phillips Curve. That is,

\[ y_t = \rho y_{t-1} + \alpha (p_t - p^*_t) + \epsilon_t, \]  

(2.6)

where \( p^*_t \) is the private agent’s expectation of \( p_t \) at time \( t - 1 \), \( \rho \) and \( \alpha \) are constants and \( \epsilon \) is an i.i.d. shock with variance \( \sigma^2 \). For the points that I wish to make here, this closed economy model is sufficient. In the empirical section, I expand the analysis to an open-economy version that includes import prices as well.

The job of the central bank is to choose a path for the price level \( p_t \) that minimizes the loss (2.5) subject to (2.6). Assuming rational expectations, I can use the techniques described in Svensson (1997, 1999a) to first derive the first order conditions, guess the solution and then use the method of undetermined coefficients. The first order conditions include the output equation (2.6) and

9\( p^*_t = 0, \pi^*_t = 0, y^*_t = 0, p_0 = 0 \) and \( y_0 = 0 \).

10I choose the Neo-Classical Phillips Curve because of its theoretical tractability. There are a number of alternatives, including the now common New-Keynesian Phillips Curve in which the output gap depends on expected-future prices rather than current ones, and the aggregate supply formulation derived by Mankiw and Reis (2001) in their work on sticky information. While it would be feasible to examine these alternatives numerically, the more conventional Phillips Curve allows me to derive a wider range of conclusions.

11By adding an aggregate demand curve relating the price level to the interest rate, I could shift the problem to one in which the central bank does not choose prices directly. This increase in complexity changes none of my results.

12See also Söderlind (1999).
\[ p_t - \eta p_{t-1} = -\frac{\alpha(1 - \lambda)(1 - a\rho\beta)}{\lambda[1 - \rho\beta(\rho - b\alpha)](1 - \eta\rho\beta)} y_t. \] 

Equation (2.7) embodies the trade-off between output and prices in the loss function. It tells us the extent to which prices react to output shocks along an optimal path. Under rational expectations, we know that the solution for the price level must be of the form

\[ p_t = ap_{t-1} + by_{t-1} + c\epsilon_t. \] 

(2.8)

We can solve this for

\[ a = \eta \]
\[ b = \frac{-(1 - \rho^2\beta) - \sqrt{(1 - \beta\rho^2)^2 - 4\rho^2\alpha^2\beta^2(1 - \lambda)^2}}{2\rho\beta\alpha} \]
\[ c = \frac{-D}{1 + \alpha D}, \]
\[ \text{where } D = \frac{\alpha(1 - \lambda)}{\lambda[1 - \rho\beta(\rho - b\alpha)]}. \]

Setting \( \eta \) equal to either zero or one, this solution collapses to the one in Svensson (1999a).

This formulation allows me to write the laws of motion for output and prices, and these are

\[ y_t = \rho y_{t-1} + (1 + \alpha c)\epsilon_t \] 

(2.9)
\[ p_t = \eta p_{t-1} + by_{t-1} + c\epsilon_t. \] 

(2.10)

That is, output depends on lagged output, while prices depend on both lagged prices and lagged output.
As others have noted, for a solution to the central bankers problem to exist, the coefficient on lagged output in the price equation, $b$, must have a real value. That is, a solution exists if and only if

$$\frac{1 - \lambda}{\lambda} \leq \frac{(1 - \beta \rho^2)^2}{4 \rho^2 \alpha^2 \beta}. \quad (2.11)$$

As Parkin (2000) points out, this condition is somewhat restrictive, since only large values of $\lambda$ are consistent with high persistence in output ($\rho$ close to one). This means that if $\lambda$ is low and $\rho$ is high, there is no solution. The reason is that, under these circumstances the optimal response to stabilize output requires very high, even infinite volatility of price level (or inflation).\(^{13}\) Fortunately, most estimates that I know of suggest that central banks place much higher weight on inflation than they do on output volatility. For example, Cecchetti and Ehrmann (1999) estimate $\lambda$’s for a number of countries, and most of them are $\frac{3}{4}$ or higher. So I view this problem as unlikely to occur in practice.

### 2.2.2 Society’s Problem

With a complete characterization of the central bank’s problem in hand, we can now turn to society’s problem: What value of $\eta$ should monetary policymakers be instructed to use? To figure this out, all we need to do is find the value of $\eta$ that minimizes the social loss function, taking account of the central banker’s behavior. Recall that I assume society minimizes a weighted average of inflation and output variability. I can write this as

$$L^S = \lambda \sigma^2_\pi + (1 - \lambda) \sigma^2_y. \quad (2.12)$$

\(^{13}\)As I show in the appendix, this is a problem that only arises under discretion. If the central bank can be forced to commit to an instrument rule, then the problem always has a solution.
For now I look only at the case in which $\lambda$ is the same for society and the central bank. Using the previous results, I can write this as

$$L^S = \left[D^2 \frac{2\lambda(1 - \rho)}{(1 + \eta)(1 - \rho\eta)} + (1 - \lambda) \left[\frac{1}{1 - \rho^2} \frac{e}{D}\right]^2 \right] \sigma^2_t.$$  \hfill (2.13)

Taking the derivative with respect to $\eta$ (noting that $D$ is not a function of $\eta$ and assuming that the condition (2.11) holds) yields the optimal hybrid-targeting regime:

$$\eta^* = \frac{1 - \rho}{2\rho}. \hfill (2.14)$$

The result tells us that as $\rho$ approaches 1, so that the shocks to output are extremely persistent, $\eta^*$ goes to zero. As $\rho$ shrinks, $\eta^*$ grows, but I assume that it can never exceed one.\footnote{14} Importantly, the expression is consistent with Svensson’s result. He shows that if one is restricted to choosing $\eta = 0$ or $\eta = 1$, then the threshold is at $\rho = 0.5$.

Before proceeding, note that under commitment, where society can bind policymakers not just to an objective function but to an instrument rule as well, the best thing to do is to give the central bank society’s loss function. That’s not at all surprising. What is surprising is that if society’s loss is in terms of the price path rather than inflation, that is $L^S$ is a function of $\sigma^2_p$ rather than $\sigma^2_\pi$, then the discretionary solution is the same as the commitment solution.\footnote{15}

2.2.3 Stabilization Bias

So far, I have been concerned with the benefits to be obtained from giving the central bank a hybrid target. But in addition to choosing $\eta^*$, society has the option

\footnote{14} $\eta^* = 1$, when $0 < \rho \leq \frac{1}{3}$.

\footnote{15} If inflation’s primary cost is that it makes long-term planning difficult, then this may be the case we should all be focusing on. See the appendix for details.
of giving the central bank a $\lambda$ that deviates from its own. The incentive for doing
this comes from the fact that, left to their own devices, central bankers may choose
to stabilize output more than is socially optimal. Avoiding this stabilization bias
requires setting $\lambda^{CB}$ above $\lambda^S$.

To see how this works, I return to equation (2.13) and note first that the $\lambda$'s
here represent social preferences and that the $D$ (defined in the previous section) is
a function of the central bank’s $\lambda$. Using this, I can rewrite the expression for the
social loss as:

$$L^S = \left[ D(\lambda^{CB})^2 \frac{2(1 - \rho)\lambda^s}{(1 + \eta)(1 - \rho \eta)} + (1 - \lambda^s) \right] \left[ \frac{1}{1 - \rho^2} \left( \frac{1}{1 + \alpha D(\lambda^{CB})} \right)^2 \right] \sigma^2 \epsilon. \quad (2.15)$$

This change has no impact on the degree of optimal hybrid targeting. $\eta^*$ was not a
function of $\lambda$ before, and it isn’t now. But minimizing (2.15) requires not only finding
$\eta^*$, but also figuring out what $\lambda^{CB}$ should be as well. The first-order condition for
this second choice is given by

$$\frac{\alpha(1 - \lambda^{CB})}{\lambda^{CB} f(\rho)} = \frac{\alpha(1 - \lambda^s)}{\lambda^s},$$

where $f(\cdot)$ is an increasing function of $\rho$. So with given $\lambda^s$, as $\rho$ rises, $\lambda^{CB}$ rises as
well.

Figure 2.1 plots the relationship between output persistence and $\lambda^{CB}$ when $\lambda^s$ is
0.5 and 0.8. Throughout I assume that $\eta$ is set at the optimal level, $\eta^*$ in equation
(2.14). The result is clear: the more persistent output is, the more conservative the
central banker should be. And as the output approaches a random walk, the closer
$\lambda^{CB}$ gets to one.

This is a good place to make another important point. In the last section I noted
that there are times when the discretionary solution to the central banker’s problem
does not exist. Looking back at the restriction (2.11) required for existence, I see that there is always a solution when \( \lambda \) is big enough. So, if we are concerned that \( \rho \) may be high, we can avoid potential difficulties by instructing the central banker to care almost exclusively about inflation.

2.3 Empirical Results

We now see that the optimal hybrid-targeting regime – the degree to which the central bank should target inflation relative to targeting the path of the price level – depends on how persistent output is. This leads us to ask how persistent is output and how close is the actual behavior of prices to what it would be under an optimal targeting regime? The task of this section is to bring data to bear on these questions.

I do this in three steps. First, I estimate an empirical analog of the closed-economy model I studied in Section 2. Second, since a number of countries I consider are small open economies, I introduce external factors into the estimation. Finally, I posit a social loss function in order to do welfare comparisons and measure the gains from adopting an optimal hybrid target.

2.3.1 Closed Economy

My strategy is the following. Using quarterly data on consumer prices and industrial production, I estimate equations (2.9) and (2.10).\(^{16}\) (The data are all described in the appendix.) Taking account of the serial correlation in output, I use the following specifications:

\[
y_t = \rho y_{t-1} + \sum_{i=1}^{4} \gamma_i \Delta y_{t-i} + \epsilon_{1t}
\]  

(2.16)

\(^{16}\)I note that my exact results are not invariant to the choice of the frequency of the data.
Figure 2.1: Central Bank’s $\lambda$
\[ p_t = \eta p_{t-1} + b_1 y_{t-1} + b_2 y_{t-2} + b_3 y_{t-3} + b_4 y_{t-4} + e_{2t}, \]  

(2.17)

where \( y \) is computed as the deviation of log output from Hodrick-Prescott filtered output\(^{17}\), and \( p \) measures the deviation of the log price level from a measure of the target. During the periods when countries were employing inflation targets, I used the target itself for this computation.\(^{18}\) In the absence of an inflation target, I used a Hodrick-Prescott filter.

The results for both the full sample (1980s and 1990s), and just the last decade are reported in Table 2.1 and Table 2.2. Estimates range widely.\(^{19}\) The first table shows estimates of \( \rho \), together with standard errors. The important thing to notice is that \( \rho \) ranges from a low of 0.29 to a high of 0.82, and that it is unstable across time periods. Both the range and instability have important implications for policy, and so I will return to them later.\(^{20}\)

Table 2.2 reports my estimates of the optimal hybrid-targeting regime, this is \( \hat{\eta}^* \), as well as the estimate that is implied by the actual behavior of prices in each country, this is \( \tilde{\eta} \). My estimates of \( \rho \) suggest that a number of countries should be putting significant weight on the price path, \( \hat{\eta}^* < < 1 \), but virtually all of them exhibit behavior that is closer to inflation targeting, \( \tilde{\eta} \approx 1 \). Given these estimates, I

\(^{17}\)See Hodrick and Prescott (1997).

\(^{18}\)For the cases in which I have data for an explicit inflation target, I compute the price-path target as \( p_t^* = \log(CPI_{t-1}) + \pi^* \), where \( \pi^* \) is the annual inflation target. Details are in the data appendix.

\(^{19}\)All estimates throughout the chapter are median-bias corrected using the empirical distributions that are also used to compute the standard errors.

\(^{20}\)While I report results for an HP filter with parameter set to the standard 1600, experimentation in the range from 800 to 3200 leave the character of my results unchanged.
<table>
<thead>
<tr>
<th>Country</th>
<th>( \hat{\rho} ) (s.e.)</th>
<th>( \hat{\rho} ) (s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.64 (0.10)</td>
<td>0.49 (0.18)</td>
</tr>
<tr>
<td>Austria</td>
<td>0.76 (0.19)</td>
<td>0.66 (0.36)</td>
</tr>
<tr>
<td>Canada</td>
<td>0.73 (0.06)</td>
<td>0.74 (0.09)</td>
</tr>
<tr>
<td>Chile</td>
<td>0.57 (0.21)</td>
<td>0.47 (0.43)</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.56 (0.14)</td>
<td>0.31 (0.23)</td>
</tr>
<tr>
<td>Finland</td>
<td>0.78 (0.07)</td>
<td>0.65 (0.13)</td>
</tr>
<tr>
<td>France</td>
<td>0.61 (0.15)</td>
<td>0.61 (0.15)</td>
</tr>
<tr>
<td>Germany</td>
<td>0.70 (0.10)</td>
<td>0.61 (0.17)</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.56 (0.12)</td>
<td>0.50 (0.19)</td>
</tr>
<tr>
<td>Israel</td>
<td>0.56 (0.09)</td>
<td>0.29 (0.15)</td>
</tr>
<tr>
<td>Italy</td>
<td>0.71 (0.10)</td>
<td>0.63 (0.15)</td>
</tr>
<tr>
<td>Japan</td>
<td>0.78 (0.05)</td>
<td>0.69 (0.09)</td>
</tr>
<tr>
<td>Korea</td>
<td>0.58 (0.10)</td>
<td>0.60 (0.13)</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.64 (0.10)</td>
<td>0.69 (0.15)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.64 (0.15)</td>
<td>0.68 (0.23)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.58 (0.10)</td>
<td>0.58 (0.15)</td>
</tr>
<tr>
<td>Norway</td>
<td>0.43 (0.16)</td>
<td>0.55 (0.19)</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.76 (0.08)</td>
<td>0.69 (0.14)</td>
</tr>
<tr>
<td>Spain</td>
<td>0.72 (0.07)</td>
<td>0.70 (0.11)</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.71 (0.09)</td>
<td>0.60 (0.13)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.33 (0.22)</td>
<td>0.35 (0.33)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.80 (0.07)</td>
<td>0.78 (0.08)</td>
</tr>
<tr>
<td>United States</td>
<td>0.76 (0.04)</td>
<td>0.82 (0.06)</td>
</tr>
</tbody>
</table>

Estimates \( \hat{\rho} \) are small sample bias corrected autocorrelation coefficient from fourth-order autoregression using industrial production, equation (2.16). All data is quarterly data, seasonally adjusted and filtered using a Hodrick-Prescott filter. The full sample is 1980 Q1 to 2001 Q4 for non-euro-area countries. For countries in EMU, the sample ends in 1998 Q4. Standard errors (s.e.) are constructed from nonparametric bootstrap with 3000 replications.

Table 2.1: Output Persistence: The Closed Economy Case
Estimates of $\hat{\eta}^*$ are constructed using the $\hat{\rho}$ in Table 2.1. Estimates of $\tilde{\eta}$ are the coefficient on the lag of prices from equation (2.17). Data sources are all described in the appendix. The p-values for the tests are constructed using a nonparametric bootstrap with 3000 replications.

<table>
<thead>
<tr>
<th>Country</th>
<th>Full Sample</th>
<th>1990s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\hat{\eta}^*$</td>
<td>$\tilde{\eta}$</td>
</tr>
<tr>
<td>Australia</td>
<td>0.29</td>
<td>0.81</td>
</tr>
<tr>
<td>Austria</td>
<td>0.15</td>
<td>0.68</td>
</tr>
<tr>
<td>Canada</td>
<td>0.18</td>
<td>0.94</td>
</tr>
<tr>
<td>Chile</td>
<td>0.36</td>
<td>0.72</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.39</td>
<td>0.67</td>
</tr>
<tr>
<td>Finland</td>
<td>0.14</td>
<td>0.91</td>
</tr>
<tr>
<td>France</td>
<td>0.31</td>
<td>0.80</td>
</tr>
<tr>
<td>Germany</td>
<td>0.21</td>
<td>0.83</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.39</td>
<td>0.81</td>
</tr>
<tr>
<td>Israel</td>
<td>0.39</td>
<td>0.90</td>
</tr>
<tr>
<td>Italy</td>
<td>0.21</td>
<td>0.94</td>
</tr>
<tr>
<td>Japan</td>
<td>0.14</td>
<td>0.75</td>
</tr>
<tr>
<td>Korea</td>
<td>0.35</td>
<td>0.90</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.28</td>
<td>0.86</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.28</td>
<td>0.88</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.36</td>
<td>0.93</td>
</tr>
<tr>
<td>Norway</td>
<td>0.64</td>
<td>0.77</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.16</td>
<td>0.88</td>
</tr>
<tr>
<td>Spain</td>
<td>0.19</td>
<td>0.80</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.21</td>
<td>0.84</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.00</td>
<td>0.89</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.12</td>
<td>0.76</td>
</tr>
<tr>
<td>United States</td>
<td>0.16</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 2.2: The Optimal Hybrid-Targeting Regime: The Closed Economy Case
test whether $\tilde{\eta} = \eta^*$ and the answer is no. The p-value is reported in the 3rd and 6th column of Table 2.2.\textsuperscript{21}

### 2.3.2 Open Economy

To take account of the fact that countries like Israel, Belgium and Ireland are small and open, I introduce external factors into my analysis. Following Svensson (1998), I introduce import prices into the Phillips Curve (2.6):

$$y_t = \rho y_{t-1} + \alpha (p_t - p_t^e) + \phi_y p_t^F + \epsilon_t,$$

(2.18)

where $p_t^F$ is the foreign price level denominated in domestic currency. With this modification, all of the results in Section 2 go through, and I can rewrite empirical specification equations (2.9), (2.10) as

$$y_t = \rho y_{t-1} + \sum_{i=1}^{4} \gamma_i \Delta y_{t-i} + \phi_y p_t^F + \epsilon_{1t}$$

(2.19)

$$p_t = \eta p_{t-1} + b_1 y_{t-1} + b_2 y_{t-2} + b_3 y_{t-3} + b_4 y_{t-4} + \phi_p p_t^F + \epsilon_{2t}.$$  

(2.20)

Table 2.3 reports estimates of output persistence, $\rho$, after accounting for these external factors. The results are very similar to those in Table 2.1. The correlation between these 2 sets of estimates is 0.96 for full sample and 0.89 for 1990s, and the mean absolute difference between the estimates is 0.03 and 0.075 respectively. Looking at the estimates of the various measures of $\eta$ in Table 2.4, my conclusions from the closed-economy analysis remain. In virtually every case, my estimate of the optimal hybrid target has $\eta$ well below one, closer to price-path targeting than inflation targeting, but the actual behavior of prices in these countries suggests something close to inflation targeting.

\textsuperscript{21}Using a nonparametric bootstrap, I compute the empirical distribution of $\hat{\eta}^*$ and then report the p-value for $\tilde{\eta}$ in that distribution.
<table>
<thead>
<tr>
<th>Country</th>
<th>Full Sample</th>
<th></th>
<th>1990s</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\hat{\rho}$</td>
<td>s.e.</td>
<td>$\hat{\rho}$</td>
<td>s.e.</td>
</tr>
<tr>
<td>Australia</td>
<td>0.66</td>
<td>(0.09)</td>
<td>0.58</td>
<td>(0.19)</td>
</tr>
<tr>
<td>Austria</td>
<td>0.84</td>
<td>(0.23)</td>
<td>0.63</td>
<td>(0.50)</td>
</tr>
<tr>
<td>Canada</td>
<td>0.75</td>
<td>(0.06)</td>
<td>0.73</td>
<td>(0.11)</td>
</tr>
<tr>
<td>Chile</td>
<td>0.61</td>
<td>(0.07)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.61</td>
<td>(0.15)</td>
<td>0.13</td>
<td>(0.31)</td>
</tr>
<tr>
<td>Finland</td>
<td>0.79</td>
<td>(0.05)</td>
<td>0.78</td>
<td>(0.14)</td>
</tr>
<tr>
<td>France</td>
<td>n/a</td>
<td>(n/a)</td>
<td>0.61</td>
<td>(0.17)</td>
</tr>
<tr>
<td>Germany</td>
<td>0.73</td>
<td>(0.11)</td>
<td>0.69</td>
<td>(0.20)</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.48</td>
<td>(0.14)</td>
<td>0.60</td>
<td>(0.22)</td>
</tr>
<tr>
<td>Israel</td>
<td>0.56</td>
<td>(0.09)</td>
<td>0.15</td>
<td>(0.17)</td>
</tr>
<tr>
<td>Italy</td>
<td>0.73</td>
<td>(0.09)</td>
<td>0.63</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Japan</td>
<td>0.73</td>
<td>(0.04)</td>
<td>0.59</td>
<td>(0.09)</td>
</tr>
<tr>
<td>Korea</td>
<td>0.67</td>
<td>(0.11)</td>
<td>0.60</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.67</td>
<td>(0.11)</td>
<td>0.53</td>
<td>(0.21)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.65</td>
<td>(0.17)</td>
<td>0.59</td>
<td>(0.29)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.59</td>
<td>(0.10)</td>
<td>0.64</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Norway</td>
<td>0.46</td>
<td>(0.16)</td>
<td>0.67</td>
<td>(0.21)</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.78</td>
<td>(0.08)</td>
<td>0.75</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Spain</td>
<td>0.73</td>
<td>(0.05)</td>
<td>0.74</td>
<td>(0.09)</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.74</td>
<td>(0.10)</td>
<td>0.65</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.32</td>
<td>(0.24)</td>
<td>0.18</td>
<td>(0.43)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.81</td>
<td>(0.07)</td>
<td>0.79</td>
<td>(0.04)</td>
</tr>
<tr>
<td>United States</td>
<td>0.78</td>
<td>(0.03)</td>
<td>0.84</td>
<td>(0.04)</td>
</tr>
</tbody>
</table>

See notes to Table 2.1 and the appendix for data sources.

Table 2.3: Output Persistence: The Open Economy Case
### Table 2.4: Optimal Hybrid-Targeting Regime: The Open Economy Case

<table>
<thead>
<tr>
<th>Country</th>
<th>Full Sample</th>
<th>1990s</th>
<th>p-value testing</th>
<th>p-value testing</th>
<th>p-value testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\hat{\eta}^*$</td>
<td>$\tilde{\eta}$</td>
<td>$\tilde{\eta} = \eta^*$</td>
<td>$\hat{\eta}^*$</td>
<td>$\tilde{\eta}$</td>
</tr>
<tr>
<td>Australia</td>
<td>0.26</td>
<td>0.82</td>
<td>0.01</td>
<td>0.37</td>
<td>0.70</td>
</tr>
<tr>
<td>Austria</td>
<td>0.09</td>
<td>0.52</td>
<td>0.09</td>
<td>0.29</td>
<td>0.38</td>
</tr>
<tr>
<td>Canada</td>
<td>0.17</td>
<td>0.95</td>
<td>0.00</td>
<td>0.19</td>
<td>0.90</td>
</tr>
<tr>
<td>Chile</td>
<td>0.20</td>
<td>0.57</td>
<td>0.17</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.31</td>
<td>0.52</td>
<td>0.20</td>
<td>1.00</td>
<td>0.30</td>
</tr>
<tr>
<td>Finland</td>
<td>0.13</td>
<td>0.89</td>
<td>0.00</td>
<td>0.14</td>
<td>0.83</td>
</tr>
<tr>
<td>France</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>0.33</td>
<td>0.67</td>
</tr>
<tr>
<td>Germany</td>
<td>0.19</td>
<td>0.72</td>
<td>0.01</td>
<td>0.21</td>
<td>0.75</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.53</td>
<td>0.78</td>
<td>0.27</td>
<td>0.32</td>
<td>0.71</td>
</tr>
<tr>
<td>Israel</td>
<td>0.39</td>
<td>0.90</td>
<td>0.02</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>Italy</td>
<td>0.19</td>
<td>0.83</td>
<td>0.01</td>
<td>0.25</td>
<td>0.90</td>
</tr>
<tr>
<td>Japan</td>
<td>0.18</td>
<td>0.71</td>
<td>0.00</td>
<td>0.35</td>
<td>0.70</td>
</tr>
<tr>
<td>Korea</td>
<td>0.26</td>
<td>0.86</td>
<td>0.02</td>
<td>0.29</td>
<td>0.48</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.26</td>
<td>0.88</td>
<td>0.01</td>
<td>0.42</td>
<td>0.88</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.26</td>
<td>0.83</td>
<td>0.10</td>
<td>0.30</td>
<td>0.60</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.34</td>
<td>0.99</td>
<td>0.01</td>
<td>0.28</td>
<td>0.50</td>
</tr>
<tr>
<td>Norway</td>
<td>0.56</td>
<td>0.77</td>
<td>0.32</td>
<td>0.24</td>
<td>0.62</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.14</td>
<td>0.85</td>
<td>0.00</td>
<td>0.16</td>
<td>0.85</td>
</tr>
<tr>
<td>Spain</td>
<td>0.18</td>
<td>0.78</td>
<td>0.00</td>
<td>0.17</td>
<td>0.90</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.19</td>
<td>0.80</td>
<td>0.00</td>
<td>0.26</td>
<td>0.53</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.00</td>
<td>0.86</td>
<td>0.48</td>
<td>1.00</td>
<td>0.87</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.11</td>
<td>0.76</td>
<td>0.00</td>
<td>0.13</td>
<td>0.44</td>
</tr>
<tr>
<td>United States</td>
<td>0.14</td>
<td>0.91</td>
<td>0.00</td>
<td>0.10</td>
<td>0.63</td>
</tr>
</tbody>
</table>

See notes for Table 2.2 and the appendix for data sources.
It is interesting to relate all of these results to what King (1999) referred to as an evaluation horizon for central bankers. He suggested that in practice an inflation targeting central bank will be evaluated on whether it met its target on average over some number of years. The evaluation horizon is related to the hybrid regime. The longer the period over which inflation is averaged, the closer the regime is to price-path targeting. Using this intuition, I can construct approximate measures of the horizon as \((\frac{1}{\eta})\). For many countries I find that \(\eta^*\) is between 0.2 and 0.3, implying a horizon of between 3 and 4 quarters. To get a number that is usable in practice, I need to add another 4 to 6 quarters that it takes for policy changes to have an impact on prices and output. The implication is that the evaluation horizon should be in the range of 2 to 3 years.

Before continuing, note that I recomputed all of the results for both the closed and open economy versions of my model substituting core consumer prices for the headline measures used in Sections 2.3.1 and 2.3.2. Tables analogous to 2.2 and 2.4 are in the appendix. Overall, I find that the change in the price measure makes very little difference. Estimates of \(\tilde{\eta}\) from the price equation are highly correlated between the two sets of matching results. For the full sample, the correlation for the 17 countries for which I have data is 0.79 for the closed economy model and 0.83 when import prices are included.

2.3.3 Loss Comparison

Simply computing the optimal value for \(\eta\), the degree of a hybrid regime, is only the first step. What I really want to know is whether adopting the optimal hybrid makes any difference to welfare. Given the fact that estimates of \(\eta\) are fairly imprecise,
this question is particularly important. To address it, I construct estimates of the social loss, $L^S$, for different targeting regimes and compare them. Computing the loss requires that I choose a series of parameters. Before turning to the data, it is useful to look at some simulations. Using the theoretical results, I can estimate the extent of the welfare gain that comes from going from an inflation targeting regime to an optimal one. That is, I compare $L^S[\eta = 1]$ with $L^S[\eta = \eta^*]$ for various values of the parameters of the model. Note that throughout this exercise, I assume that the preference parameter $\lambda$ is the same for society and the central bank.

While it would be interesting to look across a wide range of values for the preference parameter $\lambda$, output persistence $\rho$ and the slope coefficient $\alpha$, the condition (2.11) places restrictions on the relationship among these. So instead, we look at a representative example. First, the restriction has a few simple properties: (1) Given $\alpha$, the higher $\rho$ the higher the minimum $\lambda$; and (2) Given $\rho$, the higher $\alpha$ the higher the minimum $\lambda$. What that means is that the more persistent output and the flatter the aggregate supply curve – that’s the inverse of $\alpha$ in equation (2.6) – the higher the preference for inflation stability has to be for there to be a solution to the central bank’s problem. To understand how restrictive this is, we have done a few simple calculations. Setting the discount factor $\beta = 0.99$, I see that for $\alpha = 0.5$ and $\rho = 0.7$, $\lambda$ must be greater than 0.65. As $\alpha$ decreases, the range of permissible values grows. So when $\alpha = 0.3$, $\lambda$ can be as low as 0.4 for $\rho = 0.7$. This creates a potential problem for the choice of $\alpha$. While I would like to work with relatively low values, I choose $\alpha = 0.5$. This is the choice made by Dittmar, Gavin and Kydland (1999), who use estimates in Rudebusch and Svensson (1999) as justification.
<table>
<thead>
<tr>
<th>Country</th>
<th>Full Sample</th>
<th>1990s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L^S(\eta^*)$</td>
<td>$L^S(\eta^*)$</td>
</tr>
<tr>
<td></td>
<td>/$L^S(\eta = 1)$</td>
<td>/$L^S(\eta = 0)$</td>
</tr>
<tr>
<td>Australia</td>
<td>0.94</td>
<td>0.99</td>
</tr>
<tr>
<td>Austria</td>
<td>0.71*</td>
<td>0.71*</td>
</tr>
<tr>
<td>Canada</td>
<td>0.82</td>
<td>1.00</td>
</tr>
<tr>
<td>Chile</td>
<td>0.91</td>
<td>0.99</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.96</td>
<td>0.99</td>
</tr>
<tr>
<td>Finland</td>
<td>0.71*</td>
<td>0.71*</td>
</tr>
<tr>
<td>France</td>
<td>0.96</td>
<td>0.99</td>
</tr>
<tr>
<td>Germany</td>
<td>0.87</td>
<td>1.00</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>Israel</td>
<td>0.98</td>
<td>0.99</td>
</tr>
<tr>
<td>Italy</td>
<td>0.87</td>
<td>1.00</td>
</tr>
<tr>
<td>Japan</td>
<td>0.85</td>
<td>1.00</td>
</tr>
<tr>
<td>Korea</td>
<td>0.93</td>
<td>0.99</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.93</td>
<td>0.99</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.96</td>
<td>0.99</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.96</td>
<td>0.99</td>
</tr>
<tr>
<td>Norway</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.71</td>
<td>1.00</td>
</tr>
<tr>
<td>Spain</td>
<td>0.86</td>
<td>1.00</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.86</td>
<td>1.00</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.00</td>
<td>0.97</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.71*</td>
<td>0.71*</td>
</tr>
<tr>
<td>United States</td>
<td>0.71*</td>
<td>0.71*</td>
</tr>
</tbody>
</table>

Notes: Computations use $\alpha = 0.5$ and $\lambda = 0.8$, as well as the estimated value of $\rho$ reported in Table 2.1. Stars (*) indicate values of $(\alpha, \lambda, \rho)$ for which the restriction (2.11) is not met, and so the loss cannot be computed. The reported value is the minimum for which it can be computed.

Table 2.5: Loss Comparison
Using these parameter values, I examine the improvement in the social loss for each country for two changes: (1) Moving from strict inflation targeting to the optimal hybrid regimes, that is \( L^S[\eta^*]/L^S[\eta = 1] \); and (2) Shifting from a strict price-path targeting regime to the optimal hybrid, \( L^S[\eta^*]/L^S[\eta = 0] \). Throughout I assume that the preference parameter \( \lambda = 0.8 \) and the discount rate \( \beta = 0.99 \). The results are somewhat sensitive to the choice of \( \lambda \), but not to the choice of \( \beta \). Looking at Table 2.5, I see that there is an important pattern. In no case does a move from price-path targeting to the optimal hybrid bring a sizable welfare gain. The same is not true of a move from inflation targeting. That is, the first and third columns include numbers that are far below one – e.g., 0.82 for Canada and 0.87 for Germany – while the second and fourth columns contain none.

It is worth examining this result in more detail. Figure 2.2 plots the two ratios \( L^S[\eta^*]/L^S[\eta = 0] \) and \( L^S[\eta^*]/L^S[\eta = 1] \) for a range of values for \( \rho \) and \( \lambda \), assuming \( \alpha = 0.5 \) and \( \beta = 0.99 \). Taken together, these give us a striking picture of the potential benefits from adopting various regimes. First, note from Figure 2.2.A that even if \( \rho \) is very small, and so the optimal regime is close to one of pure inflation targeting, the loss from adopting price-path targeting is small. Only when \( \lambda \) is set to 2/3rds, a relatively low value, and when output has virtually no persistence does a move from price-path targeting to the optimal hybrid imply a welfare gain of as much as 10 percent.

This is in stark contrast with Figure 2.2.B, where I see the consequences of shifting from a pure inflation targeting regime to the optimal hybrid. As output persistence rises above 0.6, the ratio of the losses starts to decrease very quickly. (Note that the lines end at the point where the restriction (2.11) is no longer met.) That is, the gain
A. Comparing Price-Path Targeting to the Optimal Hybrid Regime (\( \alpha=0.5 \))

B. Comparing Inflation Targeting to the Optimal Hybrid Regime (\( \alpha=0.5 \))

Figure 2.2: Loss comparing Targeting Regimes with Optimal Targeting
from moving from inflation targeting to the optimal hybrid can be very large. To use Svensson’s terminology, there is a “free lunch” and it can be big. And since we are unsure how big $\rho$ really is, it is likely prudent to move to price-path targeting.

2.4 Conclusion

I have examined whether a country is well-advised to target inflation, target the price path, or doing something in between. The issue turns on the persistence of output deviations from their trend. With high persistence, which is what we tend to observe, my theoretical results suggest that countries are best off if they adopt a hybrid target that is close to price-path targeting. But such a policy regime would be difficult to adopt for two reasons. First, there is the technical one. The exact targeting procedure depends on the estimation of both the output trend and output persistence, both of which are going to be measured with substantial error. And second, the success or failure of any monetary policy regime rests critically on the ability of central bankers to communicate what they are doing to the public. Explaining a hybrid target would be challenging for even the best central bankers.

Taking these problems into account, I examine the welfare loss from adopting pure inflation or price-path targeting rather than the optimal hybrid. My conclusion is that price-path targeting is less risky, in that the maximum social loss from being wrong – choosing price-path targeting when something else is better – is much smaller than if one chooses inflation targeting.
3.1 Introduction

It is widely believed that central bankers are and should be conservative. Sometimes even their personal characters are described as such. A conservative person would prefer things to be the same as before, and would act with caution. Conservative central bankers too would prefer things to be the same as before, and would act with caution.

Since one of the major goals of central banks is price stability, maintaining low and stable inflation, it is not surprising that being conservative becomes a virtue for central bankers. Especially so when they are faced with constant pressure for immediate action that can lead to unstable prices.

In fact, researchers have suggested that central bankers should be conservative. More specifically, they suggest that central banks should place higher importance on price stability than the general public does. It is a so-called weight conservative central bank argument, which is based on an observation that central banks tend to decide what is best for the moment, which may not be the best in the long-run.
Rogoff (1985) argues that society can be better off by selecting central bankers who place higher importance on inflation rate stabilization (relative to unemployment stabilization) than the general public does. Svensson (1997) too argues for conservative central bankers, especially when output is persistent.  

Rogoff’s (1985) argument for conservative central bankers starts with an observation that attempts to achieve full employment despite the existence of employment market distortion will likely create too high an inflation rate. This is called an inflation bias. Appointing central bankers who place a large weight on price stabilization will reduce this inflation bias, therefore society will be better off.

Svensson (1999) takes a similar view. But, his case is when output is persistent, that is, when a shock to output has a lasting effect. Since a long-lasting shock causes output volatility to be very large, central banks may make too much effort to stabilize output. This is called a stabilization bias. Society can reduce this stabilization bias by selecting central bankers who place very high importance on price stabilization.

Although there seems to be little doubt that appointing conservative central bankers would be beneficial to society, the question remains as to how much conservativeness is optimal.

Throughout history, there have been times when appointing not so conservative central bankers resulted in very high inflation and unstable economy. There have also been occasions when appointing too conservative central bankers was believed to be the main cause of economic disaster.

This chapter shows that there is an optimal level of conservativeness for central bankers, which means that when central bankers place a specific weight on price stabilization bias.  

---

\(^{22}\)Svensson (1997) assumes employment persistence, but it can be easily shown that this is equivalent to output persistence.
stability, there can be an welfare improvement. I argue that optimal level of conservativeness depends critically on output persistence. High output persistence, which is common to many countries, tends to keep inflation off the target, as well as output itself. Therefore, to maximize long-run social welfare, central banks need to put higher weight on inflation so that it gets closer to the target level.

The optimal level of conservativeness for central bankers, however, is derived from an assumed model for the structure of the economy. Our limited understanding of the structure of the economy limits our ability to make a convincing conclusion using a single model. Therefore, I derive a level of optimal conservativeness from different rules that implicitly imply different structures of the economy. I start with a very simple rule, which is general enough to imply a wide range of structures of the economy. Then I derive the level of optimal conservativeness with a rule that considers output persistence, and finally with a rule derived from the Neo-classical Phillips Curve.

Although the theoretical derivation of optimal conservativeness is straightforward, it is difficult to measure an actual level conservativeness from data, and also difficult to implement it in practice. As an attempt to measure the level of conservativeness of central bankers, I later present two relationships that represent two different factors through which output persistence affects conservativeness.

The first factor is through hybrid targeting. Hybrid targeting is, as treated in detail in chapter 2, a combination of inflation targeting and price-path targeting. An inflation-targeting central bank sets the target price at the level that stabilizes inflation, the change rate of the price, while a price-path targeting central bank sets the target price at the level that is on the desired price-path. This means that the
past miss of the target is ignored under inflation targeting, but it is reversed under price-path targeting.

As shown in chapter 2, when output is persistent, the optimal targeting regime is close to price-path targeting, since there is a welfare gain in long-run inflation volatility from bringing price level back to the desired price path quickly. When inflation volatility gets lowered, there is room to further stabilize output. This extra output stabilization will cause a shift of importance toward output stabilization, and will make central bankers less conservative than society.

The second factor through which output persistence affects conservativeness of central bankers is a direct effect of output persistence, and is closely related to targeting horizon. The higher output persistence, the more inflation deviates from the desired path, requiring more importance should be placed on inflation, so that the price level is brought back to the desired path quickly.

This can be interpreted as having a shorter targeting horizon, which is defined as a period of time needed for the actual price level to be brought back to the desired price-path. I show that the more conservative the central bank is, the shorter the targeting horizon becomes.

This is very similar to King’s (1999) argument about the targeting horizon. He argues that there is little difference in inflation targeting and price-path targeting\(^{23}\) in practice, since whether central banks target inflation or the price-path is just a matter of degrees.

If the horizon is infinite it is inflation targeting, and if the horizon is close to 0 then it becomes the price-path targeting.

\(^{23}\)King (1999) uses the term price-level targeting. See the footnote 5 in chapter 2 for the terminology.
I extend King’s (1999) concept to conservativeness and argue that the more conservative central bankers are, the shorter the targeting horizon becomes, and the less conservative central banks are, the longer the horizon becomes.

This chapter is organized as follows. First, I derive the optimal level of conservativeness for different rules. Next, I show how conservativeness is related to the hybrid targeting and targeting horizon. And, finally, I draw the conclusion.

3.2 Optimal Conservativeness

It is quite conventional to derive an optimal rule from a standard optimal control problem with a quadratic loss function and a linear structure of the economy. I follow this convention for the baseline optimal rule.

The loss function, which the central bank is supposed to minimize, is

\[ \text{Min } E_t \sum_t \left[ \lambda(p_t - p_t^*)^2 + (1 - \lambda)y_t^2 \right], \quad (3.1) \]

where \( p_t \) is a measurement of the price level, \( p_t^* \) is a desired level of the price level, \( y_t \) is output gap, which is defined as a deviation of an output measure from its desired level, or potential level, \( \lambda \) is the weight toward price stability and represents the conservativeness of central bank when compared to society’s \( \lambda \).

Note that \( p_t^* \) can be defined in such a way that it includes a wide variety of targeting regimes with inflation targeting and price-path targeting on either extreme. That is, under inflation targeting

\[ p_t^*(IT) = p_{t-1} + \pi^*, \quad (3.2) \]

and under price-path targeting,

\[ p_t^*(PPT) = p_{t-1}^* + \pi^*, \quad (3.3) \]
where $\pi^*$ is the desired inflation rate.

This loss function is to be minimized subject to the structure of the economy or an aggregate supply curve. In this chapter, the structure of the economy is assumed to be linear, and has the form of

$$ y_t = \rho y_{t-1} + \alpha (p_t - p^*_t) + \epsilon_t, $$

(3.4)

where $\alpha$ is the slope of the supply curve, $\epsilon_t$ is assumed to be i.i.d shock with variance of $\sigma^2_{\epsilon}$. One thing to note here is that this equation includes a lag of output, $y_{t-1}$, and its coefficient, $\rho$. Output persistence plays an important role, as will be shown later.

### 3.2.1 Optimal Rule

As indicated in the introduction, all the solutions derived in this chapter are discretionary solutions. It is assumed that central bank directly controls the level of $p$ each period in response to $p_{t-1}$, $y_{t-1}$ and $\epsilon_t$. Then the problem will be solved by taking a derivative of the loss, (3.1), with respect to $p_t$. The first order condition of this optimal control problem is as follows. $^{25}$

$$ p_t = p^*_t - \Lambda D y_t, $$

(3.5)

where $\Lambda = \frac{\alpha (1 - \lambda)}{\lambda}$,

$$ D = \frac{1}{1 - \rho (\rho - b\alpha)}, $$

(3.6)

and $b$ is the sensitivity of $p_t$ to $y_{t-1}$. I call the equation (3.5) the baseline rule.

This form of the rule can encompass a wide range of targeting regimes, if we define $p^*_t$ appropriately. That is, with a few simplifying assumptions, which do not affect

$^{24}$If this curve is seen as a Phillips Curve, then $\alpha$ is the inverse of the slope of the Phillips Curve.

$^{25}$See the appendix for derivation.
any of the results in this chapter, equation (3.5) represents price-path targeting, if $p_t^* = 0$, it represents inflation targeting, if $p_t^* = p_{t-1}$, or a hybrid targeting with a weight parameter $\eta$, if $p_t^* = \eta p_{t-1}$.

I will derive the baseline optimal rule with $p_t^* = \eta p_{t-1}$, so that we can see how conservativeness depends on this weight parameter, $\eta$. Aside $\eta$, there is another parameter of interest, $D$, which determines the optimal conservativeness along with $\eta$. $D$ represents how active a central bank is toward output fluctuation.

We established the optimal rule of the central bank with a given $\lambda$. Now it is time to frame the society’s problem and find the optimal $\lambda$.

### 3.2.2 Society’s Problem

Society knows that central bankers tend to act under discretion, and that their actions likely take the form of (3.5). Now, society has to make two different but related decisions. The first decision is about the best targeting regime, that is, choosing $\eta$, how close a targeting regime is to inflation targeting. And, the other decision is how much conservative central bankers have to be, that is, choosing $\lambda$, the importance of price stability, which is based on but different from society’s $\lambda$. The focus of this chapter is the second decision, and how it is related with the first decision.  

Should the society appoint central bankers whose $\lambda$ is higher than society’s own $\lambda$? If the central bankers’ $\lambda$ is higher than society’s $\lambda$, we can call them conservative, or if lower, then active. The question follows is, if society decides to appoint conservative central bankers, should it be very conservative or moderately conservative? 

---

26See the chapter 2 for the discussion of the first decision.
This question can be answered by finding optimal $\lambda$ that minimizes society’s loss function, which is defined as,

$$L^S = \lambda^s \sigma^2_\pi + (1 - \lambda^s) \sigma^2_y,$$

where $\sigma^2_\pi$ and $\sigma^2_y$ are the inflation variance and output variance respectively. $\lambda^s$ is a measure of importance of price stability to society. In other words, this is the cost of inflation for society relative to output.

Central bank’s $\lambda$ that is different from society’s $\lambda$ shows how one distortion - central banks’ inability to commit - can be corrected by another distortion, a difference in $\lambda$’s.

**Optimal $\lambda$**

The optimal value for $\lambda$ can be obtained from minimization of equation (3.7). With a central bank’s reaction function, equation (3.5) given, and optimal $\eta^* = \frac{1 - \rho}{2\rho}$, the society’s loss becomes

$$L^S = \left[\Lambda(\lambda; \cdot) D\right]^2 \left( \frac{2\lambda^s(1 - \rho)}{(1 + \eta)(1 - \rho\eta)} + (1 - \lambda^s) \right) \left[ \frac{1}{1 - \rho^2} \left( \frac{1}{1 + \alpha \Lambda(\lambda; \cdot) D} \right)^2 \right] \sigma^2_\epsilon. \quad (3.8)$$

Taking derivative of this with respect to $\lambda$ yields following first order condition.\(^{28}\)

$$\frac{\alpha(1 - \lambda)}{\lambda} DE = \frac{\alpha(1 - \lambda^s)}{\lambda^s},$$

where

$$E = \frac{2(1 - \rho)}{(1 + \eta)(1 - \rho\eta)} = \frac{8(1 - \rho)^{\rho}}{(1 + \rho)^2} = 1 \quad \text{when } \rho > \frac{1}{3},$$

$$= 1 \quad \text{otherwise.}$$

\(^{27}\)See chapter 2 for derivation.

\(^{28}\)See the appendix for derivation.
Before we discuss the relationships between key parameters, let’s take a moment to see what $D$ and $E$ represent. As is clear in equation (3.5), $D$ is how central banks respond to output gap. High $D$ means central bank is very responsive for output stabilization. $E$ represents welfare gains in terms of lower inflation variability from adopting $0 < \eta < 1$. See Figure 3.1.

Now, it becomes apparent that the values of $D$ and $E$ affect the relative sizes of $\lambda$ and $\lambda^*$. That is,

$$\lambda > \lambda^* \text{ if } DE > 1,$$

Figure 3.1: Inflation Gain under Optimal Hybrid Targeting
\[
\lambda = \lambda^s \text{ if } DE = 1, \\
\lambda < \lambda^s \text{ if } DE < 1.
\]

It is also apparent from the definitions of \(D\) that it is always greater than 1, \(^{29}\) and from the Figure 3.1 \(E\) is smaller than 1. Then, how we determine the size of \(DE\)? It could be answered with a numerical exercise, but instead I will show this by comparing with other cases, since it gives more intuitive insight of this problem.

### 3.2.3 Simple Rules

**Case I**

First, let’s find out the optimal level of conservativeness with a simple rule that central banks would follow, such as

\[
\pi_t = \Lambda D'y_t, \tag{3.9}
\]

where \(D' = 1\).

This type of rule may be obtained with a model similar to the baseline model except the existence of output persistence. In fact, the baseline rule becomes this type, if we put \(\eta = 1\) and adjust the definition of \(D\) appropriately. The adjustment of \(D\) comes from the fact that this rule does not take into account output persistence. Since \(\eta = 1\), there is no benefit of hybrid targeting, so \(E = 1\).

The condition for the optimal \(\lambda\) is

\[
\frac{\alpha(1 - \lambda)}{\lambda} = \frac{\alpha(1 - \lambda^s)}{\lambda^s},
\]

\[
\lambda = \lambda^s.
\]

\(^{29}\)In order to prove this, expression for \(b\) is needed. See chapter 2 equation (2.8).
With this type of rule, there is no need to have conservative ($\lambda > \lambda^s$) nor active ($\lambda < \lambda^s$) central bankers.

**Case II**

This case is the same as the case I, except, it is the price level, not inflation, that central bank uses when responding to output.

$$p_t = \Lambda D'y_t.$$  \hfill (3.10)

This can be called a simple rule with price-path targeting flavor. Then, the condition for the optimal $\lambda$ is

$$\frac{\alpha(1 - \lambda)}{\lambda} E' = \frac{\alpha(1 - \lambda^s)}{\lambda^s},$$

$$\lambda \leq \lambda^s,$$

where $E' = 2(1 - \rho)$ when $\rho > \frac{1}{2}$, otherwise 1. The second line comes from $E \leq 1$. This result is striking because even though the case we are considering here is just a simple rule, it still bears similarity of the rules proposed elsewhere. So, the suggestion of *active* central bankers under the price-path targeting is against the conventional wisdom of for conservative central bankers.

The intuition behind this result is that when there is a gain in inflation from adopting price-path targeting, the central bank has room to further stabilize output. So the weight of importance ($\lambda$) should shift toward output stabilization.

**3.2.4 Simple Rule with Output Persistence**

So far, we considered the cases where output is not persistent. Now we study the case that is simple enough to analyze key relationships, yet takes into account output persistence.
A rule to consider for this case is

\[ p_t = \eta p_{t-1} - \Lambda D'' y_t, \quad (3.11) \]

where \( D'' = \frac{1}{1 - \rho^2} \).

In this rule, optimal hybrid targeting is assumed and output persistence is included, but in a coarse way. It is a rule derived from an optimization framework, but it can be studied as a reference case for the rule derived from central bank’s optimization.

The first order condition for the optimal \( \lambda \) under this rule is

\[ \frac{\alpha(1 - \lambda)}{\lambda} D'' E = \frac{\alpha(1 - \lambda^s)}{\lambda^s}. \]

The key parameteres to note are \( D'' E \). After some simplification, we have

\[ D'' E = \frac{8\rho}{(1 + \rho)^2} \quad if \quad \rho > \frac{1}{3}, \]

\[ = D'' \quad otherwise. \]

It becomes apparent that \( D'' E \) is always greater than 1, so we can conclude that central bankers should be conservative, that is, \( \lambda > \lambda^s \). See Figure 3.2. Now, conservative central bank argument is restored.

Let’s try to answer another question at this point. How does a change in output persistence affect conservativeness? To answer this question, let’s take a derivative of \( D'' E \) with respect to \( \rho \), output persistence parameter.

\[ \frac{\partial D'' E}{\partial \rho} = \frac{8}{(1 + \rho)^3}(1 - 2\rho), \quad (3.12) \]

\[ > 0 \quad if \quad \rho < \frac{1}{2}, \]

\[ < 0 \quad if \quad \rho > \frac{1}{2}. \]
This result tells us that when output is already very persistent, then more persistent it becomes, the less conservative the central bank has to be.

Explanation of this phenomenon involves two opposing effects. First, the higher output persistence is, the higher the gains in inflation variance from hybrid targeting. This effect leads to a less conservative central bank. On the other hand, the higher output persistence is, the more volatile policy response should be, and higher inflation follows. Therefore, it leads the central bank to care more about inflation. When $\rho$ is high, however, the first effect offsets the second.
3.2.5 Optimal Rule

So far, we analyzed simple rules which may not be derived from explicit optimization framework. In this section, we consider a rule, which is explicitly derived from the optimization laid out earlier.

I rewrite (3.5) with \( \eta \) incorporated.

\[
p_t = \eta p_{t-1} - \Lambda D y_t. \tag{3.13}
\]

The first order condition for the optimal \( \lambda \) with this rule is

\[
\frac{\alpha (1 - \lambda)}{\lambda} \frac{D E}{D E} = \frac{\alpha (1 - \lambda^*)}{\lambda^*}.
\]

Unlike previous cases, the complexity of the solution of this kind prevents us from getting the explicit expression for \( D E \), therefore the optimal \( \lambda \) can not be obtained algebraically. Instead of trying to find an optimal \( \lambda \) from an explicit expression for \( D E \), I numerically derive \( D E \) and find optimal \( \lambda \). Figure 3.3 plots optimal \( \lambda \) relative to \( \lambda^* \) for different values of output persistence.

In this figure, it is obvious that over the whole range of \( \rho \), except where solution does not exist, \( D E > 1 \), which in turn implies \( \lambda > \lambda^* \). When compared with Figure 3.2, it is increasing dramatically as output persistence increases. For this rule, policy response, \( p_t \), considers not only present and future outputs but also private agents’ expectation. That is,

\[
\rho - b\alpha > \rho, \\
D > D'', \\
D E > D'' E \geq 1.
\]
Figure 3.3: Optimal Conservativeness under Optimal Rule with Output Persistence

Let’s turn to the question of how the conservativeness changes as output persistence changes. We take a derivative of $DE$ with respect to $\rho$, then it is

$$\frac{\partial DE}{\partial \rho} = D\{D(2\rho - b\alpha - \rho\alpha \frac{\partial b}{\partial \rho}) + \frac{\partial E}{\partial \rho}\}.$$ 

This is positive because $D > 0$, $b > 0$, $\frac{\partial b}{\partial \rho} > 0$, and $\frac{\partial E}{\partial \rho} > 0$. Also, it is greater than \(3.12\), which means that the central bank needs to be more conservative as output persistence gets high when the effect of private agents expectation is included in the central bank’s rule.
3.3 Interpretation of Conservativeness

In this section, I will show that there are a few alternative measures, through which the central banks’ conservativeness could be observed. In order to do this, we need to study the relationships between conservativeness and these measures.

The first one is the optimal horizon, over which the actual price level be brought back to the desired price-path. King (1999) argues that the distinction between inflation targeting and price-level targeting is a matter of degrees. And, he further introduces $H$, the targeting horizon over which the price level is brought back to the path.

Equation (3.14) describes the relationship between this $H$ and the price path.

$$\pi_t^{**} = \pi^* - \frac{1}{H}(p_t - p_t^*)$$

(3.14)

Here, $\pi_t^{**}$ is an operational inflation target at time $t$ for the future periods, $\pi^*$ is the desired inflation, or the slope of the desired price-path. $p_t$ is the actual price level at time $t$, and $p_t^*$ is a point in that price-path at time $t$. This equation can be seen as a price-path adjusted inflation target. $H$ is the adjustment speed.

Then, what should determine $H$? It could be just a matter of preference of the central bank. I argue instead that this can be seen, in part, as a realization of central bank’s conservativeness. The more conservative the central bank is, the shorter $H$ becomes.

This is not, however, the whole story about $H$. As King (1999) and the chapter 2 in this dissertation argue, $H$ can be viewed as the degree of mixed strategy of inflation

---

See the footnote in chapter 2 on usage of the term price-path targeting instead of more common price-level targeting.
targeting and price-path targeting, represented by the parameter \( \eta \) in chapter 2. In next section, I present these relationships using graphs.

### 3.3.1 Illustration

Figure 3.4 shows how actual target \( p_t \) is determined. This is a representation of the equation (3.15).

\[
p_t = p_{t-1} - \Lambda D y_t.
\]  

(3.15)

The dotted line indicates a portion of the target, that depends on the targeting regime. In this case it is \( p_{t-1} \), so it is inflation targeting. \( \Lambda D y_t \), represented by two thick arrows, indicates a portion of the target that reflects output stabilization.
This graph shows how conservativeness affects actual target under inflation targeting. Dotted line is the price-path that would be followed under pure inflation targeting, when there is no output stabilization consideration. However, in reality, the central bank takes output into consideration when it sets the target for the price level. So, when the central bank is less conservative by having low value for $\lambda$ (thickest line), then actual price target deviates from the dotted line. When the central bank is very conservative, on the other hand, by having high value for $\lambda$ (line in the middle), then actual price target deviates less than previous case.

This shows that under pure inflation targeting, tendency for the price level to drift is further exacerbated by low value for $\lambda$. 

Figure 3.5: Conservativeness under Price-Path Targeting
Figure 3.5 is for price-path targeting. The equation (3.16) is a response function central banks would have in this case.

\[ p_t = -\Lambda Dy_t. \quad (3.16) \]

Thin solid line indicates price-path that would be followed under pure price-path targeting, when there is no output stabilization consideration. The central bank tries to restore the desired path immediately.

When the central bank takes output stabilization into consideration, then the actual price-path depends on the value for conservativeness, \( \lambda \). Restoration of the desired price-path is now not immediately pursued. Instead, the restoration is allowed to take longer\(^{31}\), depending on how conservative the central bank is.

Figure 3.6 is for the hybrid targeting case, which is

\[ p_t = \eta p_{t-1} - \Lambda Dy_t, \quad (3.17) \]

where \( \eta \) is the parameter determining how close it is to inflation targeting. So when it gets close to 1, it gets closer to inflation targeting.

This case shares many aspects with the price-path targeting case. The desired price-path is likely restored in times, and, considering that the output shows high persistence in actual data, \( \eta \) under optimal hybrid targeting is usually very close to 1, the value for \( eta \) under price-path targeting. Only, time it takes for the price-path to be restored may be longer than for pure price-path case.

Before we proceed, it should be clear that these figures show the links between restoration of the desired price-path and conservativeness through conservativeness

\(^{31}\)Unless the central bank is extremely pro output stabilization, it is reasonable to think that the desired price-path is to be restored in the long-run.
parameter, $\Lambda(=\frac{1-\lambda}{\lambda})$ in equation (3.9), (3.10), (3.11), or (3.13). From these, we can see that $\lambda$, which is different from the society’s $\lambda$, corresponds to the central bank’s $H$, which is different from the society’s $H$.

### 3.3.2 Optimal Horizon and Hybrid Targeting

The notion of the targeting horizon, represented by $H$, is about how soon the desired price-path is to be restored. As illustrated in previous sections, there are 2 factors that affect this restoration speed.

The first is through $\eta$, the hybrid targeting parameter: how close a targeting regime is to inflation targeting. Picking a value for $\eta$ implies picking a point on the desired price-path stretched into the future. Therefore, the high value for $\eta$ is
equivalent to high value for $H$, and the low value for $\eta$ is equivalent to low value for $H$. This can be explicitly written as the following equation.

\[
\eta^* = 1 - \frac{1}{H^*},
\]
\[
H^* = \frac{1}{1 - \eta^*}.
\]

It is easy to see from this relationship that the optimal horizon, $H$, becomes infinite when inflation targeting is adopted. And, $H$ becomes 1 when price-path targeting is adopted.

3.3.3 Optimal Horizon and Conservativeness

As shown in the figures, the second part of the target, $\Lambda D\gamma_t$, is the distance between thick and thin lines. It is not hard to see that the larger this value gets, the higher ‘$H$’ will become. A large value comes from either $\Lambda$, $D$ or both. Let’s look at $\Lambda$ first.

If we rewrite $\Lambda$,

\[
\Lambda = \frac{\alpha(1 - \lambda)}{\lambda}.
\]

Recall that the higher $\lambda$ is, the more conservative central bank becomes. It follows that a high level of conservativeness means small value for $\Lambda$, therefore it corresponds to a short distance in the figure. It implies low ‘$H$’. Another part, $D$, depends on output persistence. High persistence means high value of $D$. Therefore, it corresponds to a large distance in the figure. It implies low ‘$H$’.

To keep ‘$H$’ from becoming too big due to high output persistence, the central bank should employ price-path targeting (low $\eta$) and/or very conservative stance (high $\lambda$).
3.4 Conclusion

In this chapter, I showed that there exists an optimal level of conservativeness, which depends critically on output persistence. And later I showed that this conservativeness has close relationships with other important issues, such as the optimal targeting regime and the targeting horizon.

Considering the fact that output shows very high persistence in almost every country, it would be a good idea to appoint conservative central bankers. And how conservative they should be would depend on the actual degree of output persistence. Finally, as I have shown in this chapter, society would also be choosing relatively shorter targeting horizon to restore the desired price-path by appointing conservative central bankers.
4.1 Introduction

Inflation, defined as a change of the general price level, is and should be the primary concern of central bankers. The wide adoption of inflation targeting in the 1990s shed even more light on the need to focus on inflation. After the adoption of inflation targeting, it became explicit that not only did central bankers care about inflation, but they had to target it. An inflation-targeting central bank announces the target level of inflation, works to achieve that level, and is held accountable for missing the target. For this, an accurate measurement of inflation is needed.

The Consumer Price Index (CPI) is widely used as a measure of the general price level, and its change rate is used as a measure of the inflation rate. However, for the purpose of monetary policy, for inflation targeting in particular, CPI may not be the most suitable measure of inflation.

CPI is a weighted average price of a basket of consumer goods and services. The price changes of a good or service are known to be very noisy. A price may change because of a sudden preference change. It may change because of an introduction of
an sector-specific new technology, or because of a monetary expansion or contraction. It may appear to have changed more than it really has.

Consider the major goal of the central bank, maintaining low and stable inflation against various shocks. Due to the noisy nature of CPI data, if the central bank makes decisions to react to price changes solely based on CPI, the price may become more unstable rather than be stabilized. Some price changes need to be countered, while others do not. For example, even though a temporary change in oil price does affect the general price level, it should not invoke any action from the central bank, because it is a temporary shock, and not an underlying monetary price change.

One of the popular ways to reduce noise in price data is to exclude sectors with high frequency shocks, such as food and energy sectors. However, even though food and energy sectors may be noisy overall, some goods and services in these sectors may not be so. Also, there could be other sectors that may include individual goods or services that contain as much noise as those in food or energy sector.

Many have suggested alternative ways of finding money-induced long-run trend inflation as an accurate inflation, that is, core inflation. Although they differ in definition and purpose, for the purpose of my study, long-run trend of the price change is good enough of a definition. It is not my intention here to survey these definitions or suggest yet another new concept of core inflation, but rather to suggest estimation methods that provide better information, to which the central bank reacts.

Considering the forward-looking nature of inflation targeting, a good forecast of inflation is crucial. Under inflation targeting, future inflation, not past nor even

---


33See Svensson (1999) and Batini and Haldane (1999)
current inflation, is to be targeted. Therefore, inflation targeting, or the monetary policy in general, inevitably needs not only an accurate measurement of inflation, but also a good forecast of it.

Core inflation studied here is built on Bryan and Cecchetti (1994, 2000). They suggest a trimmed mean estimator for core inflation. The cross-sectional distribution of the price change in CPI is trimmed at both tails in such a way that the mean after the trim would give the best forecast. In this chapter, I extend the methods introduced by Bryan and Cecchetti (1994, 2000) and show that there is room for an improvement. I also apply these methods to Korea’s CPI data from 1990 to 2000, and report the results.

This chapter is organized as follows. First, I explain the methods of estimating core inflation, including a potential improvement. Then, I apply these methods to Korea’s CPI data and report the results. Finally, I conclude.

4.2 Efficient Estimators of Core Inflation

Many methods of measuring core inflation have been suggested, with different definitions and different methods of core inflation. One of them is a trimmed mean estimator suggested by Bryan, Cecchetti and Wiggins(1997) and Bryan and Cecchetti(2000). It is a class of estimators, which gives robust results to distributions with fat-tail, and more efficient than other types of estimators. These estimators are efficient estimators in that these have the least Root Mean Squared Error (RMSE), a measure of deviation of estimator from a true value. RMSE is used as an efficiency measure in Bryan, Cecchetti and Wiggins(1997) and Bryan and Cecchetti(2000), and in this chapter as well.
4.2.1 Optimal Trim

The method of finding efficient estimators used in this chapter is basically to find how much of the tails of the cross-sectional distribution of price change should be trimmed.

The first step of the estimation is to trim the distribution at both tails starting from 0%, and gradually increase up to 50%. The next step is to calculate the mean of the trimmed distribution for each iteration. Then, calculate RMSE for this trimmed mean using 24-month centered moving average of the headline CPI as the true value of the mean of the distribution, the assumed true core inflation. Finally, find a trim among all iterations that has minimum RMSE.

Equation (4.1) is the definition of RMSE used here.

\[
RMSE = \sqrt{\frac{1}{T} \sum_{t=1}^{T} (\pi_t - \pi_c)^2},
\]

(4.1)

where \(\pi_t\) is the mean of the price change distribution after the trim, \(\pi_c\) is the assumed true mean of the cross-sectional distribution. In this chapter, 24 month centered moving average of actual inflation is used for the true mean. See Figure 4.1 for Korea’s CPI.

4.2.2 Bias and Asymmetric Trimming

While trimming the tails of the distribution symmetrically can be done very conveniently, and this method produces big efficiency improvement compared to the headline CPI, as shown for Korean case in table 4.1 trimmed mean can be biased, since the price change distribution is known to be skewed.

The bias can be calculated from the 24 month centered moving average used for the population mean, the time-series average of the trimmed estimator used for
the expectation of the estimator. Difference of these two will be the bias of this estimator. If the distribution is positively skewed then the bias will be negative, and if the distribution is negatively skewed then the bias will be positive. That is, if the distribution is skewed to the right, it has more mass on the right-hand side than the left-hand side. So, if both tails of the distribution is trimmed equally, the distribution will be still skewed, so there exists a bias.
In order to make the estimator unbiased, we need to calculate the \textit{mean percentile} first. Mean percentile is the percentile of the distribution that yields average inflation equal to that of official(mean) inflation. Now, both tails are to be trimmed asymmetrically based on the mean percentile. For example, if the mean percentile is 60%, then, 60% of the total trim will be made at the left tail instead of 50% as in symmetric trimming.

4.2.3 Biased Trimming

While unbiased estimator of the core inflation is desirable, it would be interesting to see how much efficiency can be gained by allowing a possibly small bias. I called this a biased trimming, and it gives an efficiency gain over symmetric trimming and asymmetric trimming.

As is shown Figure 4.2, which is the case for Korea’s CPI, the lowest RMSE can be off the diagonal line on lower-tail and upper tail plane, which means the minimum RMSE cannot be achieved by the symmetric trimming. Also, since the focus of asymmetric trimming is to get rid of the bias, it does not give the minimum RMSE either.

Main question for the biased trimming is whether efficiency gain is big enough to justify the bias. This is addressed later when I apply this to Korea’s case.

4.2.4 Trimming with Changing Weights

The headline CPI is a weighted average of all the components in a given basket of goods and services. The weights used here are the expenditure weights. One of the justifications for using these weights is that these weights roughly reflect the relative importance in cost of living. However, using these weights in constructing an
estimator for core inflation may not be easily justified, other than by its simplicity. That is because there is no guarantee that a price movement of a component in CPI carries the same degree of information about true inflation as the expenditure weight of the component.

Then, an ideal way of averaging a price change distribution for core inflation estimation is to use the weights that correspond to the degree of co-movement between
each component and true inflation. However, we should not modify the weights too much, since we may lose important information that the original weights carry.

So, I calculate the correlation between the price change of each component and a trend of inflation. Then, I modify the weight of each component according to this correlation. There is an adjusting factor to prevent this modification from becoming too drastic.

\[
W_i^{new} = W_i^{old} \times (1 + \rho_i \times AF).
\]

\(\rho_i\) : Correlation between component \(i\) and trend inflation  
AF : Optimal Adjusting Factor

Selecting the best adjusting factor is very important, because new weights critically depend on this factor. To prevent this factor from being arbitrarily determined, a definite criterion should be established. Another problem with this adjustment is regarding \(\rho\). It may well be time varying and, even worse it does not necessarily represent the causal link between individual items and trend inflation. For all these issues, further studies are needed.

4.3 Application: Korea’s Case

So far, I explained how core inflation can be estimated using a class of trimmed mean estimators. Now, I apply these estimation methods to actual data and report the results. Here I use Korea’s CPI data.
<table>
<thead>
<tr>
<th>Horizon</th>
<th>Mean</th>
<th>Variance</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.051 (0.049)</td>
<td>0.030 (0.052)</td>
<td>0.877 (2.443)</td>
<td>13.857 (10.462)</td>
</tr>
<tr>
<td>3</td>
<td>0.051 (0.038)</td>
<td>0.013 (0.018)</td>
<td>0.566 (1.989)</td>
<td>10.185 (6.926)</td>
</tr>
<tr>
<td>6</td>
<td>0.051 (0.029)</td>
<td>0.006 (0.005)</td>
<td>0.417 (1.827)</td>
<td>9.091 (5.673)</td>
</tr>
<tr>
<td>12</td>
<td>0.051 (0.023)</td>
<td>0.003 (0.002)</td>
<td>0.341 (1.414)</td>
<td>6.864 (3.533)</td>
</tr>
</tbody>
</table>

Note: All figures are time-series averages and standard deviations (in the parenthesis).

Table 4.1: Moments of Price-change Distribution of Korean CPI

I use monthly Korea’s CPI-U (the Consumer Price Index for All Urban Consumers)\(^{34}\) from Jan. 1990 to Aug. 2000. \(^{35}\) There are 3 ways to break-down the CPI, which are 9, 43 and 57 components. I use 43 components in this chapter.

### 4.3.1 Price Change Distribution: Korea’s CPI

The price-change distribution of Korean CPI is summarized in table 4.1. These are time-series means and standard deviations (in the parenthesis) of the mean, variance, skewness and kurtosis of cross-sectional price change distribution. I calculated the price changes with different horizons, which is the period of time over which price changes are calculated. I report the statistics with 4 different horizons, which are believed to be the most relevant in monetary policy. \(^{36}\)

\(^{34}\)The data is obtained from The National Statistics Office of Korea. I did the seasonal-adjustment by SAS X-11 procedure with ARIMA option

\(^{35}\)This is rather a short time series. One of the reasons is that Other Housing component is missing until Dec. 1989. Another more important reason is that there have been several occasions of irregularities, such as political turmoils and dramatic labor movements throughout 1980’s.

\(^{36}\)Throughout this chapter, horizon means \(\log(p_{it}/p_{it-h})\), where \(i\) the index of component, \(t\) the index of time(month) and \(h\) the index of horizon.
Table 4.2: Efficiency (RMSE) Gain by Trimming

The first column is the time-series means of the cross-sectional mean of the price change distribution, and their standard deviations. The mean is 0.051, throughout the horizons with standard deviation of it decreasing from 0.049 to 0.023 as the horizon increases from 3 month to 12 month. The second column is the time series mean of the variance of the distribution. Both mean variance and the standard deviation of it decrease as the horizons grows. The third column is the time series mean of the skewness of the distribution. The last column is the time series mean of the kurtosis of the distribution.

From this table, a few point need to be made. First, the price change distribution is very fat-tailed. Kurtosis ranges from 13.9 to 6.9 for different horizons. However, regardless of the horizon, the distribution is not normal, rather leptokurtic. This is related with the issue of gaining efficiency by trimming the fat tails.

Second, the distribution is positively skewed. This is true for all horizons. The skewness ranges from 0.88 for 1 month horizon to 0.34 for 12 month horizon. The existence of bias becomes the basis of asymmetric trimming.
4.3.2 Symmetric Trimming

As described in previous section, optimal trim is the one that gives the minimum efficiency. For each trimming starting from 1% trimming up to 50%, RMSE is calculated, and then compared. Figure 4.3 is illustrating how minimal RMSE, thereby optimal trim is obtained.

Table 4.2 reports the result of symmetric trimming. The first column is RMSE for the original data. The second column is that of excluding Food and Energy...
<table>
<thead>
<tr>
<th>Horizon</th>
<th>Expectation of Trimmed Mean</th>
<th>Population Mean</th>
<th>Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>0.038</td>
<td>0.051</td>
<td>-0.012</td>
</tr>
<tr>
<td>3 month</td>
<td>0.042</td>
<td>0.051</td>
<td>-0.009</td>
</tr>
<tr>
<td>6 month</td>
<td>0.043</td>
<td>0.051</td>
<td>-0.007</td>
</tr>
<tr>
<td>12 month</td>
<td>0.046</td>
<td>0.051</td>
<td>-0.004</td>
</tr>
</tbody>
</table>

Table 4.3: Bias of Trimmed Estimator

components. The third column is that after trimming optimal trim off both tails. For example, for the 3 month horizon, the optimal trim is 45% and it gives RMSE of 0.2125, which is about 48% efficiency improvement from the original data, and still a big improvement even when compared with ex. Food and Energy.

As horizon gets longer, optimal trim is getting smaller as is efficiency gain. The optimal trim is 45%, when the horizon is 1 month, but when it becomes 12 month, the optimal trim shrinks to 28%. Efficiency gain decreases from 89% to 23% too.

4.3.3 Asymmetric Trimming

As pointed out earlier, one of the problems in symmetric trimming is that it is allowing the trimmed distribution still have bias. To correct this, we are considering asymmetric trimming.

Let’s go back to the Table 4.1 third column to see how much the price change distribution is skewed. This skewness is in fact the source of a bias in estimation. As Table 4.3 shows, it is quite clear that positively skewed distribution creates negative biases over the all horizons.
Now, we need to calculate how much bias remains after the symmetric trimming. First step is to calculate mean percentile. Mean percentile is the portion of the distribution that yields average inflation equal to that of official (mean) inflation. For example, mean percentile of the monthly price change distribution in Korea for Jan. 1991 to Aug. 2000 is 56.5%. 6 month and 12 month horizon are 55.7% and 54.3% respectively.

Figure 4.4: Mean Percentile of Monthly CPI

Mean Percentile

[Graph showing mean percentile over time from 1991 to 2001]

66
Table 4.4: Asymmetrically Trimmed Mean Estimator

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Symmetric Trimming</th>
<th>Asymmetric Trimming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Optimal Trim</td>
<td>RMSE</td>
</tr>
<tr>
<td>1 month</td>
<td>45%</td>
<td>0.2506</td>
</tr>
<tr>
<td>3 month</td>
<td>47%</td>
<td>0.2125</td>
</tr>
<tr>
<td>6 month</td>
<td>33%</td>
<td>0.1602</td>
</tr>
<tr>
<td>12 month</td>
<td>28%</td>
<td>0.1052</td>
</tr>
</tbody>
</table>

So it means that if we trim the tails in such a way that the lower tail be trimmed 56.5% and upper tail be 43.5%, then this trimmed mean produces unbiased estimator.

Figure 4.4 shows the mean percentile for the price change distribution. Table 4.4 reports the results of asymmetric trimming, and compare them with those from symmetric trimming. When trimming is asymmetric, not only there is no bias any more, it seems that, except for monthly horizon, efficiency increases as well. This can be due to using 2 different trimming parameters instead of just one. For monthly horizon, a decreasing in efficiency from the unbiasedness restriction is greater than an increase in efficiency from using 2 parameters.

### 4.3.4 Biased Trimming

Table 4.5 reports the results when trimming is asymmetric and bias is allowed. The first two columns are optimal trims from the tails of the price change distribution, and the next two columns are comparison of RMSE between biased asymmetric and unbiased asymmetric trimming. The last column is the bias left after the trimming.

\[\frac{35}{35 + 46} \approx 56.5\]

\[^{37}\text{the ratio } \frac{35}{35 + 46} \approx 56.5\]
Table 4.5: Estimator with Biased Asymmetrical Trimming

As expected, without unbiasedness restriction, efficiency increases compared to both symmetric trimming and (unbiased) asymmetric trimming. This is shown in Figure 4.2. Minimum point of RMSE surface is located off the diagonal, which represents asymmetric trimming.

Of course, including a bias in this estimator is problematic. Even though the bias decreases as the horizon increases, it is still significant relative to the mean of the distribution. Question remains as to how much bias is to be tolerated to get higher efficiency.

4.3.5 Trimming with Changing Weights

CPI is the weighted mean of its component goods and services categories. The weight used for each component is an expenditure weight of a base year. Considering that core inflation measures underlying money-induced inflation, using these expenditure weights to form an estimator is less desirable.

Desirable weights should reflect how much each component contributes to the underlying inflation. Table 4.6 reports efficiency gains when the expenditure weights is replaced with correlation based weights for the estimators for Korea’s CPI. The
Table 4.6: Changing Weights and Symmetrical Trimming

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Optimal Trim</th>
<th>Adjustment Factor</th>
<th>Efficiency(RMSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>25%</td>
<td>Correlation × 0.67</td>
<td>0.1921</td>
</tr>
<tr>
<td>3 month</td>
<td>26%</td>
<td>Correlation × 0.66</td>
<td>0.2102</td>
</tr>
<tr>
<td>6 month</td>
<td>No gain</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12 month</td>
<td>No gain</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

results from symmetric trimming and symmetric trimming with changing weights described in the previous chapter are compared.

For the monthly horizon, RMSE increases from 0.2506 to 0.1921, and for 3 month horizon, 0.2125 to 0.2102. Other than these two horizons no efficiency can be obtained. As noted before, the problem in this approach is how to justify the adjustment factor. Here I used 0.66 and 0.67.

4.4 Conclusion

In this chapter I presented a class of estimators for core inflation, using different methods of trimming the tails of the cross-sectional price change distribution. These estimators are more efficient than the headline CPI in that these have lower Root Mean Squared Error (RMSE).

The first was the symmetrically trimmed mean estimator. Then, I showed how to get unbiased estimator by using asymmetrical trimming. I also compared these estimators with an estimator from biased trimming to show the trade-off between efficiency and bias. Finally, an estimator, which is calculated with an alternative
set of weights, is suggested. As an application, estimates for Korea’s CPI for each estimation methods are reported.

Different estimation methods result in different levels of efficiency. Even though all the estimators in this chapter are improvements in efficiency compared to the headline CPI inflation, the question remains, how to decide which is the best estimator. Some estimators give higher efficiency, but with bias. Some are unbiased, but leave room for more efficiency gains. Some are straightforward in estimation method, while others are complicated. The answer should be based on how well these estimators fit the purpose. More specifically, due to its forward looking nature, inflation targeting requires a good forecast of inflation. Therefore, an estimator that give better forecast should be given more consideration.
CHAPTER 5

CONCLUSION

Despite the success of inflation targeting in the 1990s around the world, maintaining low and stable inflation is still a major concern for central banks. And, due to its weaknesses, inflation targeting needs further refinements.

When output is persistent, inflation targeting tends to have high long-run inflation volatility, since the past miss of the target is forgotten and added up in the long-run. Many researchers have suggested price-path targeting as a remedy, since it reverse the miss of the target right away so that long-run inflation volatility can be reduced.

In this dissertation, I went one step further and suggested an optimally chosen hybrid of inflation targeting and price-path targeting gives better results in inflation volatility.

Another weakness of inflation targeting, bias toward to much output stabilization, can be overcome by appointing conservative central bankers, who place high importance on inflation stabilization. I confirmed this result, and showed that the optimal conservativeness depends on output persistence. Also, I argue that high conservativeness can be interpreted as having a short targeting horizon, over which price level is brought back to the desired price-path.
Emphasizing the importance of inflation forecast under inflation targeting, I suggested efficient estimators of core inflation. By trimming the tails of cross-sectional price change distribution, this underlying or long-run trend inflation can be forecast more accurately than headline CPI inflation.

However, recognizing the importance of trust in monetary policy, I argued that these suggestions and elaborations should be implemented accompanied by the public’s trust, therefore central banks need to find the right balance between performing monetary policy optimally and earning the public’s trust.
APPENDIX A

THE DATA DESCRIPTION FOR CHAPTER 2

All data are quarterly beginning in 1980 Q1. For EMU countries, data are through 1998 Q4. For non-EMU countries, data are through 2001 Q4.


2. Output: Industrial Production from the IMF International Financial Statistics, except for Portugal and Ireland, which are entirely from the OECD; New Zealand is from the OECD for 2000 Q3 on; Italy is from OECD for 2001 Q1 on; and Chile is manufacturing production only.

3. Core Consumer Prices: From the OECD

4. Import Prices: The import price index from the IMF International Financial Statistics, except for Spain, New Zealand, Netherlands, Canada, France, Ireland, Israel, Italy where the Unit Value of Imports from IFS is used; Mexico Import Price Index from Haver Analytics; Austria uses the German CPI; and Portugal is an equally weighted average of the CPIs for the UK, Spain, France and Germany.
<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Inflation Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1993 Q1 - 2001 Q4</td>
<td>2.5%</td>
</tr>
<tr>
<td>Austria</td>
<td>1993 Q1 - 2001 Q4</td>
<td>2.0%</td>
</tr>
<tr>
<td>Canada</td>
<td>1992 Q1 - 1994 Q4</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>1995 Q1 - 2001 Q4</td>
<td>3.0%</td>
</tr>
<tr>
<td>Chile</td>
<td>1991 Q1 - 1991 Q4</td>
<td>18.0%</td>
</tr>
<tr>
<td></td>
<td>1992 Q1 - 1992 Q4</td>
<td>17.5%</td>
</tr>
<tr>
<td></td>
<td>1993 Q1 - 1993 Q4</td>
<td>11.0%</td>
</tr>
<tr>
<td></td>
<td>1994 Q1 - 1994 Q4</td>
<td>10.0%</td>
</tr>
<tr>
<td></td>
<td>1995 Q1 - 1995 Q4</td>
<td>8.0%</td>
</tr>
<tr>
<td></td>
<td>1996 Q1 - 1996 Q4</td>
<td>7.0%</td>
</tr>
<tr>
<td></td>
<td>1997 Q1 - 1997 Q4</td>
<td>6.0%</td>
</tr>
<tr>
<td></td>
<td>1998 Q1 - 1998 Q4</td>
<td>5.0%</td>
</tr>
<tr>
<td></td>
<td>1999 Q1 - 1999 Q4</td>
<td>4.3%</td>
</tr>
<tr>
<td></td>
<td>2000 Q1 - 2000 Q4</td>
<td>3.5%</td>
</tr>
<tr>
<td></td>
<td>2001 Q1 - 2001 Q4</td>
<td>3.0%</td>
</tr>
<tr>
<td>Finland</td>
<td>1993 Q1 - 2001 Q4</td>
<td>2.0%</td>
</tr>
<tr>
<td>Israel</td>
<td>1992 Q1 - 1992 Q4</td>
<td>14.5%</td>
</tr>
<tr>
<td></td>
<td>1993 Q1 - 1993 Q4</td>
<td>10.0%</td>
</tr>
<tr>
<td></td>
<td>1994 Q1 - 1994 Q4</td>
<td>8.0%</td>
</tr>
<tr>
<td></td>
<td>1995 Q1 - 1995 Q4</td>
<td>9.5%</td>
</tr>
<tr>
<td></td>
<td>1996 Q1 - 1996 Q4</td>
<td>9.0%</td>
</tr>
<tr>
<td></td>
<td>1997 Q1 - 1997 Q4</td>
<td>8.5%</td>
</tr>
<tr>
<td></td>
<td>1998 Q1 - 1999 Q4</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>2000 Q1 - 2000 Q4</td>
<td>3.5%</td>
</tr>
<tr>
<td></td>
<td>2001 Q1 - 2001 Q4</td>
<td>3.0%</td>
</tr>
<tr>
<td>Korea</td>
<td>1999 Q1 - 1999 Q4</td>
<td>3.75%</td>
</tr>
<tr>
<td></td>
<td>2000 Q1 - 2000 Q4</td>
<td>2.5%</td>
</tr>
<tr>
<td></td>
<td>2001 Q1 - 2001 Q4</td>
<td>3.0%</td>
</tr>
</tbody>
</table>


Table A.1: Annual Inflation Target

Continued
<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Inflation Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>1995 Q1 - 1995 Q4</td>
<td>19.0%</td>
</tr>
<tr>
<td></td>
<td>1996 Q1 - 1996 Q4</td>
<td>20.5%</td>
</tr>
<tr>
<td></td>
<td>1997 Q1 - 1997 Q4</td>
<td>15.0%</td>
</tr>
<tr>
<td></td>
<td>1998 Q1 - 1998 Q4</td>
<td>12.0%</td>
</tr>
<tr>
<td></td>
<td>1999 Q1 - 1999 Q4</td>
<td>13.0%</td>
</tr>
<tr>
<td></td>
<td>2000 Q1 - 2000 Q4</td>
<td>10.0%</td>
</tr>
<tr>
<td></td>
<td>2001 Q1 - 2001 Q4</td>
<td>6.5%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1992 Q1 - 1996 Q4</td>
<td>1.0%</td>
</tr>
<tr>
<td></td>
<td>1997 Q1 - 2001 Q4</td>
<td>1.5%</td>
</tr>
<tr>
<td>Norway</td>
<td>2001 Q1 - 2001 Q4</td>
<td>2.5%</td>
</tr>
<tr>
<td>U.K.</td>
<td>1992 Q1 - 2001 Q4</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

5. Inflation targets are computed from the "Inflation Targeting Country Fact Sheets" by Frank Gaenssmantel of the Institute of International Economics, courtesy of Edwin Truman. The target $p_t^*$ is computed as follows

$$p_t^* = p_{t-1} + \pi^*$$  \hspace{1cm} (A.1)

$$p_t = \log(CPI_t) - p_t^* \hspace{1cm} \text{when there is } p_t^*$$  \hspace{1cm} (A.2)

$$p_t = \log(CPI_t) - HPtrend_t \hspace{1cm} \text{otherwise}$$  \hspace{1cm} (A.3)

where $\pi^*$ is the annual inflation target in the following table, divided by four.

When the target is a range, the midpoint is used.
APPENDIX B

THE COMMITMENT CASE FOR CHAPTER 2

Our solutions in the text assume that the central bank operates under discretion. Discretion means that policymakers re-optimize the loss function every period after observing the state variable $y_{t-1}$ and the shock $\epsilon_t$. The alternative to this is commitment, in which the central bank optimizes once and commits to an instrument rule once and for all.

To find the commitment solution we take the derivative of the central bank’s loss (2.5) with respect to $p_t$ and $p_t^e$, subject to the constraint imposed by the Phillips curve (2.6). The resulting policy rule, the equivalent to equation (2.8), is

$$p_t = \eta p_{t-1} + \tilde{c} \epsilon_t$$

(B.1)

where

$$\tilde{c} = -\frac{\tilde{D}}{1 + \alpha \tilde{D}} \quad \text{and} \quad \tilde{D} = \frac{\alpha(1 - \lambda)}{\lambda(1 - \rho^2 \beta)}$$

This is exactly the same as the case under discretion considered in Section 2.2.1, except that $b = 0$. That is, under commitment the optimal response is to react only to the past price level and the shock, not to $y_{t-1}$. And recall that the condition for a solution to exist under discretion, shown in (2.11), arises in computing $b$, and so is not present here.
Continuing with the problem under commitment, society’s loss, the equivalent to (2.13), is now

\[ \tilde{L}_S = \left[ \frac{2\lambda \tilde{c}^2}{1 + \eta} + \frac{1 - \lambda}{1 - \rho^2} \left( \frac{\tilde{c}}{D} \right)^2 \right] \sigma^2 \]  

(B.2)

The \( \eta \) that minimizes this loss is trivially 1, which implies inflation targeting. Under commitment, it is optimal to simply give the central bank society’s loss function.

**A.3 When Society Prefers Price-Path Targeting**

What if society’s preferences are in terms of the path of the price level rather than an inflation target? In this case, the central bank’s problem is the same as the one in Section 2.2.1. It is the social loss, (2.12), that changes. Assuming society cares about the price path implies that the social loss function is

\[ L^S = \lambda \sigma_p^2 + (1 - \lambda)\sigma_y^2. \]  

(B.3)

Substituting in the solution for the central bank’s problem, this becomes

\[ L^S = \left[ \lambda \sigma_p^2 \left( \frac{1}{1 - \eta^2} \right) \left( \frac{1 + \eta \rho}{1 - \eta \rho} \right) + (1 - \lambda) \right] \sigma_y^2. \]  

(B.4)

Equation (B.4) is the equivalent to text equation (2.13). The optimal \( \eta \) that minimizes this loss is 0. So, if society cares about the price-path, then the central bank should be told to care about it, too.
APPENDIX C

SUBSTITUTING CORE FOR HEADLINE CONSUMER PRICES FOR CHAPTER 2

The following tables are from substituting measures of the core CPI for the headline CPI in the computations of Section 2.3. Table C.1 is the analog to text Table 2.2 and Table C.2 is the analog to text Table 2.4. Note that since the output equations (2.16) and (2.19) do not include the price level, the estimates of $\rho$ and $\eta^*$ are unchanged, and so the corresponding columns in the tables are identical. Comparing these results to those in the text, we conclude that substituting core for headline prices changes little.
### Table C.1: Optimal Hybrid-Targeting Regime: Closed Economy with Core CPI

<table>
<thead>
<tr>
<th>Country</th>
<th>Full Sample</th>
<th>1990s</th>
<th>p-value testing</th>
<th>p-value testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\hat{\eta}^*$</td>
<td>$\tilde{\eta}$</td>
<td>$\tilde{\eta} = \eta^*$</td>
<td>$\hat{\eta}^*$</td>
</tr>
<tr>
<td>Australia</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>0.50</td>
</tr>
<tr>
<td>Austria</td>
<td>0.15</td>
<td>0.44</td>
<td>0.14</td>
<td>0.25</td>
</tr>
<tr>
<td>Canada</td>
<td>0.18</td>
<td>0.93</td>
<td>0.00</td>
<td>0.18</td>
</tr>
<tr>
<td>Chile</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.39</td>
<td>0.56</td>
<td>0.25</td>
<td>1.00</td>
</tr>
<tr>
<td>Finland</td>
<td>0.14</td>
<td>0.91</td>
<td>0.00</td>
<td>0.26</td>
</tr>
<tr>
<td>France</td>
<td>0.31</td>
<td>0.92</td>
<td>0.06</td>
<td>0.32</td>
</tr>
<tr>
<td>Germany</td>
<td>0.21</td>
<td>0.90</td>
<td>0.00</td>
<td>0.32</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.39</td>
<td>0.81</td>
<td>0.08</td>
<td>0.49</td>
</tr>
<tr>
<td>Israel</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Italy</td>
<td>0.21</td>
<td>0.94</td>
<td>0.00</td>
<td>0.29</td>
</tr>
<tr>
<td>Japan</td>
<td>0.14</td>
<td>0.39</td>
<td>0.00</td>
<td>0.23</td>
</tr>
<tr>
<td>Korea</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>0.34</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.28</td>
<td>0.91</td>
<td>0.01</td>
<td>0.23</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.28</td>
<td>0.79</td>
<td>0.07</td>
<td>0.24</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.36</td>
<td>0.81</td>
<td>0.03</td>
<td>0.36</td>
</tr>
<tr>
<td>Norway</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>0.38</td>
</tr>
<tr>
<td>Portugal</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>0.23</td>
</tr>
<tr>
<td>Spain</td>
<td>0.19</td>
<td>0.79</td>
<td>0.00</td>
<td>0.22</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.21</td>
<td>0.78</td>
<td>0.00</td>
<td>0.33</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.00</td>
<td>1.02</td>
<td>0.39</td>
<td>1.00</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.12</td>
<td>0.70</td>
<td>0.00</td>
<td>0.14</td>
</tr>
<tr>
<td>United States</td>
<td>0.16</td>
<td>0.97</td>
<td>0.00</td>
<td>0.11</td>
</tr>
</tbody>
</table>

See notes to text Table 2.2 and Appendix A.
<table>
<thead>
<tr>
<th>Country</th>
<th>Full Sample p-value testing</th>
<th>1990s p-value testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\hat{\eta}$</td>
<td>$\tilde{\eta}$</td>
</tr>
<tr>
<td>Australia</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Austria</td>
<td>0.09</td>
<td>0.26</td>
</tr>
<tr>
<td>Canada</td>
<td>0.17</td>
<td>0.94</td>
</tr>
<tr>
<td>Chile</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.31</td>
<td>0.44</td>
</tr>
<tr>
<td>Finland</td>
<td>0.13</td>
<td>0.91</td>
</tr>
<tr>
<td>France</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Germany</td>
<td>0.19</td>
<td>0.87</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.53</td>
<td>0.79</td>
</tr>
<tr>
<td>Israel</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Italy</td>
<td>0.19</td>
<td>0.83</td>
</tr>
<tr>
<td>Japan</td>
<td>0.18</td>
<td>0.37</td>
</tr>
<tr>
<td>Korea</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.26</td>
<td>0.95</td>
</tr>
<tr>
<td>Netherland</td>
<td>0.26</td>
<td>0.79</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.34</td>
<td>0.82</td>
</tr>
<tr>
<td>Norway</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Portugal</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Spain</td>
<td>0.18</td>
<td>0.79</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.19</td>
<td>0.76</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.00</td>
<td>1.02</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.11</td>
<td>0.71</td>
</tr>
<tr>
<td>United States</td>
<td>0.14</td>
<td>0.94</td>
</tr>
</tbody>
</table>

See notes to text Table 2.4 and Appendix A.

Table C.2: Optimal Hybrid-Targeting Regime: Open Economy with Core CPI
APPENDIX D

DERIVATION OF OPTIMAL CONSERVATIVENESS

1. Central Banker’s Problem

   • Objective Function and Constraint The central bank is facing loss minimization problem subject to a constraint represented by a Neo-Classical Phillips Curve. That is,

   $$\text{Min } E_t \sum_t \left[ \lambda (p_t - \eta p_{t-1})^2 + (1 - \lambda) y_t^2 \right]$$

   $$\text{s.t } y_t = \rho y_{t-1} + \alpha (p_t - p_t^e) + \epsilon_t$$

   • Discretionary Solution Without a credible way to commit itself to a rule, the central bank is assumed to act discretionally. So only the discretionary solution is found.

   $$p_t = \eta p_{t-1} - Dy_t$$

   where

   $$D = \frac{\alpha (1 - \lambda)}{\lambda[1 - \rho/\beta(p - \alpha)]}.$$ 

2. Society’s Problem The society is facing a similar minimization problem, only with slightly different objective, subject to the central bank’s action, which is derived in the previous section.
Society’s Loss

The society is to minimize

\[\text{Loss}^s = \lambda^s \sigma^2 + (1 - \lambda^s)\sigma^2_y\]

\[= \left(D^2 E \lambda^s + (1 - \lambda^s)\right)\sigma^2_y\]

\[= \left(D^2 E \lambda^s + (1 - \lambda^s)\right)\frac{1}{1 - \rho^2} \left(\frac{1}{1 + \alpha D}\right)^2 \sigma^2_e\]

\[= \left\{\left(\frac{D}{1 + \alpha D}\right)^2 E + \frac{1 - \lambda^s}{\lambda^s} \left(\frac{1}{1 + \alpha D}\right)^2\right\} \frac{\lambda^s}{1 - \rho^2} \sigma^2_e\]

where \(E = \frac{2(1 - \rho)}{(1 + \eta)(1 - \rho \eta)}\).

Optimal \(\lambda\)

In order to find the optimal \(\lambda\), let’s take a derivative of the \(\text{Loss}^s\) with respect to \(\lambda\). Here, we can take \(\eta\) as fixed, because of the Envelope Theorem. (\(\eta\) is already an optimizer.) The first order condition is

\[\frac{d\text{Loss}^s}{d\lambda} = \frac{\lambda^s}{1 - \rho^2} \sigma^2_e \left[\frac{2C}{(1 + \alpha D)^2} - \frac{2\alpha D^2}{(1 + \alpha D)^3} E - \frac{1 - \lambda^s}{\lambda^s} \frac{2\alpha}{(1 + \alpha D)^3} \frac{dD}{d\lambda}\right]\]

\[= K \left[DE - \frac{1 - \lambda^s}{\lambda^s} \frac{dD}{d\lambda}\right]\]

\[= 0\]

where \(K = \frac{2\lambda^s}{1 - \rho^2} \sigma^2_e (1 + \alpha D)^3\)

Then this condition is reduced to

\[\frac{\alpha(1 - \lambda)}{\lambda} D' E = \frac{\alpha(1 - \lambda^s)}{\lambda^s}\]

where \(D' = \frac{\alpha}{[1 - \rho \beta(\rho - b\alpha)]}\).
BIBLIOGRAPHY


