



# Research on the Inflation Cost Evaluation and Appropriate Inflation Management Based on the Taylor Rule

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**Abstract.** Inflation has a number of negative effects, including the potential for reducing investment and slowing economic development due to volatility and uncertainty. Inflation can reduce an individual's savings value and shift the income away from savers to lenders and people with assets in society. When inflation reaches dangerously high levels, society can become unstable and people's faith in the economy might be lost. This paper evaluates the costs of inflation and how to manage inflation in an appropriate way by introducing the Taylor rule, a targeting monetary policy used by central banks to control inflation. According to the Taylor Rule, the Federal Reserve should raise rates when inflation exceeds the desired level or when GDP growth exceeds its potential.

**Keywords:** Real money balance · Menu cost · Price level target · Zero inflation target · Taylor rule

## 1 Introduction

Maximizing societal welfare is the ultimate purpose of the economic policies that central banks adopt. However, stabilizing the price level is necessary in order to achieve this objective. For this reason, central banks have been concentrating on reducing inflation since the 1970s. Price level increases as a result of inflation, which may result in an increase in living expenses as well as other charges. Greater uncertainty and fluctuation in price level would be associated, in particular, with an unexpectedly high inflation rate. It is common for central banks to employ monetary policy to preserve monetary stability, but determining an acceptable target inflation rate may be challenging.

This paper analyzes two different kinds of targets, the price level target and the zero inflation target, which would achieve disparate goals. Besides, it also introduces two main target rates, namely the zero inflation rate and the positive inflation rate. Meanwhile, more details about the costs of inflation and which target or rate is more effective in a specific condition will be discussed. Finally, the Taylor rule will be introduced and how it is used by central banks to control inflation and economic growth will be further explained.

## 2 The Costs of Inflation

While it is quite theoretical and necessary that all agents have similar inflation expectations, completely anticipated inflation means that all economic actors can consistently forecast the future inflation rate [1]. Spending real money is taxed by inflation, and inflation expenses are frequently linked to inadequate money holdings. In normal situations, “ $i$ ” stands for the nominal interest rate, “ $r$ ” for the real interest rate, and “ $\pi$ ” for the inflation rate. According to the Fisher equation,  $i$  equals  $r$  plus  $\pi$ . The real money balance (RMB) that private persons keep decreases as a result of a rise in the inflation rate since it results in a greater opportunity cost of holding money.

With the premise that  $r$  is constant, Fig. 1 shows a negative relationship between  $i$  and RMB. Price stability and 0% inflation are present at point B. The demand for RMB is  $OE$ . Money holders receive a consumer surplus equal to the area  $ABH$  in such a situation. Assuming zero marginal cost, central banks have the ability to generate money and purchase bonds at a profit. Seigniorage revenue can be obtained by the central bank as a result, which increases government expenditure and decreases taxation. One may consider Area  $HBD0$  to be a producer surplus. When the inflation rate is positive,  $i0$  increases to  $i1$ , which indicates the opportunity cost of keeping money increases. Private individuals demand less money and choose to hold less RMB ( $OF$ ). Consumer surplus falls to  $AGC$  and producer surplus changes to  $GCF0$ . Total welfare falls from  $ABE0$  to  $ACF0$ , so  $CBEF$  is the net welfare loss for society. The higher the inflation is, the greater this welfare loss will be. With a positive  $i$ , enterprises and households must waste unnecessary time managing RMB transactions that could be spent on leisure or production of goods [2]. For instance, individuals would go to the bank more frequently in order to change their money holdings into interest-bearing forms of investment such as securities. The sellers might reduce their stocks in order to increase the velocity of circulation of the money. This cost is also called “shoe leather costs” of inflation caused by a lower level of money holding.

Menu costs include all costs of correctly anticipated inflation and arise from the fact that a changing price level leads to an adjustment of all nominal magnitudes. Due to inflation, price of raw materials and wage of workers would be higher, which leads to a higher cost of manufacturing. If companies do not change the price of the products,

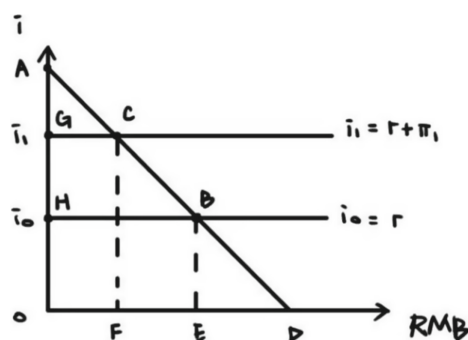


Fig. 1. The relationship between nominal interest rate and real money balance.

there could be no profits, even a loss. For instance, if companies sell the product with a price lower (higher) than the market clearing price, there would be an excess demand (supply). Menu costs would make price mechanism less efficient, which might lead to incorrect decisions made in production, investment, and consumption. Companies will inform their customers of price changes and this will increase the cost of informing such as printing new menus, retagging items, and even hiring experts to determine the new price strategy. If customers are unaware that increased prices are due to inflation and they seek out other restaurants and suppliers, the lost sales is also included in menu costs. Due to the increased ambiguity, businesses would modify their production plans and cut down on investment. The tax system incurs additional inflationary costs since tax rates, thresholds, and exemptions are frequently set in nominal terms. For instance, bracket creep happens when income enters higher tax rates as a result of inflation. As a result, income taxes will grow without a corresponding increase in real income, which lowers people's spending power and their standard of life. Inflation can also change the real value of deductions. A firm borrows money to invest, and  $r$  is 4%. The firm needs to yield more than 4% to make a profit. If there is inflation at a 10% rate, it requires a yield only higher than -6% to be profitable.

In real world, it is unlikely to predict inflation rates accurately. Higher prediction inaccuracy rates are typically correlated with higher inflation rates [3]. Since governments often enact stabilization actions to lower inflation, a high inflation rate causes more inflation volatility. Governments would implement additional stabilizing measures because the current ones are ineffective in a long term and are only successful temporarily. Resources may be misallocated as a result of unexpected inflation. A supplier can believe that greater sales of her products at the price she established in nominal terms are a result of higher demands if she is unable to differentiate between absolute and relative pricing. In fact, a rise in the average price of all other goods is what is driving consumers' increased tendency to purchase. Even when the actual demand for a company's products remains constant, this misperception causes businesses to manufacture more things. Long-term relationships are more seriously affected by the price of unexpected inflation. Most long-term contracts are unable to adjust their nominal salary during times of high inflation, which causes real salaries to fall. Long-term financial agreements are also affected. The debtors benefit and the creditors' interests are harmed if the actual inflation rate is higher than anticipated. Unexpected inflation thus causes a shift of wealth and risk. Feldstein indicates that a decrease of the inflation rate from 2% to 0% would entail a welfare gain equal to around 1% a year [4].

### 3 Price Level Target vs Zero Inflation Target

It is vital to choose a target for controlling the inflation. While a zero inflation target is typically thought to indicate a short-term realization timeframe, a price level target is regarded to signify a medium to long-term objective [5]. With a price level target, the central bank aims to keep the price level at its current level. A central bank committed to the price level target would undo the consequences of past failures to achieve the target price level. There is 50% chance for economy to deflate or inflate during shocks. The central bank uses monetary policy to bring the price level down (push it up) when

the economy faces a price level higher (lower) than the target. The total output in the economy will also fluctuate due to the implementation of monetary policy. With a zero inflation target, the central bank would not intervene the economy faced a shock since after the shock inflation returns to zero, shocks can be forgiven, although there is huge uncertainty of price level in the distant future and the price level is a random walk. For example, if there is an unexpected increase in prices, the central bank would not reduce the price since it aims for no further changes in price. Therefore, actual inflation and total output is less variable with a zero inflation target than with a price level target, which leads to higher costs of output fluctuation under a price level target.

## 4 Zero or Positive Inflation Rate

Even though everyone agrees that society benefits from low inflation, most central banks prefer to target a positive rate rather than a zero. There are four primary causes. First, there is a lower bound of zero. The Fisher equation states that when  $\pi$  is set to zero and  $i$  is assumed to be larger than zero,  $r$  cannot be lower than zero. Central banks must drop  $r$  below zero to boost the economy during severe recessions. If they are unable to do it, the issue is referred to as a liquidity trap. Second, fixed nominal wages may cost money when there is no inflation. With a somewhat positive inflation rate, changing the structure of real wages is simpler [6]. Most of the time, workers are oblivious to real pay declines and are primarily concerned with the changes in nominal salaries. Firms would lower the real pay to offset certain costs if they experienced a negative production shock. When inflation is zero, however, nominal earnings will see the same decrease as real wages, which is unacceptable to employees. Even with a 3 percent inflation rate, there is still a nominal salary rise of 1 percent following a real wage loss of 2 percent.

Thirdly, biased consumer price indices may result from wrongly applied index algorithms and arbitrary selection of the commodities to be included in the basket. Although the CPI may, to a limited extent, take into account significant technical advances, quality bias occurs when consumers disregard the improvement in the quality of items. When customers move from purchasing items whose relative price is growing to those whose relative price is decreasing, product substitution bias emerges. However, the CPI uses preset weighting schemes, which causes an overestimation of the real decline in buying power. Outlet bias suggests that customers are constantly searching for the greatest offer at the lowest cost. The official numbers also partially reflect this significant change. All the bias tends to make inflation figures overstate the effective inflation rate, and such distortions are around 0.2% to 2% per year [7]. Deflation, which has the potential to be worse than inflation, will ensue if the inflation target is set to zero since the real rate will be less than zero. Last but not least, an aim of zero inflation may prevent central banks from creating money because doing so would raise inflation and turn the rate positive. However, the optimum taxation argument contends that all taxation should be used by nations to generate money for their governments.

## 5 Introduction of Taylor Rule

Taylor rule is a rule created by the American economist John Taylor and a rule to adjust the policy rate when the output gap exists and could be either positive or negative. It is

also useful when inflation is different from a target rate. The original formula can be written as  $i = r^* + \pi + b_1 (\pi - \pi^*) + b_2 (y - y^*)$  where  $*$ ,  $i$ , and  $r$  means an equilibrium value, the nominal short-term interest rate, and the real short-term interest rate, respectively.  $\pi$  and  $y$  means the inflation rate and the total output (GDP) in the economy, so  $(\pi - \pi^*)$  is the deviation in inflation from the target rate and  $(y - y^*)$  means the output gap. The parameters  $b_1$  and  $b_2$  are weights chosen by the monetary policy maker and should be both positive. According to the formula, it can be seen that  $i$  would be relatively high (low) when inflation is above (below) the target or when the output is above (below) its full-employment level. Based on averages, there is a more specific formula that can be written as  $i = 2\% + \pi + 0.5(\pi - 2\%) + 0.5(y - y^*)$ . This implies that  $r^*$  and the inflation target ( $\pi^*$ ) both equal to 2%, and meanwhile, the output gap and inflation deviation have the same weighting. According to this formula, it is known that the nominal short-term interest rate ( $i$ ) will rise when inflation rate exceeds 2% or when there is a positive output gap. It is possible that the Taylor rule could create instability in the economy. A simple representative model is shown below [8]:

$$y_t = -\beta(i_t - \pi_t r^*) + u_t \quad (1)$$

$$\pi_t = \pi_{t-1} + \alpha y_{t-1} + e_t \quad (2)$$

$$i_t = g_\pi \pi_t + g_y y_t + g_0 \quad (3)$$

where  $y_t$  is the output gap,  $i_t$  is the nominal short-term interest rate,  $\pi_t$  is the inflation rate,  $(i_t - \pi_t)$  is equal to  $r_t$  which is the real short-term interest rate,  $e_t$  and  $u_t$  are uncorrelated stochastic shocks while the parameters  $\alpha$  and  $\beta$  are positive and  $g_\pi = 1 + b_1$ . In the real world, there is a lag between changes of policy rates and change of inflation. This model captures this feature. A change of nominal interest rate at time  $t$  leads to a change of output gap in the same time period  $t$ . According to (2), there is a lag between the change of output gap and inflation. It takes one period for the change of nominal interest rate to influence inflation in the model. After substituting (3) into (1), we can get an aggregate demand (AD) relationship between  $\pi$  and  $y$ , assuming  $g_y > 0$  and  $\beta > 0$ . After differentiation, the slope of this AD curve is  $-\beta(g_\pi - 1)/(1 + \beta g_y)$ . The stability of economy depends on the parameters of the rule. If  $g_\pi > 1$ , then the model is stable and vice versa. If  $g_\pi < 1$ , the slope of AD curve is negative. Assume there is a positive stochastic shock  $e_t$ ,  $\pi_t$  increases which leads to higher  $i_t$  as a contractionary monetary policy based on (3). Since  $g_\pi$  is greater than 1,  $\pi_t$  increases more than  $i_t$ . In Eq. (1), there would be an increasing  $r_t$  while the aggregate demand  $y_t$  will fall due to negative  $\beta$ . According to (2), the fall of  $y_t$  will make inflation fall back down in the next period. That is the reason AD curve is downward sloping. Nevertheless, assume there is a same positive stochastic shock  $e_t$  and  $g_\pi$  is less than 1.  $\pi_t$  and  $i_t$  still increases but  $i_t$  increases less than  $\pi_t$ . In the Eq. (1), there will be a decreasing  $r_t$  and  $y_t$  will increase due to negative  $\beta$ . More  $y_t$  will cause inflation to increase again in the next period. Under a  $g_\pi$  less than 1, AD curve is upward sloping and inflation and total output have a positive relationship, so they will keep increasing without a bound, which is destabilizing in the economy. Overall, if a central bank chooses to use the short-term interest rate as its instrument, it is crucial to choose an appropriate parameter  $g_\pi$  to

achieve good performance. Taylor rules quickly became a standard, and they are widely used to determine the optimal monetary policy. Several studies have been conducted to support the outcome of the Taylor rule. It is essential to understand the magnitude of the inflation and output coefficients. Different policymakers place different weights on inflation and output, making it difficult to determine which is the best [9]. In his study, Ball introduces a simple macroeconomic model that determines the optimal ranges of coefficients on inflation and output to determine an optimal monetary policy. Meanwhile, he points out that an efficient policy would minimize the sum of output and inflation variances for some choice of weights. According to the model, there are mainly two equations:

$$\bar{y}_t = -\beta \bar{r}_{t-1} + \lambda \bar{y}_{t-1} + \varepsilon_t \quad (4)$$

$$\bar{\pi}_t = \bar{\pi}_{t-1} + \alpha \bar{y}_{t-1} + \eta_t, \alpha > 0 \quad (5)$$

where  $\bar{y}$  is the gap between potential output and actual output,  $\bar{r}$  is the difference between the real interest rate and its equilibrium value,  $\bar{\pi}$  is the difference between actual inflation and inflation target, both  $\eta$  and  $\varepsilon$  are white-noise shock. There is an assumption that policy makers set the real interest rate after observing shocks  $\varepsilon$  or  $\eta$ . Policy affects the economy with lags, taking a period for policy to influence the output, and a period for output to change inflation. For example, if there is an increase in the real interest rate, the output gap will fall in the next period. A fall in the output gap will lead to a fall in inflation in the next period so two periods are needed to affect inflation. The dynamic IS relation (4) could imply the expected output as  $E(\bar{y}_{t+1}) = -\beta \bar{r}_t + \lambda \bar{y}_t$ . The equation of an accelerationist Philips curve (5) could imply the expected inflation as  $E(\bar{\pi}_{t+1}) = \bar{\pi}_t + \alpha \bar{y}_t$ . There is an assumption that  $\varepsilon$  and  $\eta$  are unforecastable.  $E(\bar{\pi}_{t+1})$  is a state variable. Due to lags in the model,  $E(\bar{\pi}_{t+1})$  is taken by the policy maker as a given variable during forming the  $E(\bar{y}_{t+1})$ . Thus,  $E(\bar{y}_{t+1})$  can be set as a function of  $E(\bar{\pi}_{t+1})$  and shows that the optimal policy is linear, which is  $E(\bar{y}_{t+1}) = -qE(\bar{\pi}_{t+1})$ . After changing the formula,  $\bar{r}_t = \frac{q}{\beta} \bar{\pi}_t + (\frac{\lambda+q\alpha}{\beta}) \bar{y}_t$ . This is a Taylor rule since the interest rate responds positively to the output and inflation. A representation of  $q$  that minimizes the loss function can be found as  $q = \frac{-(1+\alpha^2\mu) + \sqrt{(1+\alpha^2\mu) + 4\alpha^2\mu}}{2\alpha}$ . According to this formula, it can be seen that if  $\mu$  is equal to zero, then  $q$  will be zero as well. This means the central bank does not care about inflation. If  $\mu$  approaches infinity,  $q$  will approach  $\frac{1}{\alpha}$ , which means the central bank only cares about inflation. After rewriting the Taylor rule, a form can be obtained as  $i_t = (\pi + r^*) + \frac{q}{\beta} \bar{\pi}_t + (\frac{\lambda+q\alpha}{\beta}) \bar{y}_t$ . Then, an optimal Taylor rule can be obtained. When the range of  $q$  is 0 to  $\frac{1}{\alpha}$ , the weight on the output lies between  $\frac{\lambda}{\beta}$  and  $\frac{\lambda+1}{\beta}$ . At the same time, the weight on inflation will lie between 0 and  $\frac{1}{\alpha\beta}$ . Base on the previous research,  $\beta$ ,  $\lambda$ , and  $\alpha$  can be set as 1, 0.8, and 0.4, respectively. For these values, the weight on inflation lies between 0 and 2.5 and the weight on output lies between 0.8 and 1.8. As Taylor suggested, the weight on inflation is 0.5 which is in the efficient range but the weight on output is 0.5, which is lower than the efficient range. The policy maker should be more aggressively in response to the changes in output. The rule for optimal monetary policy should have the weights within the range. The reason the author choose this model is that it is a simple model which is easier to be understood

compared with some large models. Although large models could provide more accurate values, this simple model also gives an accurate result with clear economic explanations.

## 6 Conclusion

The fact that central banks should be in charge of implementing policies to keep inflation at a low and stable rate is generally acknowledged, despite the fact that the precise effects and costs of inflation are difficult to quantify. This is similar to estimating the social loss of redistribution since one group gains while the other loses. While Fischer showed a persistently negative connection between inflation and growth in a panel regression of 80 nations from 1961 to 1988 [10], some contend that inflation may increase the economic growth by raising employment and productivity. Is the goal of zero inflation really a terrible one? NO, zero inflation keeps the price level very stable in the short term and encourages strong confidence, which leads to more investment and consumer spending and growth. In the long run, nevertheless, the price level follows a random walk with an inflation objective of zero. Due to the factors mentioned above, a long-term zero inflation goal would lead to deflation, further constraining expenditure and possibly causing the economy to enter a recession. Strong evidence supports the conclusion that a modest, positive goal rate between one and three percent would be ideal for limiting inflation. Furthermore, the Taylor rule should be introduced to control the inflation rate and there should be a specific range for the parameters in the formula.

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