China's Macroeconomic Policies, Restrictive Independence of the Central Bank and Market Expectation

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Abstract

The monetary policy in China is neither a solely top-down order of government to the puppet-style central bank, nor a completely independent decision of monetary authority. Instead, it is implemented by central bank subject to restrictions and cost of policy bargaining. This paper constructs a political economic model where the monetary policy maker and fiscal policy maker with heterogeneous preferences interact in independent, non-independent and restrictively independent monetary policy regimes, respectively. Three major findings emerge from the framework. Firstly, the cyclical overshoot of macroeconomic policies seen in early periods of reform in China might have to do with the similarity in preference of central bank and government. Second, the fact that central bank under restrictions makes discretionary decisions of monetary policy brings the market uncertainties to form correct expectation. But in general, it guarantees a lower price expectation than under non-independent central bank. Third, the gradually uprising status of central bank has contributed to the declining price expectation of the market in recent years.

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1. Introduction

This paper explores the relationship between the institutional constraints faced by the central bank and the macroeconomic dynamics of China in past two decades. It focuses on the interactions between monetary policy maker that enjoys restrictive independence and the fiscal policy maker and the impacts of such interactions on the market expectation of price.

China has been sustaining rapid economic growth while maintaining relatively stable price level since middle 1990s. This period witnessed much less volatility of macroeconomic environment compared to earlier years of reform, a period characterized by drastic ups and downs. Although the economic growth rate kept high over the whole reform years, overheating and economic recessions took place with each other periodically in earlier periods. The drastic cyclical pattern became more smooth after the government fully liberated the price of goods in early 1990s. In recent two decades, even experiencing two rounds of severe global crisis in 1998 and 2008, China's economy maintained an average 10% yearly growth rate and 3.2% annual inflation.

In the meantime, the inflation expectation of market has become lower and better anchored than before. For example, the average price expectation between 1999-2009 was close to zero according to Zhang and Joel(2010). Partly because of the low expectation, the occasional price hikes persisted shortly and was later brought down by policy makers. In general, the fiscal and monetary policies of the country have been considered well coordinated in balancing the multiple goals such as GDP growth and price stability. But at the same time, the monetary policy was at times found lagged and took into effect imperfectly. Pressure of inflation increased in periods like 2003-2005 and 2010-2011, though much lower than before.

All of this evolved under a central bank without institutionalized independence enjoyed by its western counterparts. The People's Bank of China(PBoC), the central bank is only a subsidiary body of the state council, namely the central government and its status as a central bank has not been legalized until 1995, when the national congress promulgated the Laws of People's Bank of China. The higher authority not only controls the appointments and promotion of the bank governors through the party's bureaucratic system, but also directly influences monetary policy making. It is important to ask how the monetary policy in China managed to establish its credibility and maintained a low price expectation given such institutional constraints. If the central bank has been solely a puppet which caters government's needs in any time, it would be hard to account for the relatively stable price level and low price expectation in past two decades.

Studies in both economics and political economy domains took an institutional change perspective and attributed the macroeconomic policy performance to the uprising status and gradually gained independence of central bank in China. For example, Bell and Feng(2010) traced back the history of PBoC since its inception to the current stage, arguing that the bank obtained increasing autonomy in policy implementation level for its expertise advantage and the multiplicity of monetary policy instruments. Shih(2008)pointed out the important role played by political leaders in strengthening the status of central bank in the policy arena. Arnone(2009) made distinctions between political independence and economic independence and assigned high score to PBoC in the later indicator despite low in the former. China was ranked in the middle among all economies in terms of the central bank independence according to Dincer and Barry(2014). The similar arguments were echoed by literatures which provided empirical evidence for the independence-oriented development and hawkish movement of PBoC in recent decade. (Zhang and Joel, 2010; Girardin, etc, 2014). Besides, it has been found by some studies that the PBoC was implementing monetary policies in implicit or informal targets of inflation instead of solely output-oriented.(He,etc, 2008; Girardin, etc, 2014) As shown in these studies, the change of institutional environment is a key factor which should not be omitted in the framework understanding macroeconomic policies in China. It is essential to endogenize the interaction between central bank and its higher authority, likewise the fiscal policy maker in a macroeconomic model of China's economy. This paper tries to construct a framework allowing for the variations of policy-making regime and examines its impacts on the market expectation.

The monetary policymaking is neither merely a top-down order of central government nor independent decision of monetary policy authority. Rather, it carries varying features dependent upon the interaction between policy makers. The process was termed by He and Laurent (2008)as " PBOC proposes but state council disposes.", which was also thought as the reason for lagged response of monetary policy as often observed. In reality, the decision of state council can be better treated as an outcome of policy bargaining of different departments under state council. The monetary policy acts under restrictions. Implementing preferred policy is not costless and faces uncertainties. Sometimes the central bank might be able to implement its preferred policy, but at a cost. As shown in later sections, the special institutional feature has impacts on the level of both realized price and market expectation in China.

The empirical puzzle concerned by this paper is closely related to previous theoretical research on the uncertainties of policy game between monetary policy maker and the market associated with political frictions. Based on the seminal work by Barro and Gordon(1983a, 1983b, 1986), Vickers (1986), Cukierman and Meltzer(1986a,1986b) modified the classical model of monetary policy game to incorporate asymmetric information, imperfect control of monetary policy and varying preferences of policy makers. Their hypothesis stated that the uncertainty of inflation lowers inflation expectation, which was supported by Narayan, etc(2009) based on the empirical study on China's economy in recent two decades. This paper shares the concern about policy-making frictions with their work, but it believes that key factor is policy restriction due to the relationship between two policy makers instead of uncertainty of single policy maker's preference. Based on these literatures, this paper extends the monetary policy model between central bank and market to incorporate the interaction between monetary policy authority and fiscal policy authority. It is found that the policy interaction of two is related to the declining trend of price expectation in long run.

In this paper, the basic structure of the model is drawn from Obstfeld's(1996,1997)model used to explore the fundamental-based currency crisis. His model was itself developed from Barro and Gordon's work. The special advantage of Obstfeld's setting is its convenience of interchange between a domestic background and international background. Although not major concern here, it allows us to integrate the exchange rate issue into the single framework in future research. Exchange rate policy was found to be used implicitly by PBoC to convey signals and build credibility to the market.(Sachs,1996)

The paper is structured into four sections. Section 2 is to set up the baseline model. Section 3 considers the policy interactions between monetary policy maker and fiscal policy maker under three policy regimes: non-independence, independence and restrictive independence of central bank. Section 4 examines and compares the market expectation of price under different regimes. Section 5 concludes the major findings of the model and its implications for the empirical dynamics of macroeconomies in China.

2. Model Setting

The benchmark model this paper constructs is an extension of Obstfeld (1991, 1994). Obstfeld's framework was originally built to understand the currency crisis and it explicitly spells out the objective function of monetary policy maker and incorporates the economic fundamentals in the model. The core is the interaction between central bank and market, two players, under short-run New Keyesian settings allowing for rational expectation. My model shares the spirit with Obstfeld's but diverges from it by turning the single-policy-maker game to a double-policy-makers one. As it turns out in following discussions, the interaction between the fiscal policy maker, namely the central government, and the monetary policy maker, the central bank plays the central role in the story of current paper. Besides, the model preserves Obstfeld's way of treating the change of domestic price and that of exchange rate equivalently under the assumption of purchasing power parity, though it will be interpreted in a domestic perspective. It easily fits an open-economy background.

Now let's turn to the specifics. Firstly, there are monetary policy maker C, fiscal policy maker G and a representative market agent M in the model. Both policy makers run loss from inflation(or deflation)and deviation from output target. This characterizes the short-run trade-off between creating inflation to stimulate economy and bearing the loss from suboptimal output performance to maintain price stability. Importantly, they assign different weights to two goals in loss function. The central bank dislikes inflation more than the fiscal policy maker does.[1] The following equations lay out the loss functions of two players.

$$L_c = (Y - Y^*)^2 + \beta_c \epsilon^2 \tag{1}$$

$$L_g = (Y - Y^*)^2 + \beta_g \epsilon^2 \tag{2}$$

$$\beta_c > \beta_g \tag{3}$$

$$\epsilon = \epsilon_t - \epsilon_{t-1} \tag{4}$$

L_c and L_g are the losses of two policy makers separately; Y stands for the actual output; Y^* is the output target shared by both players;[2] ϵ is the price change in current period relative to previous period(equivalent to exchange rate change in Obstfeld's paper). The condition given by (3) ensures the preference order of two players, which turns out to be critical in shaping the nature of the game.

Second, price change ϵ is no longer solely set by the monetary policy maker like in original models, rather it is dependent upon both monetary policy and fiscal policy, as shown below.

$$\epsilon = \lambda \epsilon_0 + \mu c \chi \tag{5}$$

ϵ_0 is the monetary policy controlled by central bank C. It contributes to the price change directly with a control error parameterized by λ. For simplicity purpose, the current paper

[1] In China's case, although the central bank is assigned multiple goals to fulfill, price stability and employment rate are still two most important ones. Importantly, the central bank is more concerned about price level than central government does, the same as advanced economies.

[2] Each year, the Chinese central policy makers, state council specially together with other economic departments, sets the GDP growth target for the next year as the part of the annual economic planning. Such target is a compromised outcome provided different views of economic situations and conflicting policy preferences and it is naturally shared by policy makers. Compared to advanced economies, it is even more obvious in China of the output-target-oriented macroeconomic policy-making inherent in the theoretical framework.

assumes λ to be permanently 1. Obviously, positive ϵ_0 stands for expansionary monetary policy, negative being tightening. zero being neutral.

χ is fiscal policy determined by central government, standing for expansionary policy when positive and tightening when negative. It contributes to price change with parameter c and control error μ. Similarly, the μ is from then on assumed to be 1 constantly. Noting that in addition to this the fiscal policy also directly stimulate economic output, as modeled below. A simpler model may assume away the impact of fiscal policy on price level and only allows it to affect output level(the standard way fiscal policy works). But the current paper adopts a comprehensive setting. This approach of modeling fiscal policy has been likewise adopted by Dixit and Luisa(2001).

Third, the short-run output function in response to fiscal policy and monetary policy is given as below.

$$Y = \bar{Y} + \alpha(\epsilon - \epsilon^e) + \theta\chi - u \tag{6}$$

This is a standard response function of short-run output, combining Philips Curve with fiscal policy. It includes natural output level $\bar{Y}$, surprising effect of market expectation $\alpha(\epsilon - \epsilon^e)$, fiscal stimulation $\theta\chi$ and exogenous output shock u. u is uniformly distributed within $[-U, U](U > 0)$. $\bar{Y}$ is the natural output, a constant during certain period; ϵ^e is the market expectation of inflation which forms prior to the output shock and macroeconomic policies. Both α and θ are positive parameters respectively associated with indirect stimulation by surprising inflation and direct fiscal stimulation. The relation of the two parameters roughly speaks to the relative effectiveness of policies and carries information relevant to later discussions. Besides, without loss of generality, α is assumed to be in the range of (0,1). (Detailed discussion seen in Appendix)

In previous models, the output target Y^* was assumed from the start to be substantially greater than natural output $\bar{Y}$. It is necessary for generating incentives of policy makers to stimulate the economy. Current model basically preserves the assumption but implicitly assumes that the difference of the two is small enough so that sometimes a positive output will push the output above the target, leading to overheating economic situations. Neither underperforming nor outperforming economy is welcomed by policy makers, thus both require counter-cyclical macroeconomic policies.

By specifying the fiscal policy maker and monetary policy maker separately, the model is able to better capture the economic realities with policy makers with heterogeneous preference. But so far we have not yet defined the relationship between the two. The interactions of the two policy makers vary under different types of relationship of policy makers.

3. Three Policy Regimes

The hierarchical relationship between central bank and central government shapes the interaction of two and further affects the macroeconomic dynamics. This section turns to examine three regimes under different types of relationships. They can be lined up along the spectrum by the degree of independence central bank enjoys. On one extreme, the central bank is purely a puppet which simply acts in the order of central government. Its own preference has no impact upon the economic outcome. On the other extreme, the central bank is independent from fiscal policy authority and the two play a conflict game. Between the two extremes is the middle ground where the central bank's preference differs from central government's but it only possesses restrictive independence. This is a more realistic situation resembling China's political economic feature. I will first discuss the two extreme cases and then give a detailed discussion of realistic situation in China. Since this section focuses on the interaction of two policy makers, we temporarily assume the market expectation fixed.

3.1. Non-Independent Regime

Imagine the situation where the central bank is not able to implement monetary policy independently based on its own preference. Now the monetary policy and fiscal policy are both in the control of the single policy maker. If so it is even not necessary to pre-specify the loss function of central bank as done in previous section for the preference of central bank is no longer relevant to the outcome. But equivalently we can model this situation within the current framework. We consider the scenario where the monetary policy is predetermined or made pegged to certain level and then the fiscal policy is flexibly chosen to optimize government's objective function. It reflects the non-independence of monetary policy. An even more extreme case than this is that the government simultaneously chooses the optimal pair of monetary policy and fiscal policy. This is not discussed here since it is relatively unrealistic in practice because very often at least one of the two policies faces certain restrictions. The fixed monetary policy case to be discussed here is sufficient to generate insights for the paper's purpose.

Now it is assumed here that the monetary policy is locked at a given level $\tilde{\epsilon_0}$. $\tilde{\epsilon_0}$ can be arbitrarily set in the model but it is decided by and thus known to the central government in practice, the higher authority. In order to minimize the loss function, the central government now only needs to decide optimal fiscal policy $\hat{\chi}$, which is given below(See in Appendix)

$$\hat{\chi} = \frac{\Delta Y + \alpha\epsilon^e - \tilde{\epsilon_0}(\alpha + \frac{c\beta_g}{\alpha c+\theta})}{\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta}} \tag{7}$$

where we define

$$\Delta Y = Y^* - \bar{Y} + u \tag{8}$$

ΔY is a ready measurement of output gap after random shock u. Eq.(7) gives the optimal fiscal policy provided a pegged monetary policy $\tilde{\epsilon_0}$. It shows the negative and linear correlation between the two. If the an aggressive monetary policy is in hands, moderate fiscal stimulation is sufficient. Alternatively, the moderate monetary policy is accompanied by extensive fiscal policy. No matter which pair of macroeconomic policies are chosen, the outcome is always in favor of the preference of the central government in a non-independent central bank situation. Now the realized inflation $\hat{\epsilon}$ is given below.

$$\hat{\epsilon} = \tilde{\epsilon_0} + c\hat{\chi} = \frac{c(\Delta Y + \alpha\epsilon^e)}{\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta}} + \frac{\theta\tilde{\epsilon_0}}{\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta}} \tag{9}$$

The first part on the right-hand side of Eq.(9) is fixed for given output gap thus the realized inflation is solely dependent upon the predetermined monetary policy. With increasing expansionary monetary policy, the realized inflation is naturally higher.

The realized output $\hat{Y}$ is determined as below. (See in Appendix)

$$\hat{Y} = Y^* - \frac{c\beta_g(\Delta Y + \alpha\epsilon^e)}{(\alpha c + \theta)(\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta})} - \frac{c\beta_g\theta\tilde{\epsilon_0}}{(\alpha c + \theta)(\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta})} \tag{10}$$

From Eq.(10) we observe an interesting relationship between the fixed monetary policy and realized output, with the output negatively correlated with the monetary policy. This correlation is counter-intuitive at first sight but actually understandable after scrutiny. With more expansionary monetary policy , the loss-minimizing government then adjusts the magnitude of fiscal policy to be lower, leading to smaller output rise. This is so because the fiscal policy not only stimulates economy by creating surprising inflation, but also directly increases the output by fiscal spending. Therefore if both policy tools are controlled by central government, fiscal policy is favored over monetary policy in terms of the effectiveness of output stimulation. In general, such principle applies to all economies no matter which regime of policy making it stays. In practice, the fiscal policy is subject to various limitations due to political institutions and resources owned by government.

By Eq.(10) it is easy to prove that the realized output is always above the natural output level $\bar{Y}$ but below the output target Y^*. As long as both policies are accommodative, the loss-minimizing government can be satisfied with an output level below output target.

It remains now to examine the signs of the fiscal policy and monetary policy chosen in this regime. With both policies controlled by central government, it is natural that two policies should be coordinative instead of counteractive. This implies that two policies should be always in the same direction. Assuming an underperforming economy or high inflation expectation, implied by $\Delta Y + \alpha\epsilon^e > 0$, we should have $\hat{\chi} > 0$ and $\tilde{\epsilon_0} > 0$. To meet this constraint, the fixed monetary policy has to fall into a certain range given below.

$$\tilde{\epsilon_0} \in (0, \frac{\Delta Y + \alpha\epsilon^e}{\theta + \alpha c + \beta_g c}) \tag{11}$$

If the fixed monetary policy is not extremely large but moderately expansionary, the fiscal policy set by central government is thus expansionary correspondingly.

The discussion of non-independent regime above gives a rough sense of the substitute relationship between monetary policy and fiscal policy in short-run, when two policies are both in the control of central government while the central bank is only a puppet. In general the fiscal policy is preferred since it is able to stimulate economy more efficiently than monetary policy does. If fiscal policy fixed at the start, the government will adjust monetary policy accordingly to optimize its objective function. The single policy maker is always able to implement coordinative policies in equilibrium. Also, the realized inflation is positive, highlighting the inflation bias and time inconsistency problem discussed by many previous literatures.

3.2. Independent Regime

This sub-section turns to the other extreme of the relationship of monetary policy maker and fiscal policy maker. Now the central bank is independent from government and it makes individual decision on monetary policy in response to fiscal policy handed by government. The preference of central bank becomes relevant and is just as specified in the benchmark model setting. Two players make independent and simultaneous choice of χ and ϵ_0, respectively, after observing the same output shock u and market expectation ϵ^e. No direct coordination between the two exists and each one tries to minimize its own loss function.

3.2.1. Rational Expectation Equilibrium

Now, the realizations of two policies at equilibrium are obtained by deriving their respective best responses based on subjective expectation of each other's action. Define that the central bank expects the fiscal policy in current period to be $E(\chi)$ and the government expects the monetary policy to be $E(\epsilon_0)$. The realized policies are $\dot{\chi}$ and $\dot{\epsilon}$. By a series of derivation, we obtain following result. (See in Appendix)

$$\dot{\epsilon_0} = \frac{(\Delta Y + \alpha\epsilon^e) - (\theta + \alpha c + \beta_g c)E(\chi)}{\alpha^2 + \beta_c} \tag{12}$$

$$\dot{\chi} = \frac{\Delta Y + \alpha\epsilon^e - (\alpha + \frac{c\beta_g}{\alpha c+\theta})E(\epsilon_0)}{\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta}} \tag{13}$$

Eq.(12) and Eq.(13) present the relationship between policy maker's action and its guess of the other one's policy. This takes the form of a standard conflicting game between two strategic players. The mutual guess and learning process may have great variations and complexity with the static game extended to a dynamic one. But for the purpose of this paper, the rational expectation assumption is sufficient and it simplifies the game substantially. The underlying logic is that the central bank and central government gradually learns each other and are finally able to correctly guess each other's action. So the interaction of two reaches an equilibrium. Rational expectation assumption requires

$$E(\chi) = \dot{\chi} \tag{14}$$

$$E(\epsilon_0) = \dot{\epsilon_0} \tag{15}$$

Combining two with Eq.(12) and Eq.(13), we obtain the rational expectation equilibrium as below.(Derivation Seen in Appendix)

$$\epsilon_0^* = \frac{(\frac{c^2\beta_g}{\alpha c+\theta} - \beta_c c)(\Delta Y + \alpha\epsilon^e)}{(\alpha^2 + \beta_c)(\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta}) + \alpha + \frac{c\beta_g}{\alpha c+\theta}} \tag{16}$$

$$\chi^* = \frac{(\alpha^2 + \beta_c - \alpha c - \frac{c\beta_g}{\alpha c+\theta})(\Delta Y + \alpha\epsilon^e)}{(\alpha^2 + \beta_c)(\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta}) + (\theta + \alpha c + \beta_c c)(\alpha + \frac{c\beta_g}{\alpha c+\theta})} \tag{17}$$

Eq.(16) and Eq. (17), together with a whole set of specified parameters determine the magnitude and signs of equilibrium monetary policy and fiscal policy in response to particular output shock and market expectation. Based on the general expression given by two equations, the stance of two policy makers at equilibrium remain undecided thus calls for discussion case by case. The situation, as shown in next, varies with three factors: (1) the state of the economy(underperforming or outperforming); (2) the state of market expectation(inflation expectation or deflation expectation); (3)the relative size of policy and preference parameters.

3.2.2. Underperforming Economy and Inflation Expectation

All possible cases can be classified into two types of major situations according to the sign of $\Delta Y + \alpha\epsilon^e$ in Eq.(16) and Eq.(17). Now let's consider the case where $\Delta Y + \alpha\epsilon^e > 0$. It is equivalent to $u + \alpha\epsilon^e > -(Y^* - \bar{Y})$. This could be taken as if the policy makers face an underperforming economy after the output shock u or a sufficiently high expectation of inflation held by market. In the inequality above, the first possibility is implied by a negative output shock u > 0 or an sufficiently small positive shock. The second possibility is implied by a sufficiently high ϵ^e. They together make the condition above hold.

It is easy to prove that no conditions can be found so that $\epsilon_0^* > 0$ and $\chi^* > 0$ or $\epsilon_0^* > 0$ and $\chi^* < 0$ given the default preference order of two policy makers, $\beta_c > \beta_g$. (Proof Seen in Appendix)There is neither equilibrium with both policies being expansionary nor one with expansionary monetary policy and contractionary fiscal policy. The two possibilities are rolled out mainly because the central bank is in nature more hawkish than central government and thus has no incentive to loosen monetary policy in anticipation of response from fiscal policy maker. It goes against central bank's objective to cooperate with fiscal expansion, letting alone individually loosening policy when even central government does not.

Therefore, the equilibrium only exists for the other two cases seeing monetary contraction accompanied by fiscal expansion or simultaneous contraction of two, the former counteraction and later reinforcement. The counteractive scenario is feasible in face of an underperforming economy which requires stimulation. The fiscal policy maker takes expansionary stance but the central bank tries to hedge its effect. The scenario can be also interpreted as an equilibrium response to the pressure of inflation expectation of the market. The central bank wants to dampen the market expectation by monetary tightening but the fiscal policy acts to limit its effect. The simultaneous tightening, in contrast, is understandable if it is attributed to the incentive to dampen inflation expectation shared by both policy makers. But it may be an inferior outcome if the problem is mainly economic downturn instead of expectation. Let's find the conditions for these two possibilities respectively.

Counteraction Case

The counteraction case takes place if either condition A.1 or A.2 hold. Given certain α and β_g, the inequality $\frac{c\beta_g}{\alpha c+\theta} + \alpha(1-\alpha) < \beta_g$ is more likely to hold, roughly speaking, if θ is larger compared to c, thus $\frac{c\beta_g}{\alpha c+\theta}$ is smaller. The larger θ is, the more effectively fiscal policy directly generates output stimulation compared to generating surprising inflation. If so, the hawkish bank always undoubtedly tightens monetary policy to mitigate the inflation created by fiscal policy.

Condition A.1

$$\frac{c\beta_g}{\alpha c+\theta}+\alpha(1-\alpha)<\beta_g \tag{18}$$

Condition A.2 holds when θ is not as large as in condition A.1 (implied by $\beta_g < \frac{c\beta_g}{\alpha c+\theta}+\alpha(1-\alpha)$) and β_c is significantly larger than β_g (implied by $\frac{c\beta_g}{\alpha c+\theta}+\alpha(1-\alpha)<\beta_c$). It implies that if the direct output stimulation impact is not extremely sensitive to fiscal policy compared to that of surprising inflation, it is only when the preference of central bank significantly diverges from that of government that it behaves counteractively with fiscal policy maker.

Condition A.2

$$\beta_g<\frac{c\beta_g}{\alpha c+\theta}+\alpha(1-\alpha)<\beta_c \tag{19}$$

In both cases, the independent central bank acts in the opposite way of government at equilibrium. The incentive of counteraction is to mitigate the policy effect of the other one. It is a typical pattern of check and balance in a conflict game of independent monetary policy and fiscal policy.

Reinforcement Case

But interestingly, the counteraction is not the unique equilibrium situation under a purely conflict game.The reinforcement equilibrium occurs when both policy makers tighten instead of expand policies. This is the case when two conditions hold: (1)the direct impact of fiscal policy on output is sufficiently small; (2) the preference of central bank is close to that of central government. The first condition is shown by $\beta_g < \frac{c\beta_g}{\alpha c+\theta}+\alpha(1-\alpha)$. The second condition is shown by $\beta_c < \frac{c\beta_g}{\alpha c+\theta}+\alpha(1-\alpha)$. The preference parameter of central bank β_c is bounded by the upper bound $\frac{c\beta_g}{\alpha c+\theta}+\alpha(1-\alpha)$.

Condition B

$$\beta_g<\beta_c<\frac{c\beta_g}{\alpha c+\theta}+\alpha(1-\alpha) \tag{20}$$

Similarly, there are two ways of interpreting the equilibrium. One possibility is that the market inflation is so high that both policy makers find it necessary for austerity. This is easy to understand. The other possibility is that in face of an underperforming economy requiring stimulation, both policy makers, however, tighten policies. This is actually an inferior situation to both players, for neither of which acts in the right direction. The seemingly cooperation is in nature a coordination failure. Since the two are not extremely different from each other in terms of objective function, one may do nothing but rely on the other's action. This outcome is due to a lack of coordination between two policy makers.

The "cooperative" case highlights the potential problem with a weakly hawkish central bank. If the bank is only slightly more hawkish than the central government and the fiscal policy does not work very efficiently in stimulating output directly, the game of two policy makers ends up generating a policy package which paradoxically worsens the economic situation. To avoid such a problem, the preference of the two policy makers should be significantly distinct from each other. This is to say that a completely independent central bank must have a sufficiently hawkish stance. The independence per se can not ensure a favored result. With two policy makers of divergent preferences, the game stays at the unique equilibrium in the counteractive case discussed above, which is undoubtedly a compromise of two policy makers.

3.2.3. Outperforming Economy and Deflation Expectation

The similar logic works for the other type of situation where $\Delta Y + \alpha\epsilon^e < 0$, equivalent to $u + \alpha\epsilon^e < -(Y^* - \bar{Y})$. The condition may hold when the output shock is positive and large enough ($u < 0$ while $|u|$ is large)to push the realized output above its targeted level Y^*, or when the market hold a strong belief of deflation ($\epsilon^e < 0$ and $|\epsilon^e|$ is small). Both possibilities are exactly the opposite of the those two in Case 1, respectively.

It follows to examine feasible equilibrium policy outcomes. The default preference condition $\beta_c > \beta_g$ excludes two cases: simultaneous contraction, meaning $\epsilon_0^* < 0$ and $\chi^* < 0$ and the fiscal expansion combined with monetary contraction, meaning $\epsilon_0^* < 0$ and $\chi^* > 0$. These are exactly the two feasible outcomes in Case 2. In general, it implies that the central bank does not adopt contraction stance in equilibrium facing an overheating economy or sufficiently strong deflation expectation no matter what type of fiscal policy is. But it does not always counteract against fiscal policy maker unless it has a significantly distinct preference with fiscal policy maker, as shown below.

The feasible outcome maybe either counteraction combining fiscal contraction with monetary expansion or coincident expansion. The counteractive equilibrium occurs, meaning $\epsilon_0^* > 0$ and $\chi^* < 0$, when either condition A.1 or Condition A.2 holds as specified above in Case 1. In other words, if the direct stimulation impact of fiscal policy on output is sufficiently large, or if not so but the central bank is significantly more hawkish than the central government, the central bank always acts against central government. Expansion in cooperation occurs, meaning $\epsilon_0^* > 0$ and $\chi^* > 0$, if condition B holds. It means if the central bank is simply slightly more hawkish than the government, regardless of effectiveness of the fiscal policy, it chooses accommodative stance as central government does.

It is easy to imagine a scenario when a strong deflation expectation brings both policy makers together if they have similar tastes. Both react by expansion to correct the market expectation. But if the economy is overheating due to a positive and sufficiently large output shock, the policy makers' coincident expansion is inferior outcome. The possibility can be rolled out if the tastes of two policy makers are substantially different. If so the game ends up arriving at a unique equilibrium with counteraction, a characteristic embedded in a genuine conflict game.

3.2.4. Further Discussion

The table below summarizes all possible equilibrium outcomes discussed above and their conditions. ("+" expansionary; "-" contractionary)

Table 3.1

	Codition A.1	Condition A.2	Condition B
Underperforming Economy or Inflation Expectation	Fiscal +, Monetary -	Fiscal +, Monetary -	Fiscal -, Monetary -
Outperforming Economy or Deflation Expectation	Fiscal +, Monetary -	Fiscal -, Monetary +	Fiscal +, Monetary +

For simplicity of analysis, we roll out the two cases at the left in table above by pre-specifying $\beta_g < \frac{c\beta_g}{\alpha c+\theta} + \alpha(1-\alpha)$. This constraint implies that by default the fiscal policy output stimulation is not significantly more effective than creating surprising inflation. The distinction between two horizontally-lined cases is only the preference relation. The game structure is shown in table below.

Table 3.2

	Strong Hawkish Central Bank	Weak Hawkish Central Bank
Underperforming Economy or Inflation Expectation	Fiscal +, Monetary -	Fiscal -, Monetary -
Outperforming Economy or Deflation Expectation	Fiscal -, Monetary +	Fiscal +, Monetary +

If central bank's taste is sufficiently close to the fiscal policy maker, it leads to the opposite outcome of that in non-independent scenario due to the lack of coordination. In non-independent regime, the single policy maker is able to coordinate monetary policy and fiscal policy so that they are both in the counter-cyclical stance. But in the independence regime with two policy makers of similar tastes, both polices end up being pro-cyclical instead of counter-cyclical. At times, the underperforming economy is paradoxically responded by double contraction of two policies. The overheating economy waiting for a downward adjustment, however, encounters a double expansion.

In principle, this problem can be fixed as long as the central bank is much more hawkish than government. An independent central bank plays counteractive role well when its preference greatly diverges from that of government. If so the rightest two cases in table are excluded in equilibrium. In reality, however, there is no guarantee for such a case. This ambiguity speaks to what will be discussed next: the central bank with restrictive independence.

3.3. Restrictively Independent Regime

Neither one extreme discussed above perfectly captures the realistic situation in policy practice, although both carry important characteristics. Building upon the two benchmark regimes, this section combines features of both extremes to model the policy practice in China. We assume that the central bank is able to act on its preference some times but subject to special restrictions faced in the non-independent case in other times. The monetary policy is flexible only when it does not act in the opposite direction as fiscal policy does. If the central bank wants to take the opposite side of fiscal policy, it has to run a fixed cost κ. It is equivalent to imposing a zero bound to central bank's behavior, beyond which the "independence" of monetary policy is no longer costless. In theory, the bound can be arbitrarily chosen and is not necessarily zero. But zero bound simplifies the discussion without loss of generality and also maintains consistency with the previous two regimes.

The zero constraint changes the equilibrium outcomes partly. As a result, the central bank faces two trade-off options between non-act or counteract at a cost in those cases where it should have acted against fiscal policy maker. The possible equilibrium is given below.

Table 3.3

	Strong Hawkish Central Bank	Weak Hawkish Central Bank
Underperforming Economy or Inflation Expectation	Fiscal +, Monetary 0 or Fiscal +, Monetary -	Fiscal -, Monetary -
Outperforming Economy or Deflation Expectation	Fiscal -, Monetary 0 or Fiscal -, Monetary +	Fiscal +, Monetary +

The reinforcement cases on the right remain the same as in independence scenario. The reinforcement of monetary policy with fiscal policy is voluntary choice of the independent central bank. But the two counteractive cases on the left become uncertain. They will either turn out a neutral monetary policy, implying non-action of central bank or a counteractive policy. We assume that, unlike market, the central government knows the action of central bank due to informational advantage, it does not need to guess and can behave correspondingly. Therefore, in the counteraction case, the equilibrium is a pair of policies ϵ_0^* and χ^*, identical to that in rational expectation equilibrium derived in Eq.(16) and Eq.(17). In the inaction case, we may easily find that the game suddenly degenerates to a non-independence game with fixed monetary policy. In anticipating the monetary policy to be 0, the fiscal policy minimizes its loss function and adopts fiscal policy $\hat{\chi}$. By plugging $\tilde{\epsilon_0} = 0$ into Eq.7. It is given below.

$$\hat{\chi} = \frac{c(\Delta Y + \alpha \epsilon^e)}{\alpha c + \theta + \frac{c^2 \beta_g}{\alpha c + \theta}} \tag{21}$$

$$\epsilon = \tilde{\epsilon_0} + c\hat{\chi} = \frac{c(\Delta Y + \alpha \epsilon^e)}{\alpha c + \theta + \frac{c^2 \beta_g}{\alpha c + \theta}} \tag{22}$$

If the central bank's taste is close enough to that of government, its action goes the same direction as the fiscal policy does, although the equilibrium is unfavored outcome. In contrast, a central bank with divergent taste from government merely enjoys limited freedom. Unable to confront the fiscal policy maker without incurring cost, it now needs to weigh the two available options by taking into account fixed cost κ. The detailed analysis for this calculation will be discussed in next section.

It is important to note the difference between voluntary inaction and the passive obedience. After all, the freedom of non-action is still freedom. Although the central bank is disallowed to counteract, it is at least able to take an uncooperative stance with fiscal policy. This is the meaning of the restrictive independence. In the sense that central bank has its own preference and makes independent decisions of monetary policy occasionally, it is not a puppet. In the sense that the monetary policy is not always arbitrarily set by central bank but constrained by a given bound and it may incur extra cost, however, the independence is incomplete and only conditional.

Given the relation of the preference of two policy makers, we are able to determine the unique equilibrium for certain realized output and market expectation. This result is certainly known to both policy makers. But, importantly, they are ambiguous to the market. The market forms expectation without knowing exactly the policy-making regime it stays. This is the very topic of the next section.

4. Market Expectation

This section brings in the market representative agent as the third player to the game. The market tries its best to form the correct expectation of price change ϵ in the current period without knowing the realized output shock u beforehand, unlike the two policy makers do. This assumption is also used in Obstfeld's model of fundamental-based currency crisis. By the similar sequence in last part, this section firstly discusses two extreme scenarios and then focuses on the restrictively independent regimes, in which the policy restriction affects the market expectation in a different way.

In the two baseline regimes, it is easy to obtain the equilibrium price expectation by adopting rational expectation assumption. We assume that everything except for output shock u for current period is known to the market. In the non-independence game with the single player, the game in nature works in the same way as discussed in previous literatures on the two-player interaction between the central bank and the market. The only difference is that in current framework, the single policy maker changes to the central government, which does not change the game in anyway. In the completely independent central bank regime, as long as the preference and relevant parameters are known to the market, it can finally learn well of the equilibrium inflation level. By equalizing the market expectation of inflation ϵ^e to the $\hat{\epsilon}$ given by Eq.(9), we find the equilibrium expectation in non-independent regime. ϵ_1^e is as below. To consider one special case, we assume the fixed monetary policy $\tilde{\epsilon_0}$ to be zero.

$$\epsilon_1^e = \frac{c\Delta Y}{\theta + \frac{c^2\beta_g}{\alpha c+\theta}} \tag{23}$$

In independent and conflict game regime, with the equilibrium expectation denoted as ϵ_2^e, it is given by Eq(24) below.

$$\epsilon_2^e = \frac{B(\frac{c\beta_c}{\alpha c+\theta} - \beta_c)c + A(\alpha^2 + \beta_c - \alpha c - \frac{c\beta_c}{\alpha c+\theta})c}{AB - B(\frac{c\beta_g}{\alpha c+\theta} - \beta_c)c\alpha - A(\alpha^2 + \beta_c - \alpha c - \frac{c\beta_g}{\alpha c+\theta})c\alpha}\Delta Y \tag{24}$$

where $A = (\alpha^2 + \beta_c)(\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta}) + \alpha + \frac{c\beta_g}{\alpha c+\theta}$
$B = (\alpha^2 + \beta_c)(\alpha c + \theta + \frac{c^2\beta_g}{\alpha c+\theta}) + (\theta + \alpha c + \beta_c)(\alpha + \frac{c\beta_g}{\alpha c+\theta})$

ϵ_1^e and ϵ_2^e are both proportional to the output gap. The coefficient of ΔY in Eq(23) is positive constant. It means that the market will definitely expect inflation without independent central bank in underperforming economy. In independence regime, the expectation is negatively proportional to the output gap if a hard-nosed hawkish central bank is in power counteracting with fiscal policy. These expectations will be later compared with the expectation level in restrictive independence scenario. As demonstrated later, the expectation under restrictions is neither as high as non-independent one nor as low as the independence situation.

Unlike two idealistic regimes, the realistic situation brings uncertainties to the market. The ambiguities derive from central bank's non-unique action when monetary policy hit its boundary of freedom. It may either adopt the opposite stance against fiscal policy costly or stays neutral for free. We have shown before that this occurs whenever the preference of central bank is significantly different from the fiscal policy maker. By pre-specifying that condition A.2 holds, meaning $\beta_g < \frac{c\beta_g}{\alpha c+\theta} < \beta_c$, we guarantee from now on of the existence of monetary policy restriction. It follows to show the probabilities associated with central bank's double options under restriction, based on which the market form expectations.

4.1. *Market's Guess of Central Bank's Discretionary Actions*

In Obstfeld's model, the single policy maker, central bank, faces trade-off between maintaining fixed exchange rate and realigning the currency by incurring a cost. The relative cost and benefits vary with the size of output shock. There is a similar story here but differs in implications. Without restrictions, the central bank would have been capable of taking the opposite side of the fiscal policy in equilibrium. But once taking the confrontational cost into account, it needs to compare the realized loss in counteraction regime with that in inaction regime to determine whether the cost is so large that the confrontation is unwise. If the loss difference is larger than the fixed cost κ, the central bank implements monetary policy against fiscal policy; if smaller, it does not move and stays neutral in policy stance.

By Eq.(1), Eq(5) and Eq(6), the loss function of central bank can be rewritten as a function of two policies. Define the expected loss bore by central bank in inaction case to be $L_c(\epsilon_0 = 0)$ and $L_c(\epsilon_0 = \epsilon_0^*)$ in counteraction case. The difference of two is ΔL_c: $\Delta L_c = L_c(\epsilon_0 = 0) - L_c(\epsilon_0 = \epsilon_0^*)$

By a series of algebra procedures, we obtain the expression of ΔL_c in terms of the $(\Delta Y + \alpha\epsilon^e)$ as below, which takes the form of a quadratic function.

$$\Delta L_c = \psi(\Delta Y + \alpha\epsilon^e)^2 \tag{25}$$

where ψ is a sequence of complicated expressions including α,c,β_c,β_g and θ. For the purpose of the discussion here, its specific form is omitted and moved to Appendix. It suffices to know it is a positive constant given a set of specified parameters. Subject to the constraint condition A.2 and the default setting $\alpha \in (0, 1)$, any set of parameters are satisfied. For example, assume the parameters α,c,β_c,β_g and θ take values of 0.4,0.3,1,2 and

0.2,respectively, we have $\psi = 1.05$. If β_g and β_c are changed to 0.5 and 1, respectively, we have $\psi = 1.297$.

If the loss difference exceeds the antagonism cost, namely $\Delta L_c > \kappa$, it is equivalent to $(\Delta Y + \alpha\epsilon^e)^2 > \frac{\kappa}{\psi}$. Substituting ΔY with $Y^* - \bar{Y} + u$, we get $u \in (-\sqrt{\frac{\kappa}{\psi}} - Y^* + \bar{Y} - \alpha\epsilon^e, \sqrt{\frac{\kappa}{\psi}} - Y^* + \bar{Y} - \alpha\epsilon^e)$. This means that the output shock, no matter positive or negative, should be modest in size so that the central bank prefers doing nothing. Denote the upper bound and lower bound of u as $\bar{u}$ and $\underline{u}$, separately. So naturally, the loss difference is smaller than the cost, namely $\Delta L_c < \kappa$, when $u > \bar{u}$ or $u < \underline{u}$. This means only when the output shock is either extremely positive or extremely negative, the central bank has incentive to counteract fiscal policy by incurring cost.

Recalling that the output shock u is drawn from a uniform distribution of support [-U,U] and the market can not observe u directly. Therefore, the market's subjective probabilities associated with central bank's two actions are decided as below.

$$P(\epsilon_0 = \epsilon^*) = P(u > \bar{u} \text{or} u < \underline{u}) = 1 - \frac{\bar{u} - \underline{u}}{2U} = \frac{U - \sqrt{\frac{\kappa}{\psi}}}{U} \tag{26}$$

$$P(\epsilon_0 = 0) = P(\underline{u} < u < \bar{u}) = \frac{\bar{u} - \underline{u}}{2U} = \frac{\sqrt{\frac{\kappa}{\psi}}}{U} \tag{27}$$

Equations above are easy to understand by intuition. Given all other factors fixed, a higher fighting cost will make the counteraction less likely to happen. In the eyes of market, therefore, it is more probable that the central bank adopts neutral monetary policy. Unlike the situations in Obstfeld's model. the subjective probabilities of central banks's discretionary actions in my model are constants instead of variables varying with market expectations. It is for this reason that there are multiple equilibrium expectation in Obstfeld's model but there is unique equilibrium here.

The market expectation of inflation $E(\epsilon)$ is equal to $P(\epsilon_0 = \epsilon_0^*)\epsilon^* + P(\epsilon_0 = 0)\epsilon$. ϵ is given by Eq.(22) and ϵ^* is equal to $\epsilon_0^* + c\chi^*$ in Eq(16) and Eq(17). Rational expectation requires $E(\epsilon) = \epsilon^e$. Since the probabilities are constants irrelevant to ϵ^e, the equation will be linear with unique equilibrium solution. The multiplicity of equilibrium in Obstfeld's problem does not exist here. At equilibrium, the market inflation expectation is given below.

$$\epsilon_3^e = \frac{\frac{AB}{\alpha c + \theta + \frac{c\beta_g}{\alpha c+\theta}} c(1-p) + B(\frac{c\beta_g}{\alpha c+\theta} - \beta_c)cp + A(\alpha^2 + \beta_c - \alpha c - \frac{c\beta_g}{\alpha c+\theta})cp}{AB - B(\frac{\beta_g^2}{\alpha c+\theta} - \beta_c)c\alpha p - A(\alpha^2 + \beta_g - \alpha c - \frac{c\beta_g}{\alpha c+\theta})c\alpha p - \frac{AB}{\alpha c+\theta+\frac{c\beta_g}{\alpha c+\theta}} c\alpha(1-p)} \Delta Y \tag{28}$$

where $p = \frac{U-\sqrt{\frac{\kappa}{\psi}}}{U}$ and A,B are the same as in Eq(24). The unique equilibrium price expectation is also proportional to the output gap ΔY, with a positive coefficient of ΔY in the equation above. Output gap is positive either after a negative output shock or a positive shock small enough. In such a situation, the market forms a mild price rise at equilibrium. On the contrary, if an positive and sufficiently large output shock pushes the economy over the target, the market forms a deflation expectation.

4.2. Comparing Price Expectations in Different Regimes

As previously expected, it is found that the market expectation at equilibrium under restricted monetary policy lies in between two extremes. In order to see this, we assign several groups of values to the parameters as below. In the case 1 through 3, we let p, the probability of antagonism rise, possibly because of declining κ, leaving other factors unchanged. From case 4 to case 6, we let θ, the impact coefficient of fiscal policy on output, rise with all other factors fixed. From case 7-9, we let the slope of Phillips curve, α, rise with other factors fixed.

Case1 when p=0.3, $\epsilon_3^e = 0.2927\Delta Y$

Case2 when p=0.5, $\epsilon_3^e = 0.1981\Delta Y$

Case3 when p=0.8, $\epsilon_3^e = 0.0681\Delta Y$

Case4 when $\theta = 0.1$, $\epsilon_3^e = 0.1776\Delta Y$

Case5 when $\theta = 0.15$, $\epsilon_3^e = 0.1916\Delta Y$

Case6 when $\theta = 0.2$, $\epsilon_3^e = 0.1981\Delta Y$s

Case7 when $\alpha = 0.4$, $\epsilon_3^e = 0.1981\Delta Y$

Case8 when $\alpha = 0.5$, $\epsilon_3^e = 0.2096\Delta Y$

Case9 when $\alpha = 0.6$, $\epsilon_4^e = 0.2213\Delta Y$

Generally, there is a constant sequence of market expectations level in three regimes. For underperforming economies, the equilibrium price expectation ϵ_3^e is always smaller than ϵ_1^e but greater than ϵ_2^e, a characteristic shared by all nine cases below. This is reasonable in that the market expectation of price becomes lower by turning the central bank from the non-independent status to restrictive independence status. But at the same time, due to the restrictions faced by monetary policy, the market expectation does not go as low as in the pure conflict game, in which the strong hawkish central bank's hands are free from any restriction. The benefits of staying in the middle ground is a mild inflation expectation, not unbearably high and favored over deflation expectation caused by excessively hawkish central bank. But it might be still a problem because the inflation expectation is by no means eliminated.

Lower cost of confrontation results in lower price expectation. From case 1 to case 3, decreasing cost κ or increasing possibility p makes the equilibrium expectation price lower. The market is more convinced that the central bank will adopt counteractive policies thus naturally expect lower price level at equilibrium. In practice, political economic factors like institutional change, the relative power distribution and leaders' personal strength might all affect the cost of counteraction. The does provides a feasible explanation for China's uprising status of central bank and the increasingly lower and stabler price expectation.

What happens to the market expectation by having a lower θ? It turns out that the price expectation increases with θ, as shown in case 4-6. This implies that the more sensitive is the output to fiscal stimulation, the higher inflation the market expects at equilibrium. Lastly, the market expectation likewise rises with α, the surprising price effect coefficient in Phillips curve. This is shown in case 7-9 below. In practice, if the policy stimulation either by creating surprising inflation or aggregate demand approach is more effective, market will expect a larger price rise.

The policy makers prefers market expectation to be low so that the stimulation can be adopted at lower cost. In idealistic circumstances, zero expectation is welcomed. But in practice, a positive inflation expectation is unavoidable due to the time inconsistency problem. On one extreme, an independent and tough-stanced central bank is necessary to earn trust from the market. But too strong hawkish stance of central bank in a conflict game might bring the market to deflation expectation, which is an inferior outcome. On the other extreme with a puppet-style central bank, the market is unavoidably willing to expect high. There is no way to correct it since the check and balance between policy makers does not exist. In contrast with two extremes, the situation of a restrictively independent central bank is neither too good nor too bad. Although the market price expectation is certainly higher than that in independent central bank's case, the situation is at least better than that in a non-independent central bank. In some circumstances, even it can create a welcomed economic environment with a mild inflation expectation, if well managed. Noting, of course, that it is just one type of possibility.

5. Concluding Discussions

Political economy environment and policy making regimes matter for macroeconomies, especially in transitioning economies like China with different political system compared to industrial economies. It is especially important to incorporate the real-world frictions of policy making arena into the framework to understand the macroeconomic dynamics. As far as this paper is concerned, the relationship between monetary policy maker and fiscal policy maker has impacts on how the policies work and the how the market reacts. The monetary policy making in China is neither like what's described for a completely independent central bank, nor like a puppet without any autonomy. By hierarchy, the central bank in China is only a subsidiary body of central government. Its policy making is not in the full control of itself, but faces restrictions. In practice, however, the central bank does enjoy certain degree of autonomy in policy implementation and its status has gradually risen with time going on, as pointed out by many political economists. The policy making is better seen as a bargaining process among policy makers in power with distinct preferences. This introduces extra uncertainties to the market and partially changes the way market expectation forms.

Empirically, in past two decades, China has been relatively successful in managing macroeconomy and preventing super-high inflation without an independent central bank. But at times, the counter-cyclical economic policies were found lagged in response and overshoot, which resulted in inferior economic outcomes. These problems are not solely caused by technical errors and difficulties in managing the economies. Rather, they were related to the endogenous policy making process and the institutional features, as spelled out in this paper. In concluding, the framework in this paper leads to three major findings related to the economic realities in China.

Firstly, the lagged response and overshoot of pro-cyclical policies are in nature a coordination failure of two policy makers with tastes which are too similar. No matter for an independent central bank or a restrictive one, if its preference is extremely close to that of fiscal policy maker, it turns out that both policy makers might take contractions policies in response to underperforming economies and expansionary policies in response to overheating economies. This was consistent with realities in earlier periods of reform in China, when the macroeconomic policies were always overshoot and the economy went back and forth cyclically between overheating and recessions. By then, the central bank was unable to act in a strong hawkish stance against government due to limited freedom. With time going on, however, the preference of central bank gradually deviated from that of government and the overshoot and lagged response became rarer. It might have been for this reason that the macroeconomic policies came to be more properly managed in recent decade. The policy implications here is simple: no matter for an independent central bank or a restrictive one like China's, it should be hawkish enough so that the coordination failure between two does not exist.

Second, unlike an independent central bank, a monetary policy maker subject to restrictions makes discretionary decisions dependent upon the cost of confrontation. It only counteracts fiscal policy when it is worth of it. To be specific, only if the fixed cost of counteraction is low or the output shock is sufficiently large in size, does the central bank act against fiscal policy maker. In rest times, the best it can do is to stay neutral, showing an uncooperative attitude. The freedom of inaction is weaker than that of counteraction, but stronger than non-freedom. The monetary policy practice in China carries such a characteristic in some cases. The central bank is not always acting cooperatively to cater the government's needs, at least not doing so until political pressure from top became high. With rising status of central bank in policy bargaining arena, it incurs lower cost for the bank to behave in counteractive way. The introduction of restriction of monetary policy and the confrontational cost allows for the variety of monetary policy authority's action. This has impacts on market expectation, which is the third finding of this paper.

Third, under a restrictive independence central bank, the market price expectation is lower than non-independent scenario but higher than that under a central bank with well-guaranteed independence. The market has to guess central bank's discretionary actions facing restriction and forms price expectations imperfectly. But the equilibrium outcome is at least not extremely bad. If lucky, it can even generate mild inflation expectation, a superior situation over expected price decrease with a hard-nosed central bank. This provides theoretical rationale for China's relatively successful inflation control in recent decade. The macroeconomic environment, especially the price expectation of market in China has been no longer as high as earlier times of reform and became more stable in most times. People have gradually learnt of the political limitations of macroeconomic policies in China though remaining uncertain about the explicit policy choice in each period. Everyone knows well that the central bank is not free from the influence of government, but they lend certain amount of trust to the monetary policy maker. Very importantly, it is pointed out in this paper that with the lower cost of confrontation, the market expectation also becomes lower. The uprising status of central bank has been a gradual change instead of an overnight revolution. This process of transformation is well captured by a decreasing cost of confrontation.

The directions for future research following this one are twofold, both empirically and theoretically. This paper takes a theoretical perspective and does not proceed to examine the historical dynamics of macroeconomic policies in China in details, although the major changes and trends discussed are well grounded. It remains to provide a coherent and historical analysis in light of the framework proposed by this paper. Theoretically speaking, this paper extends previous work by Barro, Gordon(1986), Obstfeld(1991,1996) on monetary policy game between central bank and market by introducing the policy interactions between fiscal policy maker and the central bank to the original model. It assumes the perfect control of policies(no errors), rational expectation and complete information of the preference of policy makers by the market. These assumptions might be lifted or changed to explore more complicated cases. Besides, the model is constructed on a short-run New Keyesian basis, without considering economic fundamentals. Fiscal policy in this model is costless without government debt cost and constraints issues. These, however, are critical issues in discussing impacts and effectiveness of the fiscal policy and monetary policy. In order to incorporate these factors, the preference of policy makers can be modified in future research.

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Appendix A.

A.1. Model Setting

$L_c = (Y - Y^*)^2 + \beta_c \epsilon^2 (1)$

$L_g = (Y - Y^*)^2 + \beta_g \epsilon^2$ for central government (2)

$\beta_c > \beta_g$ (3)

$\epsilon = \epsilon_t - \epsilon_{t-1}$ (4)

L_c and L_g are the loss bore by central bank and government, respectively. β_c and β_g are their respective preference parameters associated with the output gap, which is defined as the difference of realized output Y and the output target Y^*. ϵ is the realized price change. Eq.(3) means that the central bank is by default more hawkish than government.

$\epsilon = \lambda\epsilon_0 + \mu c\chi$ (5)

Realized price change ϵ is determined by monetary policy ϵ_0 and fiscal policy χ. Control errors of two policies are assumed away by setting both to 1 permanently. c is the parameter associated with fiscal policy. Positive ϵ_0 stands for expansion, negative contraction and zero neutrality. The same as the fiscal policy.

$Y = \bar{Y} + \alpha(\epsilon - \epsilon^e) + \theta\chi - u$ (6)

Realized output Y responds to surprising price stimulation and fiscal stimulation on the basis of natural output $\bar{Y}$. $\bar{Y}$ is assumed to be smaller than Y^*. α is the slope of Philips curve. θ is the parameter associated with fiscal policy.

Combining Eq(1),(5) and (6), we get the loss function of central bank expressed by two policies, as below.

$L_c = (\alpha^2 + \beta_c)\epsilon_0^2 - 2\alpha(\alpha\epsilon^e + \Delta Y)\epsilon_0 + [(\alpha^2 + \beta_c)^2 + 2c\alpha\theta + \theta^2]\chi^2 - 2(\alpha c + \theta)(\alpha\epsilon^e + \Delta Y)\chi + 2(c\alpha^2 + c\beta_c + \alpha\theta)\epsilon^e\chi + (\alpha\epsilon^e + \Delta Y)^2$ (7)

where $\Delta Y = Y^* - \bar{Y} + u$.

Similarly, combining Eq(2),(5) and (6), we get loss function of government as below.

$L_g = (\alpha^2+\beta_g)\epsilon_0^2 - 2\alpha(\alpha\epsilon^e+\Delta Y)\epsilon_0 + [(\alpha^2+\beta_g)^2 + 2c\alpha\theta + \theta^2]\chi^2 - 2(\alpha c+\theta)(\alpha\epsilon^e + \Delta Y)\chi + 2(c\alpha^2 + c\beta_c + \alpha\theta)\epsilon^e\chi + (\alpha\epsilon^e + \Delta Y)^2$ (8)

A.2. Non-independent Regime

A.2.1. Fiscal Policy Chosen by Government Given Fixed Monetary Policy

Given $\tilde{\epsilon_0}$, the government chooses the optimal fiscal policy $\hat{\chi}$ so as to minimize L_g. Plug $\tilde{\epsilon_0}$ in Eq(8) and take the first and second order of derivatives of L_g with respect to χ. Then we get

F.O.C.: $\frac{dL_g}{d\chi} = 2[c^2\beta_g + (\alpha c+\theta)^2]\chi - 2(\alpha c+\theta)(\alpha\epsilon^e + \Delta Y) + 2(c\alpha^2 + c\beta_g + \alpha\theta)\tilde{\epsilon_0}$

S.O.C.: $\frac{d^2L_g}{d\chi^2} = 2[c^2\beta_g + (\alpha c+\theta)^2] > 0$

Let $\frac{dL_g}{d\chi} = 0$, then we get the loss minimizing $\hat{\chi}$, as below.

$\hat{\chi} = \frac{\Delta Y + \alpha\epsilon^e - \tilde{\epsilon_0}(\alpha + \frac{c\beta_g}{\alpha c+\theta})}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}}$ (9)

A.2.2. Realized Price Change and Output

Combining Eq.(9) with (5), we obtain the realized price change $\hat{\epsilon}$ after two policies.

$\hat{\epsilon} = \tilde{\epsilon_0} + c\hat{\chi} = \frac{c(\Delta Y+\alpha\epsilon^e)}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}} + \frac{\theta\tilde{\epsilon_0}}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}}$ (10)

Plugging Eq(9)and(10)in Eq(6), we obtain the realized output $\hat{Y}$.

$\hat{Y} = Y^* - \frac{c\beta_g(\Delta Y+\alpha\epsilon^e)}{(\alpha c+\theta)(\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta})} - \frac{c\beta_g\theta\tilde{\epsilon_0}}{(\alpha c+\theta)(\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta})}$ (11)

For the last two parts in Eq.(11) are all negative, $\hat{Y} < Y^*$ for any $\tilde{\epsilon_0}$.

A.2.3. Conditions for Coordination

Provided $\tilde{\epsilon^e} > 0$, we let $\hat{\chi} > 0$, or

$\frac{\Delta Y+\alpha\epsilon^e-\tilde{\epsilon_0}(\alpha+\frac{c\beta_g}{\alpha c+\theta})}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}} > 0$

Solving the inequality, we obtain $\epsilon^e < \frac{\Delta Y+\alpha\epsilon^e}{\theta+\alpha c+\beta_g c}$ for $\Delta Y + \alpha\epsilon^e > 0$

Combining it with $\epsilon^e > 0$, we have

$\tilde{\epsilon_0} \in (0, \frac{\Delta Y+\alpha\epsilon^e}{\theta+\alpha c+\beta_g c})$. (12)

A.3. Independent Regime

A.3.1. Rational Expectation Equilibrium

Anticipating fiscal policy to be $E(\chi)$, the central bank chooses the optimal monetary policy $\dot{\epsilon_0}$ to minimize L_c. By taking the first and second derivatives of L_c with respect to ϵ_0, we get

F.O.C.: $\frac{dL_c}{d\epsilon_0} = 2(\alpha^2 + \beta_c)\epsilon_0 - 2\alpha(\alpha\epsilon^e + \Delta Y) + 2(c\alpha^2 + c\beta_c + \alpha\theta)E(\chi)$

S.O.C.: $\frac{d^2L_c}{d\epsilon_0^2} = 2(\alpha^2 + \beta_c) > 0$

Let $\frac{dL_c}{d\epsilon_0} = 0$, we get the loss-minimizing $\dot{\epsilon_0}$ as below.

$\dot{\epsilon_0} = \frac{(\Delta Y+\alpha\epsilon^e)-(\theta+\alpha c+\beta_g c)E(\chi)}{\alpha^2+\beta_c}$ (13)

Anticipating monetary policy to be $E(\epsilon_0)$, the government chooses the optimal fiscal policy $\dot{\chi}$ to minimize L_g. By taking the first and second derivatives of L_g with respect to χ, we get

F.O.C.: $\frac{dL_g}{d\chi} = 2[c^2\beta_g + (\alpha c + \theta)^2]\chi - 2(\alpha c + \theta)(\alpha\epsilon^e + \Delta Y) + 2(c\alpha^2 + c\beta_g + \alpha\theta)E(\epsilon_0)$

S.O.C.: $\frac{d^2L_g}{d\chi^2} = 2[c^2\beta_g + (\alpha c + \theta)^2] > 0$

Let $\frac{dL_g}{d\chi} = 0$, we obtain the loss-minimizing $\dot{\chi}$ as below.

$\dot{\chi} = \frac{\Delta Y+\alpha\epsilon^e-(\alpha+\frac{c\beta_g}{\alpha c+\theta})E(\epsilon_0)}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}}$ (14)

Rational Expectation requires $E(\chi) = \dot{\chi}$ and $E(\epsilon_0) = \dot{\epsilon_0}$. Combining these two conditions with Eq.(15) and (16), we can solve the rational expectation equilibrium policies ϵ_0^*

and χ^* as below.

$$\epsilon_0^* = \frac{(\frac{c^2\beta_g}{\alpha c+\theta} - \beta_c c)(\Delta Y + \alpha\epsilon^e)}{(\alpha^2+\beta_c)(\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta})+\alpha+\frac{c\beta_g}{\alpha c+\theta}} \quad (15)$$

$$\chi^* = \frac{(\alpha^2+\beta_c-\alpha c-\frac{c\beta_g}{\alpha c+\theta})(\Delta Y+\alpha\epsilon^e)}{(\alpha^2+\beta_c)(\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta})+(\theta+\alpha c+\beta_c c)(\alpha+\frac{c\beta_g}{\alpha c+\theta})} \quad (16)$$

A.3.2. Conditions for Counteraction / Reinforcement

To discuss the positive/negative of $\epsilon_)^*$ and χ^* given above, we consider two major cases: $\Delta Y + \alpha\epsilon^e > 0$ and $\Delta Y + \alpha\epsilon^e < 0$. By default, we have $\alpha \in (0, 1)$. It turns out that the categorical outcomes are the same if we assume $\alpha > 1$

Situation 1: $\Delta Y + \alpha\epsilon^e > 0$

- $\chi^* > 0$ and $\epsilon_0^* > 0 \Leftrightarrow$ (1) $\beta_c > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$; (2)$\frac{c\beta_g}{\alpha c+\theta} > \beta_c$; (3)$\beta_c > \beta_g \Leftrightarrow \emptyset$
- $\chi^* < 0$ and $\epsilon_0^* > 0 \Leftrightarrow$ (1) $\beta_c < \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$; (2)$\frac{c\beta_g}{\alpha c+\theta} > \beta_c$; (3)$\beta_c > \beta_g \Leftrightarrow \emptyset$
- $\chi^* > 0$ and $\epsilon_0^* < 0 \Leftrightarrow$ (1) $\beta_c > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$; (2) $\frac{c\beta_g}{\alpha c+\theta} < \beta_c$; (3) $\beta_c > \beta_g$
  $\Leftrightarrow \beta_c > \beta_g$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$
  or $\beta_c > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$
- $\chi^* < 0$ and $\epsilon_0^* < 0 \Leftrightarrow$ (1) $\beta_c < \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$; (2) $\frac{c\beta_g}{\alpha c+\theta} < \beta_c$; (3) $\beta_c > \beta_g$
  $\Leftrightarrow \beta_g < \beta_c < \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$

Situation 2: $\Delta Y + \alpha\epsilon^e < 0$

- $\chi^* > 0$ and $\epsilon_0^* < 0 \Leftrightarrow$ (1) $\beta_c < \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$; (2)$\frac{c\beta_g}{\alpha c+\theta} > \beta_c$; (3)$\beta_c > \beta_g \Leftrightarrow \emptyset$
- $\chi^* < 0$ and $\epsilon_0^* < 0 \Leftrightarrow$ (1) $\beta_c > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$; (2)$\frac{c\beta_g}{\alpha c+\theta} > \beta_c$; (3)$\beta_c > \beta_g \Leftrightarrow \emptyset$
- $\chi^* < 0$ and $\epsilon_0^* > 0 \Leftrightarrow$ (1) $\beta_c > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$; (2) $\frac{c\beta_g}{\alpha c+\theta} < \beta_c$; (3) $\beta_c > \beta_g$
  $\Leftrightarrow \beta_c > \beta_g$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$
  or $\beta_c > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$
- $\chi^* > 0$ and $\epsilon_0^* > 0 \Leftrightarrow$ (1) $\beta_c < \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$; (2) $\frac{c\beta_g}{\alpha c+\theta} < \beta_c$; (3) $\beta_c > \beta_g$
  $\Leftrightarrow \beta_g < \beta_c < \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$

Denote $\beta_c > \beta_g$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ as condition A.1, $\beta_c > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ as condition A.2, $\beta_g < \beta_c < \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ and $\beta_g > \frac{c\beta_g}{\alpha c+\theta} - \alpha^2 + \alpha$ as condition B, respectively. In both two situations, the policies are counteractive(meaning one is "+", the other is "-") when condition A.1 or A.2 holds, while reinforcing(meaning both are "+" or "-") when condition B holds. It is summarized in the table below.

Table A.1

	Codition A.1	Condition A.2	Condition B
Underperforming Economy or Inflation Expectation	Fiscal +, Monetary -	Fiscal +, Monetary -	Fiscal -, Monetary -
Outperforming Economy or Deflation Expectation	Fiscal +, Monetary -	Fiscal -, Monetary +	Fiscal +, Monetary +

A.4. Restrictively Independent Regime

Consider the regime where condition A.2 holds, namely $\beta_g < \frac{c\beta_g}{\alpha c+\theta} + \alpha(1-\alpha) < \beta_c$. The central bank subject to restrictions makes discretionary choice of ϵ_0 between 0 and ϵ_0^*. The government acts correspondingly.

Inaction

$\epsilon_0 = 0$ (17)

$\chi = \hat{\chi} = \frac{c(\Delta Y+\alpha\epsilon^e)}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}}$ (18)

Counteraction

$\epsilon_0 = \epsilon_0^* = \frac{(\frac{c^2\beta_g}{\alpha c+\theta}-\beta_c c)(\Delta Y+\alpha\epsilon^e)}{(\alpha^2+\beta_c)(\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta})+\alpha+\frac{c\beta_g}{\alpha c+\theta}}$ (19)

$\chi = \chi^* = \frac{(\alpha^2+\beta_c-\alpha c-\frac{c\beta_g}{\alpha c+\theta})(\Delta Y+\alpha\epsilon^e)}{(\alpha^2+\beta_c)(\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta})+(\theta+\alpha c+\beta_c c)(\alpha+\frac{c\beta_g}{\alpha c+\theta})}$ (20)

A.5. Market Expectation

A.5.1. Equilibrium Price Expectations in Non-independent and Independent Regimes

1. Let $\epsilon^e = \hat{\epsilon}$ given in Eq.(10) and solve the equation, we obtain the equilibrium price expectation ϵ_1^e as below.

$\epsilon_1^e = \frac{c\Delta Y}{\theta+\frac{c^2\beta_g}{\alpha c+\theta}}$ (21)

2. Let $\epsilon^e = \epsilon_0^* + c\chi^*$ given in Eq.(17) and (18) and solve the equation, we obtain the equilibrium price expectation ϵ_3^e as below.

$$\epsilon_2^e = \frac{B(\frac{c\beta_c}{\alpha c+\theta}-\beta_c)c+A(\alpha^2+\beta_c-\alpha c-\frac{c\beta_c}{\alpha c+\theta})c}{AB-B(\frac{c\beta_g}{\alpha c+\theta}-\beta_c)c\alpha-A(\alpha^2+\beta_c-\alpha c-\frac{c\beta_g}{\alpha c+\theta})c\alpha}\Delta Y \quad (22)$$

where $A = (\alpha^2+\beta_c)(\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta})+\alpha+\frac{c\beta_g}{\alpha c+\theta}$, $B = (\alpha^2+\beta_c)(\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta})+(\theta+\alpha c+\beta_c)(\alpha+\frac{c\beta_g}{\alpha c+\theta})$

A.5.2. Equilibrium Price Expectation in Restrictively Independent Regime

Loss bore by central bank from inaction is $L_c(\epsilon_0 = 0)$ and loss from counteraction is $L_c(\epsilon_0 = \epsilon_0^*)$.

Plug Eq.(16) and (17) in Eq.(7), then we can obtain $L_c(\epsilon_0 = 0)$. Plug Eq.(17) and (18) in Eq.(7), then we obtain $L_c(\epsilon_0 = \epsilon_0^*)$. The loss difference is ΔL_c.

$$L_c(\epsilon_0 = 0) = (c^2\beta_c+(\alpha c+\theta)^2)(\frac{\Delta Y+\alpha\epsilon^e}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}})^2-2(\alpha c+\theta)(\Delta Y+\alpha\epsilon^e)^2\frac{1}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}}+(\Delta Y+\alpha\epsilon^e)^2 \quad (23)$$

$$L_c(\epsilon_0 = \epsilon_0^*) = (\alpha^2+\beta_c)\epsilon_0^*2-2\alpha(\Delta Y+\alpha\epsilon^e)\epsilon_0^*+(c^2\beta_c+(\alpha c+\theta)^2)\chi^*2-2(\alpha c+\theta)(\Delta Y+\alpha\epsilon^e)\chi^*+2(c\alpha^2+c\beta_c+\alpha\theta)\epsilon_0^*\chi^*+(\Delta Y+\alpha\epsilon^e)^2 \quad (24)$$

$$\Longrightarrow$$

$$\Delta L_c = \{\frac{2\alpha(\frac{c^2\beta_g}{\alpha c+\theta}-\beta_c c)}{A}-\frac{(\alpha^2+\beta_c)(\frac{c^2\beta_g}{\alpha c+\theta}-\beta_c c)^2}{A^2}+[(c^2\beta_c+(\alpha c+\theta)^2)(\frac{1}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}}+\frac{1}{B})+2(\alpha c+\theta)](\frac{1}{\alpha c+\theta+\frac{c^2\beta_g}{\alpha c+\theta}}-\frac{1}{B})-\frac{(\frac{c^2\beta_g}{\alpha c+\theta}-\beta_c c)(\alpha^2+\beta_c-\alpha c-\frac{c\beta_g}{\alpha c+\theta})}{AB}\}(\Delta Y+\alpha\epsilon^e)^2 \quad (25)$$

For simplicity, we use ψ to represent the complicated coefficient associated with $(\Delta+\alpha\epsilon^e)^2$. Given the default constraints, we have $\psi > 0$.To rewrite equation, we get expression as below.

$$\Delta L_c = \psi(\Delta Y+\alpha\epsilon^e)^2 \quad (26)$$

The central bank compare ΔL_c with fixed cost of confrontation κ to decide whether to counteract fiscal policy.

$$\Delta L_c > \kappa \Leftrightarrow (\Delta Y+\alpha\epsilon^e)^2 > \frac{\kappa}{\psi} \Leftrightarrow u \in (-\sqrt{\frac{\kappa}{\psi}}-Y^*+\bar{Y}-\alpha\epsilon^e, \sqrt{\frac{\kappa}{\psi}}-Y^*+\bar{Y}-\alpha\epsilon^e)$$

$\Delta L_c < \kappa \Leftrightarrow (\Delta Y + \alpha\epsilon^e)^2 < \frac{\kappa}{\psi} \Leftrightarrow u \in (-U, -\sqrt{\frac{\kappa}{\psi}} - Y^* + \bar{Y} - \alpha\epsilon^e)$ or $u \in (\sqrt{\frac{\kappa}{\psi}} - Y^* + \bar{Y} - \alpha\epsilon^e, U)$

Given $u \sim U(-U, U)$. So the subjective probabilities of market associated with the bank's two actions are as below, respectively.

$P(\epsilon_0 = \epsilon^*) = P(u > \bar{u}$ or $u < \underline{u})=1 - \frac{\bar{u}-\underline{u}}{2U} = \frac{U-\sqrt{\frac{\kappa}{\psi}}}{U}$ (27)

$P(\epsilon_0 = 0) = P(\underline{u} < u < \bar{u}) = \frac{\bar{u}-\underline{u}}{2U} = \frac{\sqrt{\frac{\kappa}{\psi}}}{U}$ (28)

Therefore, the market's rational expectation of price $E(\epsilon)$ is given below.

$E(\epsilon) = P(\epsilon_0 = \epsilon_0^*)\epsilon^* + P(\epsilon_0 = 0)\epsilon$

where $\epsilon^* = \epsilon_0^* + c\chi^*$ and $\epsilon = 0 + \hat{\chi}$.

Denote $\frac{U-\sqrt{\frac{\kappa}{\psi}}}{U}$ as p. Let $E(\epsilon) = \epsilon^e$ and solve the equation, then we obtain the equilibrium price expectation in restrictive independence scenario as below.

$$\epsilon_3^e = \frac{\frac{AB}{\alpha c+\theta+\frac{c\beta_g}{\alpha c+\theta}}c(1-p)+B(\frac{c\beta_g}{\alpha c+\theta}-\beta_c)cp+A(\alpha^2+\beta_c-\alpha c-\frac{c\beta_g}{\alpha c+\theta})cp}{AB-B(\frac{\beta_g^2}{\alpha c+\theta}-\beta_c)c\alpha p-A(\alpha^2+\beta_g-\alpha c-\frac{c\beta_g}{\alpha c+\theta})c\alpha p-\frac{AB}{\alpha c+\theta+\frac{c\beta_g}{\alpha c+\theta}}c\alpha(1-p)}\Delta Y \quad (29)$$

A.5.3. Comparing Price Expectations in Different Scenarios

Under the constraints of condition A.2 and the default settings $\beta_c > \beta_g$ and $\alpha \in (0, 1)$, we assign six sets of parameters to make the comparison of the price expectations in different scenarios. They are listed as below.

Case 1 $\alpha = 0.4$; $c = 0.3$; $\theta = 0.2$; $\beta_g = 0.5$; $\beta_c = 1$; $p = 0.3$

$\rightarrow \epsilon_1^e = 0.8807\Delta Y$; $\epsilon_2^e = -0.0105\Delta Y$; $\epsilon_3^e = 0.2927\Delta Y$

Case 2 $\alpha = 0.4$ $c = 0.3$ $\theta = 0.2$ $\beta_g = 0.5$ $\beta_c = 1$ $p = 0.5$

$\rightarrow \epsilon_1^e = 0.8807\Delta Y$;$\epsilon_2^e = -0.0105\Delta Y$; $\epsilon_3^e = 0.1981\Delta Y$

Case 3 $\alpha = 0.4$ $c = 0.3$ $\theta = 0.2$ $\beta_g = 0.5$ $\beta_c = 1$ $p = 0.8$

$\rightarrow \epsilon_1^e = 0.8807\Delta Y$; $\epsilon_2^e = -0.0105\Delta Y$; $\epsilon_3^e = 0.0681\Delta Y$

Case 4 $\alpha = 0.4$ $c = 0.3$ $\beta_g = 0.5$ $\beta_c = 1$ $p = 0.5$ $\theta = 0.1$

$\rightarrow \epsilon_1^e = 0.9851\Delta Y$; $\epsilon_2^e = -0.0013\Delta Y$; $\epsilon_3^e = 0.1771\Delta Y$

Case 5 $\alpha = 0.4$ $c = 0.3$ $\beta_g = 0.5$ $\beta_c = 1$ $p = 0.5$ $\theta = 0.15$

$\rightarrow \epsilon_1^e = 0.9474\Delta Y$; $\epsilon_2^e = -0.0062\Delta Y$; $\epsilon_3^e = 0.1916\Delta Y$

Case 6 $\alpha = 0.4$ $c = 0.3$ $\beta_g = 0.5$ $\beta_c = 1$ $p = 0.5$ $\theta = 0.2$

$\rightarrow \epsilon_1^e = 0.8807\Delta Y$; $\epsilon_2^e = -0.0105\Delta Y$; $\epsilon_3^e = 0.1981\Delta Y$

Case 7 $c = 0.3$ $\beta_g = 0.5$ $\beta_c = 1$ $p = 0.5$ $\theta = 0.2$ $\alpha = 0.4$

$\rightarrow \epsilon_1^e = 0.8807\Delta Y$; $\epsilon_2^e = -0.0105\Delta Y$; $\epsilon_3^e = 0.1981\Delta Y$

Case 8 $c = 0.3$ $\beta_g = 0.5$ $\beta_c = 1$ $p = 0.5$ $\theta = 0.2$ $\alpha = 0.5$

$\rightarrow \epsilon_1^e = 0.9130\Delta Y$; $\epsilon_2^e = -0.0031\Delta Y$; $\epsilon_3^e = 0.2096\Delta Y$

Case 9 $c = 0.3$ $\beta_g = 0.5$ $\beta_c = 1$ $p = 0.5$ $\theta = 0.2$ $\alpha = 0.6$

$\rightarrow \epsilon_1^e = 0.9421\Delta Y$; $\epsilon_2^e = 0.0055\Delta Y$; $\epsilon_3^e = 0.22213\Delta Y$

The simulation above leads to four major conclusions as below.

- $\epsilon_2^e < \epsilon_3^e < \epsilon_1^e$ for all cases.
- $p \nearrow \rightarrow \epsilon_3^e \searrow$
- $\theta \nearrow \rightarrow \epsilon_3^e \nearrow$
- $\alpha \nearrow \rightarrow \epsilon_3^e \nearrow$