Understanding the dynamics of central bank's credibility via heterogenous new Keynesian framework

Sirawit Woramongkhon*

Abstract

This study develops a heterogeneous agents new Keynesian model to investigate the dynamics of households' beliefs and the impact on monetary policy effectiveness. Within this framework, households exhibit varying degrees of risk aversion and responsiveness to changes in interest rates, which can be roughly interpreted as varying degree of beliefs in central bank's credibility. Their expectations of future consumption are influenced by the beliefs of other individuals and the conduct of monetary policy, resulting in the formation and evolution of belief distributions. The primary aim of this study is to examine the dynamics of the distribution of risk aversion coefficients, which serve as a proxy for central bank credibility, and how they evolve in response to a demand shock in the economy. The main finding suggests that a high level of central bank credibility enhances the effectiveness of monetary policy, leading to faster stabilization of output and inflation. Furthermore, the distribution of households over levels of risk aversion is shown to be dependent on the economy's response to the demand shock. Another significant factor impacting such distributions is uncertainty of shocks; when uncertainty is extremely low, households tend to have lower credibility in the central bank due to the persistent divergence between actual outcomes and expectations regarding output and inflation.

1 Introduction and Literature Review

The Dynamic Stochastic General Equilibrium (DSGE) model has long been recognized as a foundational framework for macroeconomic and monetary policy analysis. Its significance stems from its capacity to capture the intricate interdependencies among various sectors and agents within an economy, thus serving as a vital tool for comprehending the complex economic dynamics associated with business cycles, inflation, and other macroeconomic phenomena. Notably, changes in consumer expenditure exert an influence on production decisions made by businesses, consequently impacting employment levels and wage rates. Similarly, monetary policy choices have the potential to shape the behavior of households and firms by means of their effects on interest rates, loan availability, and other transmission channels. By explicitly accounting for these feedback loops and interactions, the DSGE model offers a more comprehensive and nuanced understanding of the economy compared to

*Financial Risk Management Department, Bank of Thailand. Email: sirawitw@bot.or.th

alternative modeling approaches. This enhanced comprehension equips policymakers with the means to make well-informed decisions pertaining to the stabilization of the economy or the promotion of long-term growth. Furthermore, it enables policymakers to assess the potential trade-offs associated with different policy options, weighing their costs and benefits in a more informed manner. To name a few, the DSGE models introduced by by Smets and Walter [5] and [6] provide foundation for policy analysis in both the European Central Bank (ECB) and Federal Reserve. Christiano et al. [2] also provides a medium/large scale DSGE model for monetary policy analysis.

This research study will focus on a subclass of DSGE model called new Keynesian (NK), which is used in monetary policy analysis. To fully unleash the potential of the NK model in macroeconomic and monetary policy analysis, careful estimation of its parameters to align with real-world data is essential. Bayesian probability provides a robust and powerful approach to tackle this task. Unlike traditional estimation techniques, Bayesian estimation incorporates prior beliefs about the parameters into the analysis, allowing for a more coherent and structured estimation process. The core concept behind Bayesian estimation lies in the utilization of Bayes' theorem, which updates prior beliefs based on observed data to obtain posterior distributions of the parameters. This enables researchers to quantify the uncertainty surrounding parameter estimates and derive more accurate inference about the model's behavior. Moreover, Bayesian estimation offers flexibility in incorporating various sources of information, such as economic theory and expert opinions, through the specification of informative priors. By harnessing these strengths, Bayesian estimation enhances the reliability and validity of parameter estimation in the DSGE model, ultimately leading to more reliable policy recommendations and a deeper understanding of the complex dynamics within the economy. The book by Herbst and Schorfheide [4] outlines the mathematical foundation and algorithms for Bayesian analysis tailored for DSGE model as well as practical policy analysis. Guerron et al. [3] also provides the framework for using Bayesian estimation in the DSGE model used for the Federal Reserve of Philadelphia.

The application of Bayesian probability in the DSGE and NK models extends beyond parameter estimation. Isaac and Veldkamp [1] surveys various applications of Bayesian probability for DSGE models. One application is the analysis of uncertainty by using Baye's theorem on the shock persistence and variance. Another crucial application is about the dynamics of beliefs and expectations among economic agents. This holds particular significance for monetary policymakers. Recognizing that individuals hold diverse and evolving beliefs about the effectiveness of policy actions, the Bayesian framework allows for a more comprehensive analysis of the implications of such heterogeneity. By modeling the dynamics of belief formation and updating, policymakers gain valuable insights into the impact of different policy measures on various segments of the population and how their decisions may be perceived and interpreted by different groups. By considering the interplay between economic fundamentals and the changing landscape of beliefs, policymakers can adapt their strategies to better address potential challenges and enhance the effectiveness of their policy decisions. In this context, incorporating belief dynamics within the DSGE model through a Bayesian framework provides policymakers with a valuable tool to assess the impact of policy interventions on different subsets of the population, enabling them to make more informed and targeted decisions that can better navigate the complexities of the economy.

The main objective of this article is to incorporate belief dynamics within the NK model through a Bayesian framework in order to provides policymakers with a valuable tool to assess the impact of policy interventions on different subsets of the population. The ultimate goal is to enable policymakers to make more informed and targeted decisions that can better navigate the complexities of the economy. Our contribution is via integrating the Bayesian belief updating process into a standard theoretical DSGE and New Keynesian model. Specifically, the study introduces the notion that individual households exhibit varying degrees of risk aversion, which are updated over time after the realization of economic output. By incorporating this dynamic element into the model, the research aims to shed light on how changes in households' risk aversion impact their economic decisions and, in turn, influence the effectiveness of monetary policy. The main analysis is on both the dynamics of beliefs and economic adjustment after the economy experiences shocks and the trade-off of monetary policy.

The paper is organized as follows. Section 2 describes the mathematical foundation of the Bayesian heterogenous new Keynesian framework used in our analysis. Section 3 discusses and investigates the economic adjustment after demand shock. Section 4 concludes.

2 Methodology

The economy consists of a possibly infinite countable number of representative households.[1] Let H denote the set of households. Then, the aggregate consumption C_t at period t follows

$$C_t = \sum_{h \in H} C_{h,t}, \tag{1}$$

where $C_{h,t}$ represents consumption from household h. Log-linearizing around the steady state yields

$$\tilde{c}_t = \sum_{h \in H} w_h \tilde{c}_{h,t}. \tag{2}$$

The weight w_h is the ratio of individual household h's consumption to aggregate consumption at the steady state.

We assume that a household differs in terms of risk appetite and has distinct risk aversion coefficient $\sigma' > 0$, but the associated life-time consumption optimization problem is the same as in the standard New Keynesian setting. Hence, consumption $c_{h,t}$ follows

$$\tilde{c}_{h,t} = \mathbb{E}[\tilde{c}_{h,t+1}] - \frac{1}{\sigma'}(\tilde{r}_t - \mathbb{E}[\pi_{t+1}]) + \epsilon_{h,t}, \tag{3}$$

where $\mathbb{E}[\cdot]$ is the expectation operator, $\tilde{r}_t$ is real interest rate, π_t represents inflation, and $\epsilon_{h,t}$ is the demand shock for household h.Note that (3) indicates that households realize both interest rate and inflation rates; therefore, different consumption decision stems solely from distinct levels of risk-aversion. The aggregate equation (2) also implies that each household takes into consideration others's optimization problems and risk appetite before making his or her consumption decision. As a result, the interplay of household decision-making in aggregate consumption resembles a *beauty contest*, as individual households not

[1] It is possible to assume uncountably infinite number of households as well. The summation notation may change to product, but mathematical derivation remains the same.

only optimize their own consumption but also consider the responses of others, leading to a dynamic where households react to and are influenced by each other's decisions. Generally speaking, the impact of the adjustment in policy rate will also differ because of the risk-aversion coefficients; households with lower risk aversion coefficients will react stronger to the change in interest rates.

The rest of the economy follows the basic New Keynesian framework and standard DSGE setup. The Phillips Curve and monetary policy rule are

$$\pi_t = \beta \mathbb{E}[\pi_{t+1}] + \kappa y_t + \epsilon_{\pi,t}, \text{ and} \tag{4}$$

$$\tilde{r}_t = \phi_y y_t + \kappa \pi_t + \epsilon_{r,t}. \tag{5}$$

The parameter β and κ are future discount factor and output response coefficient in Phillips curve. Additionally ϕ_y and ϕ_π are policy response parameters. The shock $\epsilon_{\pi,t}$ and $\epsilon_{r,t}$ represent supply and monetary policy shocks, respectively. There is no investment, government, and export sector. Hence,

$$\tilde{y}_t = \tilde{c}_t \tag{6}$$

The shock process is assumed to be basic AR(1) process;

$$\epsilon_{h,t} = \rho_h \epsilon_{h,t-1} + \varepsilon_{h,t} \tag{7}$$

$$\epsilon_{\pi,t} = \rho_\pi \epsilon_{\pi,t-1} + \varepsilon_{\pi,t} \tag{8}$$

$$\epsilon_{r,t} = \rho_r \epsilon_{r,t-1} + \varepsilon_{r,t}, \tag{9}$$

where ρ governs shock persistence and ε is the shock innovation.

The sequential order of actions in each period is extremely important in this framework. At the beginning of each period, every household solves the optimization problem considering the economy described in (2)-(9). This implies that each household knows the true distribution of population across level of risk-aversion.[2] The inflation and monetary policy then adjusts to the aggregate consumption. After output and inflation realization, households then again updates their belief on the distribution of population across level of risk-aversion through the basic Bayesian learning. Then, the population proportion across different risk-aversion coefficient σ changes according to the newly derived posterior distribution.

Suppose f be a generic probability function. Then, the posterior distribution of risk-aversion coefficient σ follows

$$f_t(\sigma \mid Y = y_t, P = \pi_t) = \frac{f_t(Y = y_t, P = \pi_t \mid \sigma) f_t(\sigma)}{f_t(Y = y_y, P = \pi_t)}, \tag{10}$$

where

i). $f_t(\sigma)$ is the prior probability density of the value of σ. It is assume to be the distribution of σ from the previous period

$$f_t(\sigma) = f_{t-1}(\sigma \mid Y = y_t, P = \pi_t). \tag{11}$$

ii). $f_t(Y = y_t, P = \pi_t \mid \sigma)$ is the likelihood function and the probability that the output gap and inflation are y_t and π_t conditional on different values of σ.

[2] This assumption can be theoretically relaxed.

iii). $f_t(Y = y_t, P = \pi_t)$ is the unconditional probability that output gap and inflation are y_t and π_t. Note that this term is unnecessary, computational-wise.

Note that the learning process given in (10) can be extended in such a way that $f_t(\sigma)$ differs across households.

Unsurprisingly, the dynamics of the proportion $f_t(\sigma)$ depends largely on the estimated density of $f_t(Y = y_t, P = \pi_t \mid \sigma)$ from each individual household. Given convergence, there are possibly multiple steady states of $f_t(\sigma)$ because the variance of both demand and supply shocks can influence the density of y_t and π_t when t is sufficiently large. The distribution of $f_t(\sigma)$ in (11) also describes the distribution of w_h in (2) because each household $h \in H$ has distinct σ. The evolution of $f_t(\sigma)$ can then be interpreted as the evolution of the proportion of societal risk-aversion levels.

3 Economic and Monetary Policy Analysis

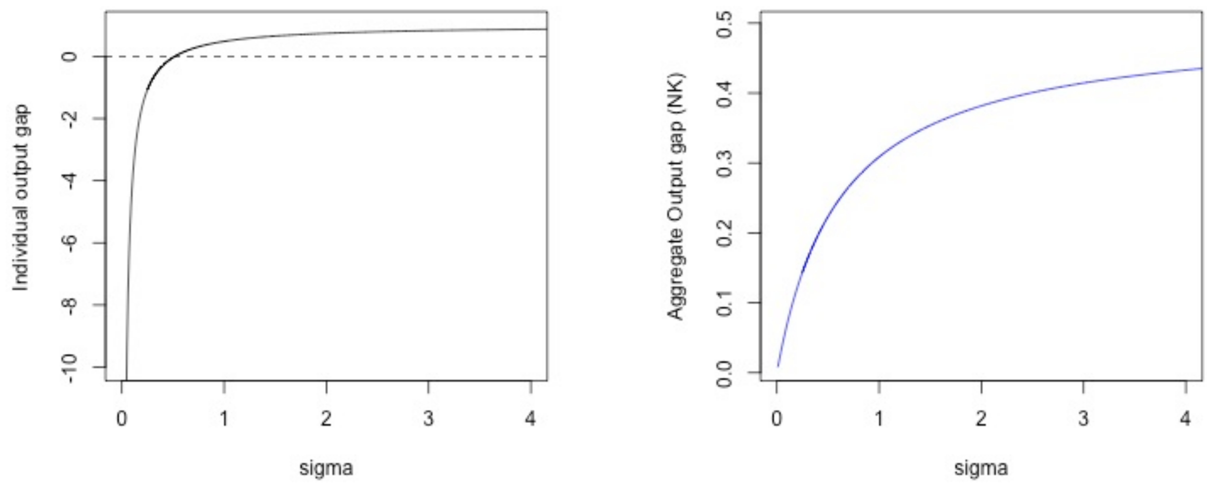
3.1 Risk-aversion and Central Bank Credibility

We propose that the risk-aversion coefficient σ, owing to its influence on households' responsiveness to monetary policy changes, is essential for understanding the dynamics of central bank credibility.

The inclusion of heterogenous risk-aversion coefficients among households in the new Keynesian framework provides valuable insights into consumption behavior. Households with varying degrees of risk aversion may respond differently to changes in monetary policy. Those with higher risk aversion levels tend to exhibit a stronger preference for precautionary savings, allocating a larger portion of their income towards savings rather than consumption. This cautious behavior reflects their desire to protect against uncertain future events, such as job loss or unexpected expenses. On the other hand, households with lower risk aversion levels may be more willing to spend and invest, resulting in a higher propensity for consumption. By incorporating heterogeneity in risk aversion, the model captures the diverse consumption patterns that emerge from different households' preferences, providing a more accurate depiction of real-world economic dynamics. The investigation of different consumption decisions across risk aversion coefficient σ's can illustrates such pattern.

Analyzing the evolution of the distribution of households over levels of risk aversion can offer valuable insights for central banks and enhance their ability to assess their credibility. By examining changes in the distribution over time, central banks can gauge whether their policies and communication efforts are effectively influencing households' risk aversion levels. A central bank that consistently delivers on its objectives and communicates its policy intentions clearly and credibly may observe a convergence of risk aversion levels among households towards the desired range. This convergence indicates that households have appropriate risk aversion degrees and are responding in a manner that aligns with the central bank's goals. Conversely, a widening or persistent dispersion in risk aversion levels may suggest that the central bank's credibility is in question, as households may exhibit heightened caution and risk aversion, hindering the effectiveness of monetary policy.

For example, let's consider a central bank that successfully establishes a credible reputation for maintaining price stability over time. Household expectations become anchored,



(a) Different individual household consumption/output gap decision in period 1 over levels of risk aversion in hetergenous setting.

(b) Sluggish movement of aggregate consumption/output gap over risk aversion coefficient in the new Keynesian setting.

Figure 1: Our heterogeneous agent model allows for different consumption decisions and is able to capture the interplay between such decisions, an additional feature to a standard new Keynesian and DSGE model.

and their risk aversion levels decrease as they trust in the central bank's ability to control inflation. This decrease in risk aversion leads to a higher willingness to engage in consumption and investment activities, driving economic growth. On the other hand, if the central bank's credibility is compromised, households may become more risk-averse and uncertain about the future state of the economy. This increased risk aversion can result in reduced consumption and investment, potentially amplifying economic downturns. Therefore, analyzing the heterogeneity of risk aversion and its evolution allows central banks to gauge their credibility and understand how households' behavior may respond to their policy actions.

3.2 Response Analysis

Suppose that the economy rests at the steady state at period 0 and the proportion of households across risk aversion coefficient is uniform over the interval $[0, 100]$[3]. Our main analysis lies in the economic adjustment after there is a one-unit demand shock to every household in the economy.

3.2.1 Heterogenous decisions and their interplay

Figure 1 illustrates different output/consumption response in our model and standard new Keynesian setting.

The basic New Keynesian model demonstrates that the response of the output gap to a demand shock exhibits an increasing pattern as the risk-aversion coefficient σ rises. Representative agents characterized by lower σ values tend to display a relatively higher sensitivity to changes in interest rates, leading to diminished inflation expectations and reduced consumption levels. Conversely, a decrease in corresponds to an attenuation in the magnitude of the demand shock. Furthermore, when households exhibit reduced risk aversion and σ increases, a greater emphasis is placed on consumption smoothing through relatively higher weight placed on $\mathbb{E}[\tilde{c}_{h,t+1}]$ in (3). Consequently, the effectiveness of monetary policy weakens, and the magnitude of the output response escalates with the risk-aversion coefficient. Notably, it is observed that a unit increase in σ yields a diminishing incremental effect on the size of the output gap. Additionally, it is worth highlighting that the output gap approaches a certain magnitude as approaches infinity. Thus, even in scenarios where households exhibit unresponsiveness to monetary policy, the impact of a demand shock remains constrained.

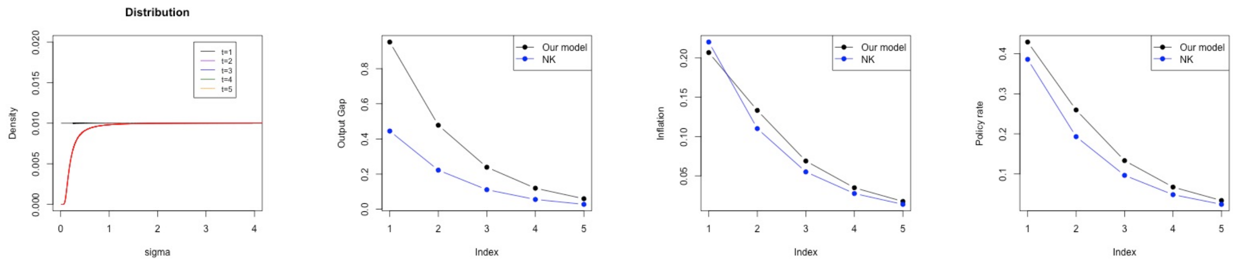
Our heterogeneous New Keynesian model provides further insights by capturing different consumption behaviors across households with varying levels of risk aversion. Additionally, this framework incorporates the influence of others' decisions on household consumption, resembling a scenario akin to the well-known Keynesian "beauty contest." Note that the estimated adjustment of the output gap remains consistent across different values of the risk-aversion coefficient. Risk-averse households continue to engage in consumption smoothing, leading to a close alignment between their consumption levels and the output gap when σ is sufficiently large. However, an intriguing divergence emerges when examining households characterized by low risk-aversion coefficients. In these cases, despite a positive demand shock, the output gap can assume negative values.

We attribute this striking deviation to the phenomenon of "ultra loyalists," which can manifest within the heterogeneous framework. Agents with extremely low σ values exhibit a heightened responsiveness to changes in monetary policy and possess a notable level of confidence in the central bank's credibility. When optimizing their consumption decisions, these loyal households take into account the consumption choices made by others, some of whom may perceive the central bank as less credible. Consequently, if the observed other's output responses surpass their expectations, these loyal households adjust their consumption downward, deliberately creating a negative gap to offset the positive consumption and stabilize the aggregate output. Notably, it is important to highlight that this behavior is observed in only a small subset of the population, emphasizing its limited prevalence.

3.2.2 Economic adjustments and belief dynamics

We will now focus our attention to the economic adjustment to the same demand shock. Figure 2 shows evolution of both belief and economic adjustments. Note that the consumption decisions depicted in Figure 1 only happens at $t = 1$ and the output gap in Figure 2 is

[3] It is possible to extend to the longer horizon or even consider the limit $[0, n]$ as n goes infinitely large. However, the result remains computationally closed to the case $n = 100$ or even lower.



(a) Proportion of households across σ's.
(b) Output gap adjustment
(c) Inflation adjustment
(d) Monetary Policy adjustment

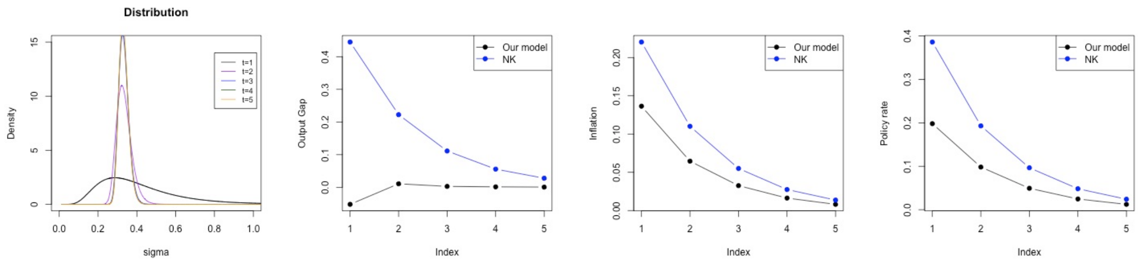
Figure 2: The economic adjustment to one-unit demand shock, compared to the standard new Keynesian result.

the corresponding aggregation.

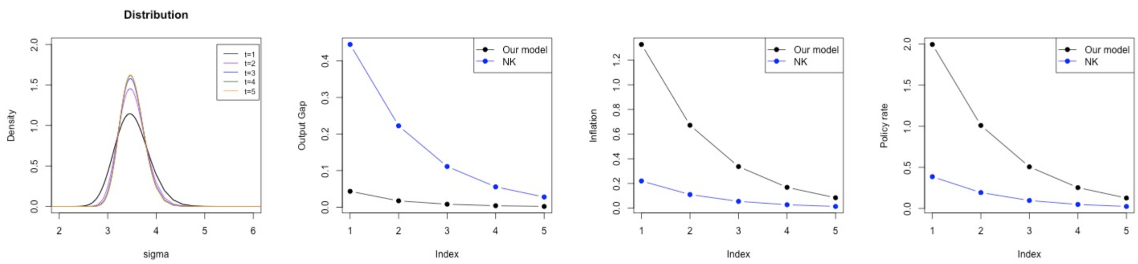
In the standard New Keynesian framework, a positive demand shock leads to an increase in aggregate demand, causing output to expand and the output gap to close. As the economy moves towards full employment, inflationary pressures increase, causing inflation to rise above the central bank's target level. To combat the rise in inflation, the central bank can respond by adjusting its monetary policy stance. Specifically, it can raise its policy interest rate to dampen aggregate demand and cool down the economy. This increase in interest rates leads to a reduction in investment and consumption, which slows down the growth of aggregate demand and inflation.

In our modified New Keynesian setting with heterogeneous households with varying levels of central bank credibility, the response of output gap, inflation, and monetary policy to a positive demand shock would depend on the degree of belief heterogeneity among households. We start by assume that the household have various beliefs in the credibility of the central bank[4] and the initial belief distribution over risk-aversion coefficient is uniform. Now, given the demand shock, households with low central bank credibility would respond to the demand shock by increasing their consumption and investment, leading to an expansion in output and a rise in inflation. They would expect to smooth their consumption over time. In contrast, households with high central bank credibility would respond to the same demand shock by reducing their consumption and investment, leading to a contraction in output and a smaller rise in inflation. The ultra loyalist might even consume less, offsetting the aggregate output. This divergence in responses between households with high and low central bank credibility leads to persistent deviations in the output gap and inflation from their long-run equilibrium levels. Our current analysis implies that the total effect in output gap from those with low credibility exceeds, creating higher positive output gap than in new Keynesian setting. The output gap then proceeds to converge to the steady states at a slower pacing. The higher interest rate is required in order to stabilize the excess demand. The inflation movement in our model is similar to the result from new Keynesian analysis despite comparatively higher output gap and interest rate. Surprisingly, the evolution of the belief distribution

[4]If households have similar beliefs about the central bank's commitment to stabilizing inflation, then the response of output and inflation to a positive demand shock and the monetary policy response would be similar to the standard New Keynesian setting.



(a) Evolution of distribution of σ's (b) Output gap adjustment (c) Inflation adjustment (d) Monetary Policy adjustment



(e) Evolution of distribution of σ's (f) Output gap adjustment (g) Inflation adjustment (h) Monetary policy adjustment

Figure 3: Comparing the economic and belief adjustment to the positive demand shock under high and low central bank's credibility scenarios. The upper panels show the adjustment when the central bank is credibile. The lower panels show the response when the central bank has low credibility

across σ is limited. The economy started with uniform distribution. After the shock the distribution quickly converges to a new distribution which is not uniform in spite of the shape. The proportion of the ultra loyal households completely disappears, while that of other households remain the same. This may imply that the extreme behavior from the ultra loyal may be unnatural and the initial belief distribution may be unstable; the economy may move towards ones where most agents behave rationally.

Hence, the initial distribution of households over the degree of risk-aversion or central bank credibility plays extremely important role in the dynamics of the output and inflation response.

3.2.3 Importance of initial belief distributions

The dynamic response of the output gap, inflation, and monetary policy to a positive demand shock can be influenced by households' ability to update their beliefs regarding the credibility of the central bank in light of new information. In such a scenario, the outcomes are not solely determined by the initial level of central bank credibility but also by how households revise their beliefs regarding the central bank's credibility over time. This highlights the importance of incorporating the element of belief updating in analyzing the macroeconomic implications of a demand shock and the subsequent policy responses.

Figure 3 presents the diverse economic adjustments that arise when a positive demand shock occurs, considering different initial distributions of the risk-aversion coefficient within the economy. The upper panels of the figure demonstrate that in cases where the central bank is highly credible, households characterized by low credibility gradually update their beliefs and converge towards the beliefs held by households with high credibility. As a result, the response of output and inflation to a positive demand shock exhibits a convergence pattern. This convergence is visually represented by the compression of belief distributions around the value of approximately 0.3. Consequently, the majority of households become more responsive to changes in monetary policy, thereby bolstering the central bank's credibility. Consequently, the magnitude of the output gap and inflation increases to a lesser extent compared to the results derived from the new Keynesian model. In fact, the output gap remains proximate to zero for the majority of the time, underscoring the remarkable anchoring of output expectations. Additionally, the inflation rate converges to its steady state at an accelerated pace. The combination of lower inflation, a nearly closed output gap, and swifter convergence renders monetary policy highly effective in this context.

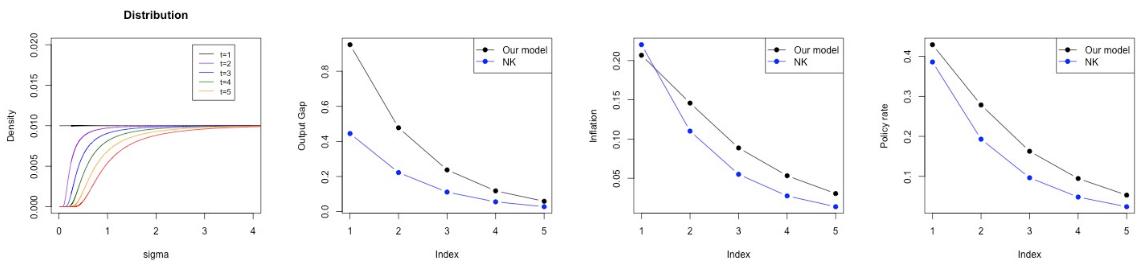
In contrast, when the central bank's credibility is low, households characterized by low credibility may exhibit a tendency to adhere steadfastly to their existing beliefs, making them less inclined to update their beliefs in response to new information. Consequently, a persistent divergence in the response of output and inflation emerges between households with high credibility and those with low credibility. The lower panel of Figure 3 illustrates this scenario, wherein the central bank may find it necessary to adopt more aggressive measures to anchor inflation expectations and signal its unwavering commitment to achieving the inflation target.

The initial state of the economy depicted in this scenario is characterized by a majority of households exhibiting lower levels of risk aversion, leading to higher values of σ, exceeding 2. However, over time, the belief distributions gradually converge, centering around a σ value of approximately 3. Despite the central bank's efforts, its credibility remains limited. As a consequence, even with higher interest rates compared to those prescribed by the new Keynesian model, inflation tends to persist at elevated levels and exhibits a slower convergence towards the steady state. While the magnitude of the output gap may be smaller compared to the result derived from the new Keynesian model, it remains higher than the dynamics depicted in Figure 2. This suggests that the central bank faces greater challenges and costs in stabilizing the economy when confronted with low credibility.

Overall, the response of output gap, inflation, and monetary policy to a positive demand shock in a modified New Keynesian setting with updating beliefs would depend on the degree of belief heterogeneity and the level of central bank credibility. If the central bank is highly credible and households are able to update their beliefs, then the response of output and inflation to a positive demand shock would quickly converge towards their long-run equilibrium levels. However, if the central bank's credibility is low, then the response of output and inflation could remain divergent and require more aggressive policy interventions to address.

3.3 Importance of uncertainty

The standard deviation of future shock innovations is an additional crucial factor to consider when making decisions under uncertainty. In the traditional new Keynesian framework, this



(a) Evolution of distribution of σ's (b) Output gap adjustment (c) Inflation adjustment (d) Monetary Policy adjustment

Figure 4: The economic adjustment under the economy where households considers only uncertainty in the first period in their consumption optimization.

factor plays a negligible role in shaping the adjustment of output and inflation, as only expected values are considered within the optimization problem. However, our framework takes into account the standard deviation of shock innovations in the calculation of the likelihood function, as shown in Equation (10). These standard deviations also determine the likelihood of various output and inflation events.

In general, higher standard deviations correspond to increased uncertainty, resulting in a convergence of likelihoods for a majority of events. Conversely, lower standard deviations indicate that households possess greater confidence in their output and inflation expectations. Consequently, when the actual output is realized, households may exhibit a propensity to update their beliefs more frequently, reflecting their heightened certainty in their expectations. Therefore, our modified framework incorporates the role of standard deviation in capturing the dynamics of uncertainty and the subsequent influence on households' belief updating process in response to output and inflation events.

In this section, our analysis assumes that the shock innovation in Equation (9) has a zero standard deviation when $t \geq 2$. As a result, our consideration of uncertainty is now confined solely to the shock experienced in the initial period. It is important to note that uncertainty diminishes as time progresses. Figure 4 depicts the distinct economic and belief responses to a one-unit increase in the demand shock under this revised assumption.

Under this new framework, the belief distribution over time converges towards scenarios where the central bank exhibits lower credibility. However, the convergence observed in this case is not as swift as in the previous analysis. The underlying intuition stems from households' increased confidence in their expected output and inflation when the standard deviation of shocks is comparatively lower. Nevertheless, any deviation between their perceived and actual output may erode the credibility of the central bank. Consequently, households become more risk-averse over time, and the belief distribution shifts towards higher values of σ, specifically $\sigma > 1$. It is noteworthy that the belief distribution eventually converges.

In this modified framework, the economic adjustments resemble those observed in scenarios where the central bank has low credibility. Notably, both output and inflation exhibit higher levels compared to the outcomes derived from the new Keynesian model, despite the implementation of more assertive interest rates. Additionally, the convergence rate of these variables is slower under the revised framework.

4 Conclusion

This article presents a heterogeneous New Keynesian model that incorporates households' expectations formation based on their peers' beliefs in the economy. Each agent is characterized by their degree of risk aversion, which influences their responsiveness to changes in interest rates. Higher risk-averse households tend to engage in consumption smoothing, indicating less confidence in the central bank's ability to stabilize the economy. Thus, the analysis focuses on the dynamics of central bank credibility through the distribution of households across different risk aversion coefficients. Surprisingly, the study identifies a portion of the population that exhibits counterintuitive behavior in order to maintain the overall effectiveness of monetary policy. When the central bank exhibits high credibility and a positive demand shock occurs, monetary policy becomes more effective, resulting in small and quick converging responses in output and inflation towards the steady state. The initial distribution of households across risk aversion coefficients significantly influences the aggregate output gap response and the dynamics of belief distributions.

A potential future direction for this analysis is to explore more complex and dynamic belief formation processes, such as the impact of social interactions, learning, and adaptation. The modified New Keynesian model with heterogeneous households' beliefs assumes that households realize the distribution of risk aversion degrees in the economy and have the same Phillips curve. A more practical approach would involve considering individual Phillips curves where each household has a different future discount factor and distinct output coefficient. This would enable the introduction of the central bank's credibility in delivering stable inflation. Analyzing this new type of credibility alongside output credibility could provide insights into monetary policy formation and enhance the central bank's ability to anchor expectations.

However, in reality, beliefs are formed through intricate and dynamic processes involving interactions with other individuals, the media, and other sources of information. Learning and adaptation to new information and experiences also play a role. Therefore, incorporating more realistic and dynamic belief formation processes could enhance the accuracy and realism of the model and provide a more nuanced understanding of the impact of central bank credibility on the economic adjustment process. For instance, introducing a more complex network Bayesian learning process where agents have belief networks and clusters of beliefs could capture the dynamics of belief formation more realistically. Some agents may exert significant influence on others' distribution of beliefs and the credibility of the central bank. Analyzing belief networks in this manner could shed light on policy communication and strategies.

To anchor expectations and ensure credibility, the central bank may need to adopt policies that improve its communication and transparency. This could involve providing more frequent and detailed information on policy decisions and economic conditions, or engaging in active and direct dialogue with households and other stakeholders. Additionally, the central bank may consider employing flexible and innovative policy tools that can effectively anchor inflation expectations and respond to changing economic conditions. Examples include price-level targeting, nominal GDP targeting regimes, forward guidance, and asset purchase programs. Further research is needed to explore these areas in more depth.

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6 Appendix

6.1 Parameters used

The parameters employed in the models are derived from a diverse range of literature and research studies, ensuring their relevance and consistency with the US economy and policy practice. These parameters are carefully selected to reflect the characteristics of households, firms, and the central bank, taking into account empirical evidence and theoretical foundations. They are based on extensive analyses of historical data, economic indicators, and policy frameworks, providing a robust foundation for the model's representation of the US economy.[5]

Parameter	Value	Meaning
β	0.99	Future discount factor
κ	0.25	Output response in Philips curve
ϕ_y	0.125	Output response in Taylor rule
ϕ_π	1.5	Inflation response in Taylor rule
ρ_h	0.5	Output shock AR term
ρ_π	0.75	Inflation shock AR term
ρ_r	0	Policy shock AR term
v_h	1	Variance of output innovation
v_π	1	Variance of inflation innovation
v_r	1	Variance of policy innovation

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