The power of forward guidance in a quantitative HANK model

Bo Li[1] and Xiao Wang[2]

[1]School of Economics, Peking University
[2]School of Economics, Peking University

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Abstract

This paper quantifies the macroeconomic effects and welfare impact of the forward guidance about interest rate in a heterogeneous agent New Keynesian (HANK) model . We find that the announcement of a decline in interest rate in the future leads to a mild economic growth and a decline in wealth and welfare in early periods and a decline in output afterwards. The expansion of government spending and the tax exemption for low-income groups are conducive to amplifying the effect of forward guidance on current output growth, but the former leads to larger welfare loss.

Keywords: Forward guidance; HANK; Welfare; Fiscal policy

1   Introduction

Forward guidance about interest rate has become an increasingly important tool to enhance the effectiveness of monetary policy. However, the effects and welfare changes of the future interest changes are different when households are heterogenous in income and wealth. Ignoring the heterogeneity will bias the assessment of the economic impact of forward guidance. As stated in McKay et al. (2016), the power of forward guidance on interest rates is less in an incomplete market than in the complete markets. Therefore, heterogenity and incomplete market setup are essential for understanding the forward guidance.

However, they ignore the channel of the wealth effect affecting the consumption smoothing, as aggregate wealth remains unchanged.[1] Intuitively, the households will increase the current consumption(substitution effect) when they expect that interest rates will fall in the future, which leads to a highed demand and higher output. On the other hand, households save less in the current priod, resulting a decrease in the future wealth

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[1]McKay et al. (2016) argues that they considered the redistribution effect of wealth, but the bond market does not clear on the transition path.

and consumption (wealth effect). Wealth effect channel is very important for us to understand the transmission mechanism of forward guidance which determines how the actions of the monetary authority affect the aggregate performance of the economy. To better capture the influence of wealth channel, we describe the distribution of wealth in the economy more accurately by introducing entrepreneurs, like Bayer et al. (2019). Besides, as fiscal policy may influence the effects of monetary policy (Kaplan et al., 2018; Acharya and Dogra, 2020), it is hard to argue whether tax cuts or government purchases is a more powerful tool of fiscal policy for stimulating the economy (Romer and Romer, 2010). The coordination of fiscal policy and unconventional monetary policy like forward guidance, still attracts increasing attention of academic research.

In this paper, we develop a heterogeneous agent New Keynesian (HANK) model to quantify the macroeconomic effects and welfare of forward guidance on interest rate. We shed light on the important role of fiscal policy in the HANK model. Expansion of government spending and tax exemption for low-income groups are conducive to amplifying the effect of forward guidance on the growth in the current period, but the former leads to a larger welfare loss.

2 Model

We extend the model of McKay et al. (2016) by distinguishing two types of households: workers and entrepreneurs. Workers supply labor and earn the wage income, and entrepreneur earn all profits. The households derive utility from the combination of consumption and labor supply

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_{i,t}^{1-\gamma}}{1-\gamma} - \frac{n_{i,t}^{1+\psi}}{1+\psi} \right] \tag{1}$$

where $c_{i,t}$ and $n_{i,t}$ represent the consumption and working hours of household i at time t. β represents the discount factor, γ denotes the relative risk aversion coefficient, and $1/\psi$ denotes the Frisch elasticity of labor supply. Following Bayer et al. (2019), we assume that the worker will become an entrepreneur with the probability of η in each period, and the entrepreneur will become a worker with the probability of ξ following a Markov chain. Besides, workers receieves an idiosyncratic labor productivity shock. A workers labor income $W_t n_{i,t} z_{i,t}$ is composed of the wage rate W_t, hours worked $n_{i,t}$, and its idiosyncratic labor productivity $z_{i,t}$. The logarithm of the exogenous labor productivity follows the AR(1) process with persistence coefficient $\rho_z < 1$, and the variance of temporary shock $\epsilon_{i,t}^z$ is σ_z^2. Since entrepreneurs do not provide labor, their labor productivity is zero. When they change back to workers with the probability of ξ, they will get an average labor productivity $\bar{z}$. Equation (2) describes the transition path of households' labor productivity.

$$z_{i,t} = \begin{cases} exp(\rho_z z_{i,t-1} + \epsilon_{i,t}^z) & \text{with probability } 1-\eta \text{ if } z_{i,t-1} \neq 0 \\ \bar{z} & \text{with probability } \xi \text{ if } z_{i,t-1} = 0 \\ 0 & \text{else} \end{cases} \tag{2}$$

Households can trade a risk-free real bond with real interest rate r_t. We assume that household can borrow to consume, but there is an exogenous debt limit $-\underline{b}$. The maximization problem can be formlized into the recursive form:

$$V_t(b_{i,t}, z_{i,t}) = \max_{c_{i,t}, n_{i,t}, b_{i,t+1}} \left[\frac{c_{i,t}^{1-\gamma}}{1-\gamma} - \frac{n_{i,t}^{1+\psi}}{1+\psi} + \beta E V_{t+1}(b_{i,t+1}, z_{i,t+1}) \right] \quad (3)$$

The budget constraints and borrowing constraints are

$$c_{i,t} + b_{i,t+1} = (1+r_t)b_{i,t} + W_t n_{i,t} z_{i,t} - \tau_y \frac{z_{i,t}}{\bar{z}} + I_{z_{i,t}=0}(1-\tau_\Pi)\frac{\Pi_t}{Pr(z=0)} \quad (4)$$

$$b_{i,t+1} \geq -\underline{b} \quad (5)$$

where $Pr(z=0)$ is the proportion of entrepreneur in the total population under the steady state. The government levies a lump-sum income tax on workers τ_y, which is based on their labor productivity relative to the average labor productivity. τ_Π is the corporate tax paid by the entrepreneur.

On the production side, we assume that there are nominal rigidity and monopolistic intermediate producers following the New Keynesian literature.

The bonds held by households are issued by the government, and in each period government debt is denoted by B_t^g. The government repays debts and fixed expenditure in each period by new bond issuances, income tax and corporate tax to maintain a balanced budget.

Our model is calibrated with China data and the calibration result is summarized in Table 1. The benchmark model well describes the characteristics of China's aggregate quantity and wealth distribution. Table 2 also reports some non-targeted moments from the model to be compared with the China data.

Table 1: List of Calibrated Parameter Values

Parameter	Definition	Value	Target/source
Households			
γ	Coefficient of risk aversion	2	McKay et al. (2016)
$1/\psi$	Frisch elasticity of labor supply	0.5	McKay et al. (2016)
β	Discount factor	0.97	Ratio of liquid assets to income
η	Probability from worker to entrepreneur	0.003	Gini of wealth
ξ	Probability from entrepreneur to worker	0.063	Bayer et al. (2019)
ρ_z	Persistence coefficient	0.69	Yu and Zhu (2013)
σ_z	Innovation variance	0.32	Yu and Zhu (2013)
$\underline{b}$	Borrowing limit	0.72	Minimum income for eight months
Producers			
θ	Probability of adjusting price	0.25	Galí (2002)
σ	Elasticity of substitution	6	Christiano et al. (2011)
Government			
$\bar{r}$	Steady-state real interest rate	2%	Kaplan et al. (2018)
τ_y	Income tax rate	0.21	Ratio of expenditure to GDP
τ_Π	Profit tax rate	0.25	China real tax system

Table 2: Quantitative properties of the benchmark economy

Variables	Benchmark	China data
Aggregate quantity		
Ratio of liquid assets to income	1.013	1.013
Ratio of debts to income	0.049	0.048
Ratio of expenditure to GDP	0.214	0.214
Gini coefficient of wealth	0.827	0.827
Gini coefficient of income	0.353	0.483
Gini coefficient of consumption	0.315	0.351
Distribution characteristics		
Top 1 percent share	12.9	17.3
Top 5 percent share	40.3	48.1
Top 10 percent share	60.1	66.1
Top 20 percent share	81.9	84.0
Top 50 percent share	104.1	98.6
Bottom 20 percent share	-2.9	-3.2
Bottom 1 percent share	-2.1	-1.5

3 Results

3.1 Baseline Experiment

In the baseline experiment, the monetary authority implements the forward guidance that promises a 50 basis point (2 percent annualized) decrease in the real interest rate for a single quarter five years in the future with interest rates in all other quarters unchanged. Figure 1 shows the response of total economic output to the forward guidance about interest rate in two cases: representative agent model and heterogeneous agent model with entrepreneur. In the case of the heterogeneous model, the response of output to forward guidance about the interest rate does not rise as much as the representative agent model, which is consistent with McKay et al. (2016), Kaplan et al. (2016) and Hagedorn et al. (2019), and the increase of output in the current period is almost zero. Even in the period right before the interest rate decrease, output only increases by 0.15% which is substantially smaller than that under representative agent model. The reasons for the weakening of the output growth in the heterogeneous agent model are as follows: First, due to the idiosyncratic income risk and the shock of the state transition between workers and the entrepreneur, households have a strong precautionary saving motive, so the intertemporal substitution effect of consumption will decrease. Second, as output continues to grow, the government need to levy more taxes on households in order to maintain a balanced budget. The decrease in individual disposable income reduces demand, leading to a slowdown in output growth. Third, when output increases, the profit of monopolistic enterprises decreases due to the increase in wage. The income of entrepreneurs will decrease, which will weaken the growth of total output to a certain extent.

Output is below the original level, though interest rate returns to the initial level in the heterogeneous agent model. When the monetary authority announces a downward trend in interest rate, the intertemporal substitution effect has caused the households to consume more and hold less assets, resulting in a continuous decline in wealth. When the wealth
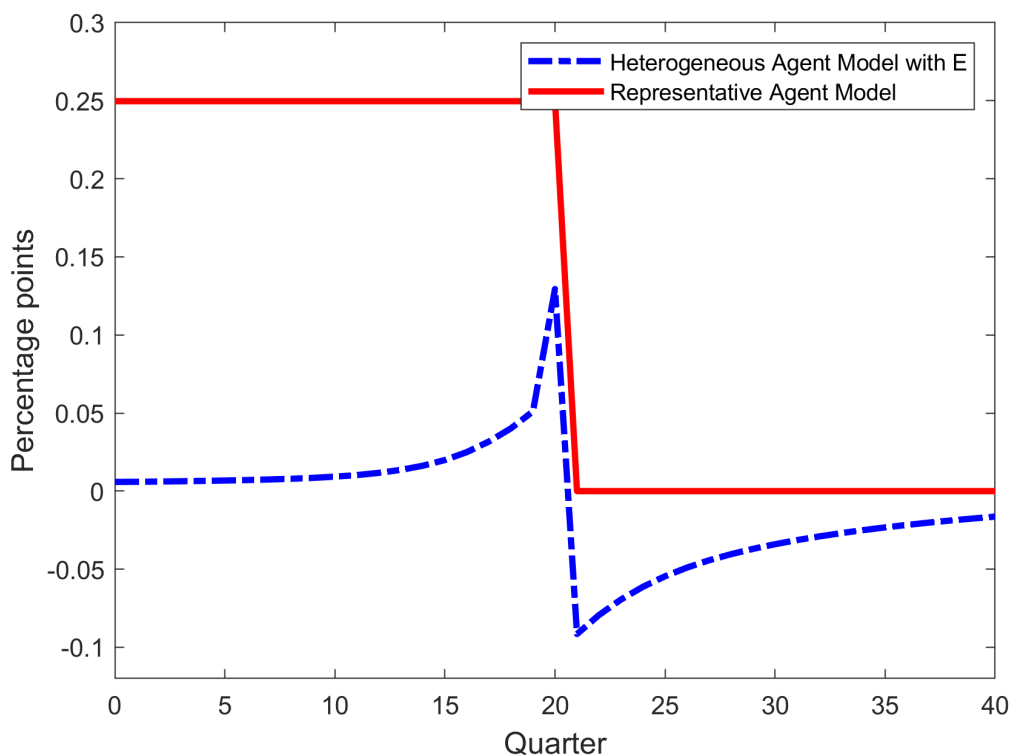
Figure 1: Response of Output to Forward Guidance about the Interest Rate in Quarter 20
(With Interest Rate in All Other Quarters Unchanged)

is sufficiently low, households reduce consumption, and the decline in demand will cause output to fall below the initial steady state.

Figure 2 shows how wealth and welfare respond to the forward guidance. According to the level of labor productivity, we divide workers into three categories: low-income, middle-income, and high-income groups. When the monetary authority announces that interest rate will fall, due to the intertemporal substitution effect, the wealth of entrepreneur and workers of different income all will decrease. When the government dynamically adjusts labor tax to maintain fiscal balanced, workers pay more tax and accumulate less wealth.[2] However, the labor tax adjustment has less impact on the wealth of entrepreneurs. Moreover, the wealth of middle-income groups decline more than that of high-income and low-income groups. For the high income group, the substitution effect of the decline in interest rates is small, leading to a mild increase in consumption and slight decline in wealth. For the low income group, the decline in interest rates is conducive to the debt repayment of the poor (McKay et al., 2016; Auclert, 2019), thus the decline in their wealth is less than that of other people who are not in debt.

As shown in the Figure 2(b), the welfare of all groups has declined. Although the wealth of low- and middle-income groups has fallen more, their welfare has fallen even lower than that of higher-income groups and entrepreneur. On the one hand, as low-

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[2]In McKay et al. (2016), the declining interest rate implies that the government needs less tax revenue in period 20 to pay the interest of the debt. Since the households pay the tax, they benefit from this fall in taxes. This is only vlid when government debt is constant.
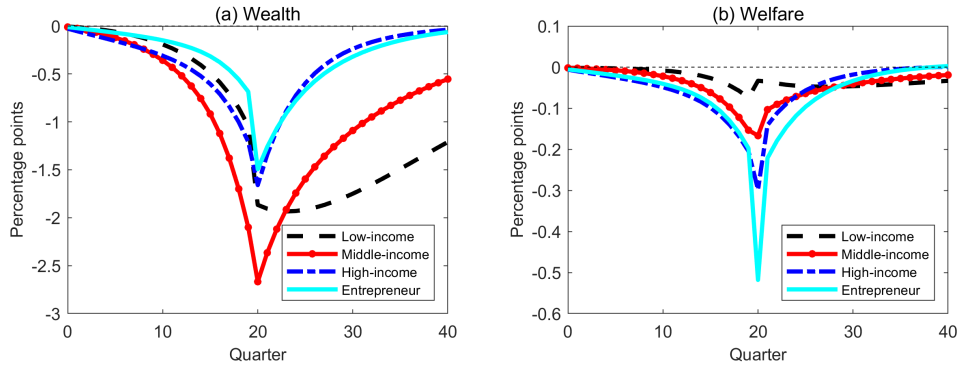
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Figure 2: Response of Wealth and Welfare for Heterogeneous Agents to Forward Guidance

income groups can borrow for consumption, their debt reduction is conducive to more consumption and increasing welfare. On the other hand, as their absolute level of consumption and utility is lower and the marginal effects is higher, the substitution effect causes more consumption currently increase, so that the current utility will increase more than the future utility will decrease, leading to an increase in the final welfare.

3.2 Horizons of Forward Guidance

As shown in Figure 3(a) , our model can also explain the *forward guidance puzzle*, like the other heterogeneous agent model (McKay et al., 2016; Kaplan et al., 2016; Hagedorn et al., 2019). Figure 3(b) also plots the welfare change as the forward guidance horizon changes from 1 to 30 quarters. With the increase in the announcement horizon, the welfare loss is smaller, indicating that the role of forward guidance is weaker. From the perspective of heterogeneous agents, since the entrepreneur group holds the most wealth, it is more affected by the expected decrease in interest rate, so the decline in welfare is more obvious. The welfare of low-income groups has also declined, because they have gained more utility in the current period, which partially offset the welfare loss caused by the decline in wealth. The difference of welfare changes among income groups diminishes when the announcement is in more distant future.
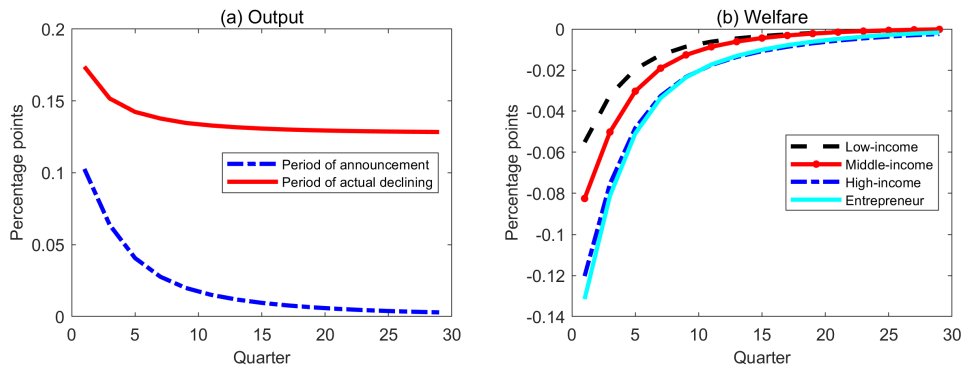

Figure 3: Response of Output and Welfare to Forward Guidance about the Interest Rate for a Single Quarter at Different Horizons

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3.3 Coordination of Fiscal and Monetary Policies

As fiscal policy influences the effects of conventional monetary policy (Kaplan et al., 2018; Auclert, 2019), it is worth studying how different fiscal policies interact with the forward guidance. We focus on the income tax exemption and government expenditures expansion.[3] Figure 4 shows that both policies are conducive to the increase of output in the current period compered with the case of no fiscal stimulus (Benchmark), but the stimulus effect of tax exemption is larger. Additionally, the welfare loss is even smaller in the case of tax exemption (-0.03% at the current period) than that the government expenditures expansion (-0.11% at the current period). The reason is that tax exemption is conducive to the improvement of the welfare of low-income groups, and the redistributive effect makes the average welfare increase. The increase in government spending squeezes out private consumption, which leads to an even lower welfare compared to the becnmark.
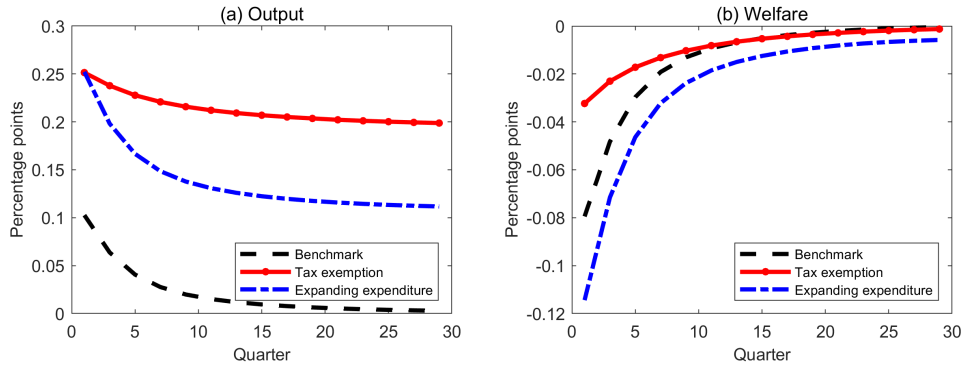

Figure 4: Response of Output and Welfare to Forward Guidance at Different Horizons with Government Simultaneously Adjusting Fiscal Policies
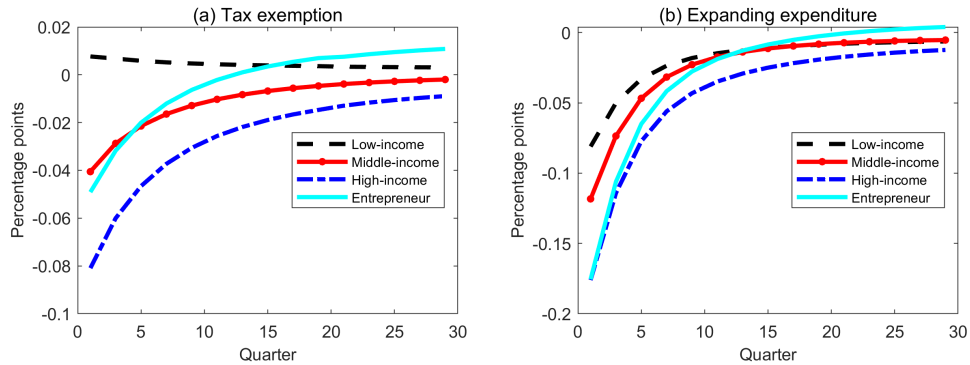

Figure 5: Response of Welfare for Heterogeneous Agents to Forward Guidance at Different Horizons with Government Simultaneously Adjusting Fiscal Policies

Figure 5 compares the redistributive effects of the two fiscal polices directly. Under the tax exemption policy, low-income groups do not need to pay taxes, and their welfare has improved significantly, while the welfare of high-income workers have fallen more.

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[3]To make the two policy comparable, we adjust the scale of government spending so that government spending and tax cuts will have the same growth effect when interest rates are announced in the next period.

In the case of expansion of government expenditures, the welfare of all groups is lower than those in the benchmark.

4 Conclusion

This paper develops a heterogeneous agent New Keynesian(HANK) model including both workers and entrepreneur. The benchmark model well describes the characteristics of China's aggregate quantity and wealth distribution. On this basis, we study the impact of forward guidance about interest rate on economic output and hosueholds' welfare. We find that when the monetary authority announces a decline in interest rate in the future, in addition to causing slight economic growth in the early period, it will also lead to a decline in wealth and hosueholds' welfare, and a decline in output in the later period. As the announcement horizon increases, the weaker the growth effect of current output, the less the effect of stimulating the current economy. Expansion of government spending and tax exemption for low-income groups are conducive to amplifying the effect of forward guidance on the current output growth, but the latter leads to a larger welfare gain.

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