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Heterogeneous stock traders, endogenous bubbles, and economic fluctuations

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ABSTRACT

The impact of stock market bubbles on the real economy has always been an important topic. By introducing heterogeneous transactions of behavioral economics into a standard dynamic stochastic general equilibrium (DSGE) model, this paper finds, first, that heterogeneous trading behaviors cause an endogenous stock bubble. Second, the endogenous inverted U-shaped bubble affects the real economy through the borrowing constraint channel, which causes an inverted U-shaped output and promotes the output to rise against the decline of the total factor productivity (TFP) shock. Third, the positive bubble and increasing bubble dominate in promoting the output and investment of the real economy.

1. Introduction

After the financial crisis in 2008, the volatility of the stock bubble cycle has attracted wide attention. Researchers mainly divide the bubble cycle into two stages — the run-up phase and the crisis phase (Brunnermeier and Oehmke, 2013), and argue that the bubble cycle is endogenously generated by the trading in the stock market. However, little attention has been paid to the systematic connection between the two stages in the bubble cycle and the mechanism of the bubble cycle on the real economy in a general framework.

By introducing heterogeneous transactions of behavioral economics into a standard dynamic stochastic general equilibrium (DSGE) model, this paper finds that heterogeneous trading behaviors cause an endogenous stock bubble, which affects the real economy through the borrowing constraint channel. The endogenous inverted U-shaped bubble then relaxes firm's borrowing constraint, which causes an inverted U-shaped output and promotes the output to rise against the decline of positive TFP shock. The positive bubble and increasing bubbles then dominate in promoting the output and investment of the real economy.

This paper connects the strands of macro and behavioral economics literature. The macro literature considers how exogenous bubbles affect the real economy and shows that there are bubbleless and bubbly equilibriums (Miao and Wang, 2012, 2014; Wang and Wen, 2012; Miao and Wang, 2015; Miao et al., 2015a,Miao et al., 2015b, 2016, 2019). They also find that there exists mutual learning between financial markets and the real economy, but the joint information production is still not endogenous by the micro-agents (Benhabib et al., 2021). The behavioral literature introduces feedback traders, whose demand is based on the history of past returns rather than the expectation of future fundamentals, and investigates the dynamics of asset price with heterogeneous beliefs to explain stock price bubbles (Black, 1986; Smith et al., 1988; Cutler et al., 1990; DeLong et al., al.,1990; Brock and Hommes, 1998; Haruvy et al., 2007; Greenwood and Shleifer, 2014; Barberis et al., 2018; Xiong and Yang, 2021). They also argue that a bubble cycle

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usually has two stages, a run-up phase and a crisis phase. In a run-up phase, bubbles form and in a crisis phase, the imbalances that build up during the boom phase suddenly materialize, and financial crises may occur (Greenwood et al., 2019). In the run-up phase, over-lapping generation (OLG) frictions and market incompleteness, and informational frictions and delegated investment can all generate bubbles, and financing is easy to acquire (Tirole, 1985; Allen and Gale, 1994; Abreu and Brunnermeier, 2003; DeMarzo et al., 2008; Sato, 2009; Doblas-Madrid, 2012; Martin and Ventura, 2012; Sockin, 2017; Gennaioli et al., 2018). Predictable increasing price endogenously attracts short-term speculators strongly and they amplify the volume by selling equity (DeFusco et al., 2018). While in the crisis phase, financial crises may occur (i.e., sovereign debt crises, bank runs) by amplification mechanisms such as financial frictions, or imperfect network structure, among others. Compared to booming markets, financial busts trigger negative emotions and substantially diminish risk-taking behaviors, even mild emotion distortions generate substantial bubbles (Upper and Worms, 2004; Vayanos, 2004; Cifuentes et al., 2005; Degryse and Nguyen, 2007; Acharya et al., 2011; Reinhart and Rogoff, 2011; Bordalo et al., 2021).

Most traditional macroeconomics papers do not consider the heterogeneity of investors, but focus on how exogenous bubbles affect the real economy rather than endogenous bubble cycles with heterogeneous traders. Although recent papers have integrated macro theory with behavioral beliefs based on exogenous shocks, the belief functions need further and more careful consideration (Farmer, 2012; Farhi and Gabaix, 2018; Farmer and Platonov, 2019; Gabaix, 2019). The behavioral literature principally studies how stock bubble cycles affect micro indexes (i.e., the price index, trading volume index, or wealth accumulation) rather than the macroeconomy.

This paper, therefore, attempts to fill the gap between these two strands of literature and has two main contributions. First, this paper introduces the heterogeneous traders' behaviors into a standard DSGE model, to study how heterogeneous trading will cause endogenous stock bubble rather than the exogenous bubble in previous macro literature. The endogenous bubble is caused by endogenous equity trading instead of exogenous component or shocks. This also introduces a specific micro-foundation for the macro DSGE model. Second, this paper argues an entire mechanism from micro to macro in which the heterogeneous traders' behaviors affect stock bubble cycles and the endogenous stock bubble cycles then influence the real economy. Besides, there is a mutual influence channel between the stock price and the real economy, which links the micro and macro rather than the micro-to-micro or macro-to-macro mechanisms addressed in previous studies.

The rest of the paper proceeds as follows. Section 2 presents the benchmark model. Section 3 presents the quantitative analysis. Section 4 further studies the extended implications of the model, and Section 5 concludes.

2. Model

This model extends a standard two-sector DSGE model by introducing two kinds of traders in the stock market. One is fundamental trader and the other is extrapolator. The fundamental trader focuses on firm value to determine when to buy or sell equity and his trading is more closely associated with a value-investing strategy rather than speculative trading. While the extrapolator always takes on risk, he attempts to predict price changes and hopes of making gains from the stock price changes. The representative firm is financial constrained, and the firm inputs labor and capital to produce final goods.

2.1. The representative fundamental trader

In an economy, a fraction of (1-*m*) are fundamental traders, and the rest *m* are extrapolators. Suppose the representative fundamental trader has the utility:

$$E_t^f \sum_{t=0}^{\infty} \beta^t \left(\ln C_{ft} - \phi_l \frac{N_{ft}^{1+\eta}}{1+\eta} \right), \tag{1}$$

where E_t^f and C_{ft} denote the expectation and the consumption of final goods by the fundamental trader respectively, and N_{ft} denotes the labor hours. $\eta>0$ is the inverse Frisch elasticity of hours worked, and $\varphi_l>0$ controls the utility weight on labor supply. The budget constraint is given by:

$$C_{ft} + D_{ft} p_t = w_t N_{ft} + D_{f,t-1}(p_t + d_t), \tag{2}$$

where D_{ft} is demand for equity shares by the fundamental trader, p_t denotes the ex-dividend share price, w_t is the wage rate, and d_t is the firm dividend. The representative fundamental trader maximizes Eq. (1) subject to Eq. (2) and chooses the optimal $\{C_{ft}, N_{ft}, D_{ft}\}$:

$$C_{ft} : 1/C_{ft} = \Lambda_t^f, \tag{3}$$

$$N_{ft} : \phi_l N_{ft}^{\eta} C_{ft} = w_t, \tag{4}$$

$$D_{ft} : \beta E_t^f \left(\frac{\Lambda_{t+1}^f}{\Lambda_t^f} (p_{t+1} + d_{t+1}) \right) = p_t. \tag{5}$$

where Λ_t^f is the Lagrange multiplier of Eq. (2). Eq. (3) is the Euler equation of fundamental trader's consumption and Eq. (4) implies that wage is equal to the marginal substitution rate of consumption and leisure. Eq. (5) determines the optimal equity purchase of the fundamental trader. It implies that the fundamental trader follows rational expectation to choose the optimal D_{ft}, thus the price of buying a unit of equity today (p_t) must be equal to the expected discounted resale revenue tomorrow.

2.2. The representative extrapolator

Extrapolator's problem is analogous to the fundamental trader. The utility is given by:

$$E_t^e \sum_{t=0}^{\infty} \beta^t \left(\ln C_{et} - \phi_l \frac{N_{et}^{1+\eta}}{1+\eta} \right), \tag{6}$$

where E_t^e denotes the extrapolator's expectation, C_{et} and N_{et} denote the consumption of final goods and the labor hours of the extrapolator. Similarly, the budget constraint is given by:

$$C_{et} + D_{et} p_t = w_t N_{et} + D_{e,t-1}(p_t + d_t), \tag{7}$$

The first order conditions are given by:

$$C_{et} : 1/C_{et} = \Lambda_t^e, \tag{8}$$

$$N_{et} : \phi_l N_{et}^{\eta} C_{et} = w_t, \tag{9}$$

$$D_{et} : \underbrace{\beta E_t^e \left(\frac{\Lambda_{t+1}^e}{\Lambda_t^e} (p_{t+1} + d_{t+1}) \right)}_{\text{discounted expected revenue}} = p_t, \tag{10}$$

where Λ_t^e is the Lagrange multiplier of Eq. (7). Eq. (8) is the Euler equation of extrapolator's consumption and Eq. (9) implies that wage is equal to the marginal substitution rate of consumption and leisure. Eq. (10) is the standard macro first order condition of equity demand like Eq. (5), which shows the extrapolator's decision-making of equity purchase. However, the extrapolator acts different from the fundamental trader, he follows adaptive expectations rule which is shown in many behavioral economics literature. So following Barberis et al. (2018), this paper assumes that the extrapolator's expectation (belief) satisfies $\beta E_t^e \left(\frac{\Lambda_{t+1}^e}{\Lambda_t^e} X_t \right)$. This means that the extrapolator expects (E_t^e) the revenue tomorrow by following the specific rule X_t. And $X_t = \left[\underbrace{(1-\theta) \sum_{k=1}^{\infty} \theta^{k-1} (p_{t-k} - p_{t-k-1})}_{\text{past price learning}} + p_t \right] / \beta$, thus past price learning[1] plus current price equals to the extrapolator's expectation about the stock price in the next period, and θ is a parameter measures the importance of past price changes. Then by equalizing the left hand side part of Eq. (10) $\beta E_t^e \left(\frac{\Lambda_{t+1}^e}{\Lambda_t^e} (p_{t+1} + d_{t+1}) \right)$, the extrapolator's discounted expectation of revenue , and the behavioral expectation rule, Eq. (10) becomes:

$$\underbrace{\beta E_t^e \left(\frac{\Lambda_{t+1}^e}{\Lambda_t^e} (p_{t+1} + d_{t+1}) \right)}_{\text{discounted expected revenue}} = p_t = \beta E_t^e \left(\frac{\Lambda_{t+1}^e}{\Lambda_t^e} X_t \right). \tag{11}$$

The left hand side of Eq. (11) is the extrapolator's discounted expectation of equity revenue, and the right hand side of Eq. (11) is the rule of extrapolator's belief which is a learning process based on past price changes. Eq. (11) implies that the extrapolator expects the future revenue of equity and chooses his equity purchase only by his belief rule of past pricing learning. Within this belief rule, the stock price and the extrapolator's equity purchase become a self-fulfilling feedback loop ($p_t \Leftrightarrow D_{et}$). If the stock price continues to increase, X_t becomes bigger and the extrapolator will expect more revenues tomorrow. As a result, he thinks the equity is more valuable and the equity purchase D_{et} increases. Increasing demand for equity will push stock price to go up further, and the rising stock price continues to stimulate extrapolator's equity purchase.

2.3. The representative firm

Firms are identical and produce with a Cobb-Douglas production function:

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}, \tag{12}$$

where K_t is the capital and N_t is the labor demand. The parameter α represents the output elasticity of capital. The total factor pro-

[1] The belief function is not a sudden change of beliefs, but rather a past learning process.

ductivity (TFP) shock A_t follows the following AR(1) process:

$$\ln A_t = \rho_a \ln A_{t-1} + \varepsilon_{at}, \tag{13}$$

where $\rho_a \in (0, 1)$ measures the degree of persistence, and ε_{at} is the standard deviation with an i.i.d. standard normal process. Capital evolution is given by:

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{14}$$

where δ is the capital depreciation rate. Suppose that the firm's investment I_t is financed by equity loan[2] and is subject to the borrowing constraint:

$$I_t \le \chi p_t D_F, \tag{15}$$

where χ is the exogenous parameter of equity loan that reflects the friction in the credit market, and D_F is the non tradable shares held by the firm. There are two points to specify: every period the firm gets the intra-period loan which has no interest rate as in Carlstrom et al. (1997); and the equity loan as in Eq. (15) is linear which follows Pascucci et al. (2013), Xia and Zhou (2017) and Zhang et al. (2018). Eq. (15) implies that the changes of stock price will affect the firm's borrowing constraint. First, total investment I_t cannot exceed an amount proportional to the equity value $\chi p_t D_F$ to avoid the "Ponzi Game". Second, the increasing stock price p_t raises the upper bound of firm's borrowing, and the borrowing constraint becomes loose. As a result, investment increases. Third, to make a further step, when combining Eq. (11) this paper finds that there is a clear relationship among the stock price, extrapolator's equity purchase and firm's borrowing constraint. An increase of the stock price promotes extrapolator's equity purchase, which further pushes the stock price to go up in turn. In the self-fulfilling feedback loop, the stock price continues to rise, and the firm can borrow and invest more by a loose constraint as firm's market value (equity value) increases. The firm maximizes expected discounted flow of dividends:

$$\max_{\{N_t, K_{t+1}\}} E_t^f \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t^f}{\Lambda_0^f} [Y_t - w_t N_t - (K_{t+1} - (1-\delta)K_t)], \tag{16}$$

s.t.

$$K_{t+1} - (1-\delta)K_t \le \chi p_t D_F, \tag{17}$$

The optimal choices of $\{N_t, K_{t+1}\}$ are:

$$N_t : w_t N_t = (1-\alpha)Y_t, \tag{18}$$

$$K_{t+1} : 1 + \lambda_t = E_t^f \beta \frac{\Lambda_{t+1}^f}{\Lambda_t^f} \left[\frac{\alpha Y_{t+1}}{K_{t+1}} + (1-\delta)(1+\lambda_{t+1}) \right]. \tag{19}$$

where λ_t is the Lagrange multiplier of Eq. (17). Eq. (18) means that the marginal production of labor is equal to wage. Eq. (19) is the optimal choice of capital stock. The left hand side of Eq. (19) is the marginal cost of investment (equals to 1) plus the marginal value of newly installed capital stock coming from the equity loan. And the right hand side of Eq.(19) is the expected marginal benefit of investment tomorrow. Eq. (19) implies that the micro heterogeneous traders' behaviors will finally affect the macro capital and output by increasing investment (equity loan).

2.4. Market clearing

Goods market clearing condition implies that:

$$mC_{et} + (1-m)C_{ft} + I_t = Y_t. \tag{20}$$

Labor market clearing condition implies that:

$$mN_{et} + (1-m)N_{ft} = N_t. \tag{21}$$

Stock market clearing condition implies that:

$$mD_{et} + (1-m)D_{ft} = f. \tag{22}$$

where f is the fixed tradable shares. For simplicity, I assume $f + D_F = 1$.

[2] An equity loan is a temporary swap of ownership. The equity lender transfers legal ownership (including voting rights) of a block of shares to the borrower, who simultaneously transfers collateral (Geczy et al., 2002).

Table 1
Calibration of parameters.

Parameters	Value	Description
β	0.99	Subjective discount factor
δ	0.035	Capital depreciation rate
α	0.5	Share of capital
η	2	Inverse Frisch elasticity of labor supply
m	0.7	Fraction of extrapolator
θ	0.9	The rule parameter
i/y	0.422	Steady-state capital-output ratio
χ	0.2	Collateral parameter
f	0.5258	Tradable shares
ρ_a	0.98	Shock persistence
ε_{at}	0.01	S.D. of the shock

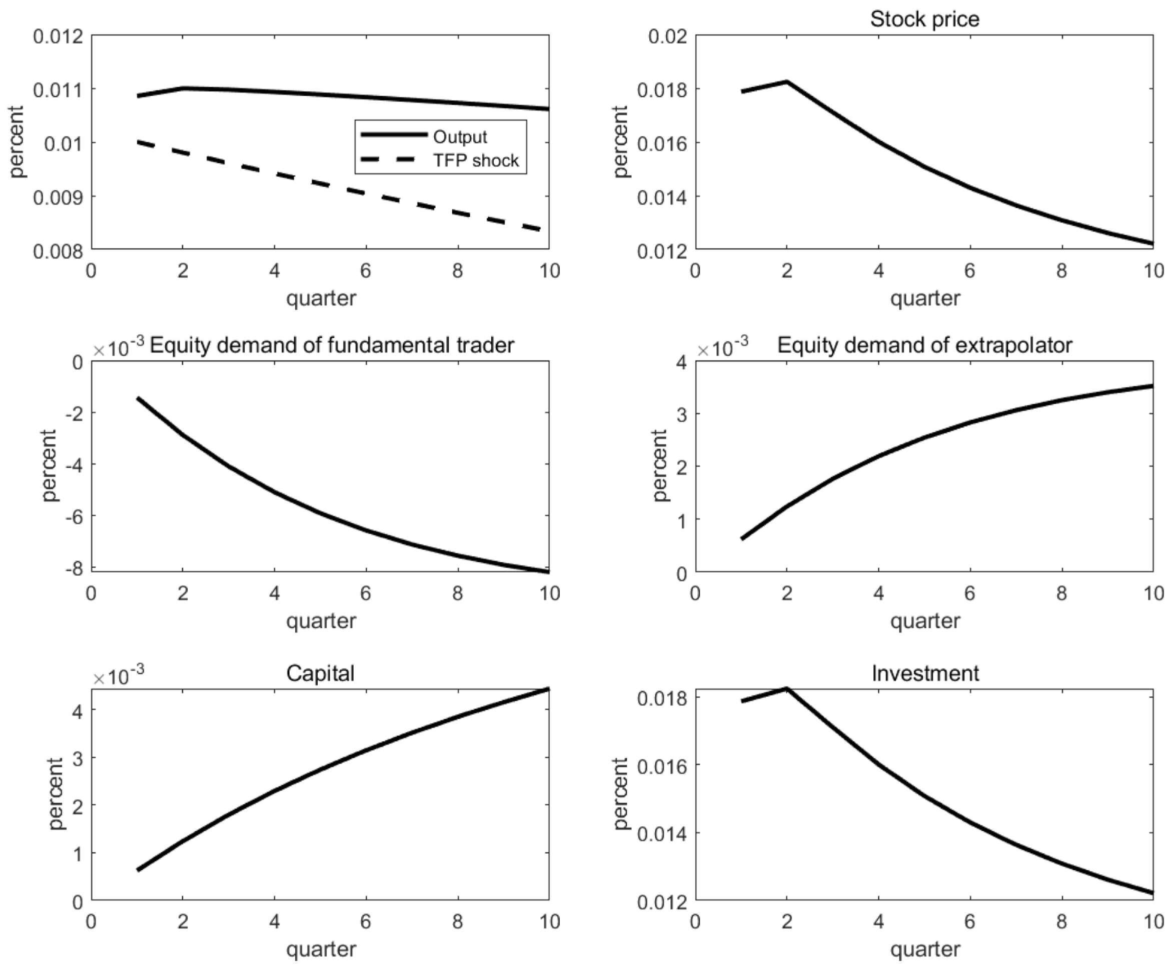

Fig. 1. Impulse response to a positive one standard deviation TFP shock (benchmark model).

3. Quantitative analysis

3.1. Calibration

This section describes the calibration of the common parameters in Table 1, which are mainly based on the Chinese Statistical Yearbook from 1998 to 2017. The subjective discount factor β=0.99 targets the average 46% aggregate savings rate between 1998 and 2017. The capital depreciation rate is set to 0.035, and the capital share α is equal to 0.5, which are consistent with the literature studying the Chinese economy (Hsieh and Klenow, 2009; Chang et al., 2015). Following Chang et al. (2015), Inverse Frisch elasticity η equals 2, implying a Frisch labor supply elasticity of 0.5. As far as I know, no micro data are available now to estimate the parameters of

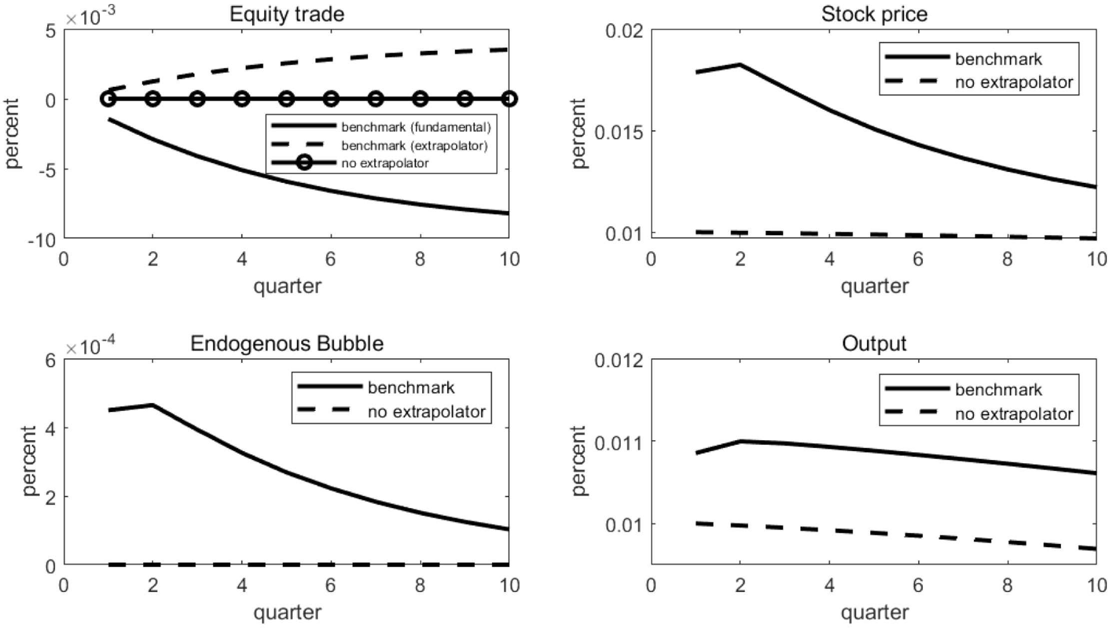

Fig. 2. Comparison with no extrapolator (with a positive one standard deviation TFP shock).

the rules of traders' behaviors in China. So the fraction of extrapolator m=0.7 and the extrapolation parameter θ=0.9 are exactly calibrated following Barberis et al. (2018). The steady-state investment-output ratio i/y=42.2% is consist with the macro data from 1998 to 2017. Covas and Hann (2011), and Miao et al. (2015a), (2015b) document that χ ranges from 0.1 to 0.3 for various sizes of firms. So I choose 0.2. The data of the issued stock and circulating stock in the A-share market are then obtained from the Chinese Statistical Yearbook from 1998 to 2017, and the average value of f=52.58% is calculated. In addition, I follow the standard macroeconomics literature to calibrate the persistence of the TFP shock ρ_{at}=0.98 and the standard deviation of the shock to one percent.

3.2. Impulse response

Fig. 1 shows the impulse response to a positive one standard deviation TFP shock. A positive TFP shock increases output at the very beginning. As a result, firm value rises and stock price increases as well. In this model, the demands of both traders have heterogeneous features. The fundamental trader decreases the equity holding as the stock price p_t increases in Eq. (5), which makes the present stock value higher than the expected income and pushes the fundamental trader to continue to sell out the equity until the next equilibrium. With the rule of Eq. (11), the extrapolator will, however, continue to buy equity under the stimulation of rising stock price. In this DSGE model with heterogeneous traders, the stock price does not decline with the slowly dropping TFP shock as in the previous standard DSGE model. On the contrary, the stock price shows an inverted-U shape because, according to the extrapolator's trading rule, the increasing stock price will stimulate the extrapolator to buy more equity, which leads to a further rise in the stock price. The increase of the stock price eases the firm's borrowing constraint by Eq. (15). Hence, the investment also has a similar inverted-U shape, which is highly correlated with stock price, and capital accumulation continues to increase as well. This has a positive impact on output, and the output in Fig. 1 keeps increasing at the first two quarters and then declines very slowly.[3] In the long run, the whole dynamic system returns to the equilibrium.

Fig. 1 shows a micro-to-macro mechanism with a positive TFP shock in which heterogeneous trading leads to an inverted-U stock price fluctuations, which promotes investment and output by relaxing the borrowing constraint. Fig. 1 also shows a mutual influence channel between the stock price and the real economy, thus a positive TFP shock causes stock price fluctuations, and stock price fluctuations driven by heterogeneous traders' behaviors lead to inverted U-shaped investment and output in turn. In Appendix A, the impulse response is drawn with 2/10 standard deviations. The results indicate that the mechanism still holds and the main results are robust.

[3] The first six quarters of output fluctuations are: 1.085%, 1.099%, 1.097%, 1.092%, 1.088% and 1.083%. This means that the values of output fluctuations do not fall below the initial level until the 6th quarter. It is worth noting that here I only give one standard deviation shock, and if the standard deviation increases, the fluctuations of the inverted-U shape will be more obvious.

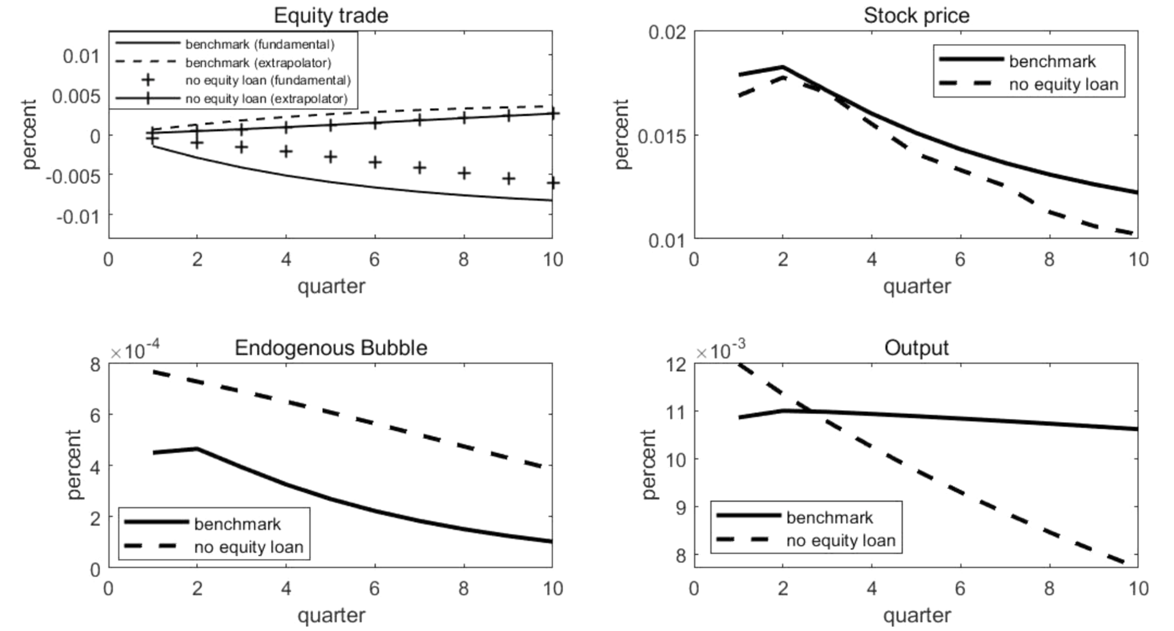

Fig. 3. Comparison with no equity loan (with a positive one standard deviation TFP shock).

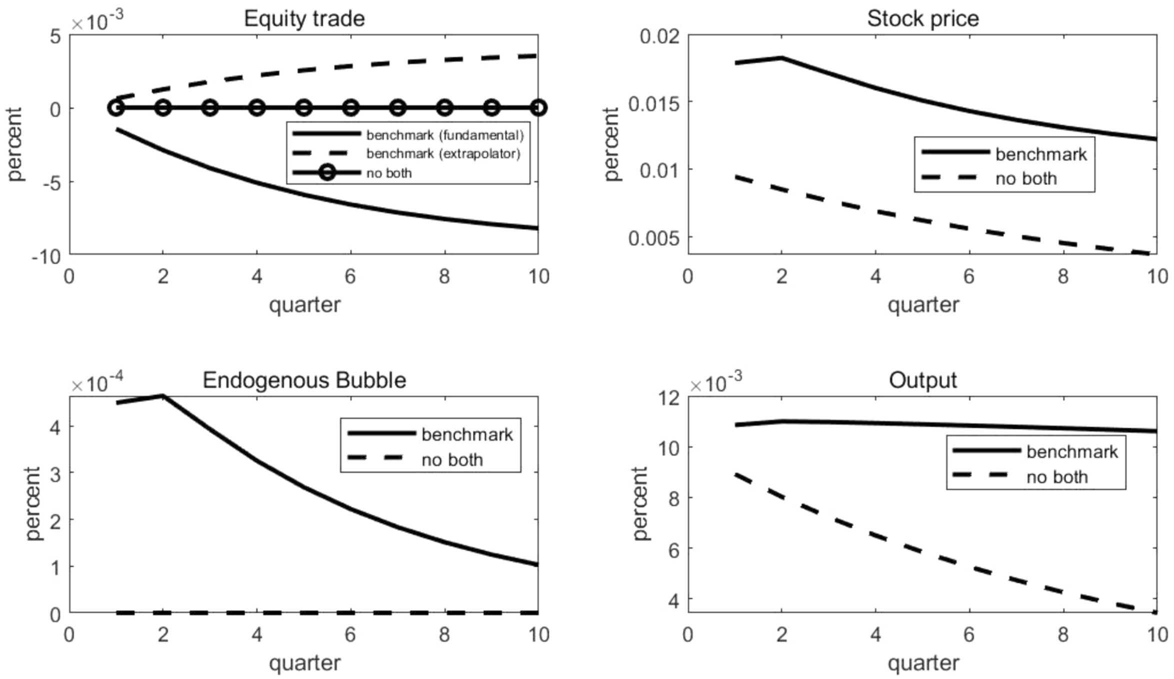

Fig. 4. Comparison with both no extrapolator & no equity loan (with a positive one standard deviation TFP shock).

3.3. Comparison

3.3.1. Counterfactual experiments

The model has two major channels. First, by introducing heterogeneous traders' behaviors, this paper can generate an endogenous bubble. Second, by equity loan the changes of the stock price can affect the real economy directly. Therefore, this section shows three counterfactual experiments in Figs. 2, 3 and 4 to test the effectiveness of these two main channels.

The quantitative comparisons between this model and the standard DSGE model with only homogenous fundamental traders,

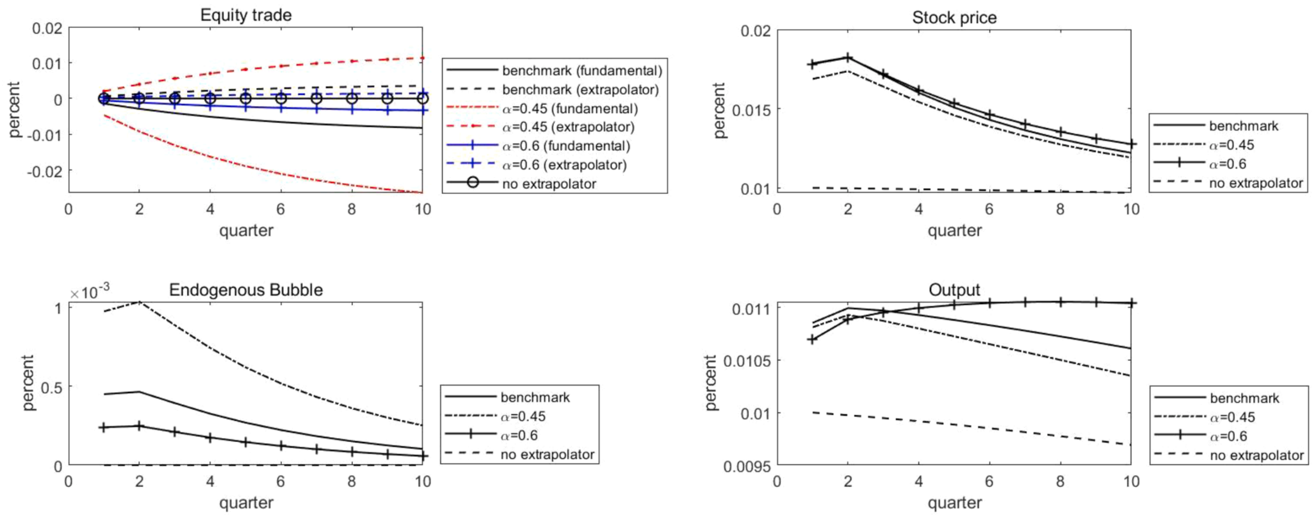

Fig. 5. Robustness check: α.

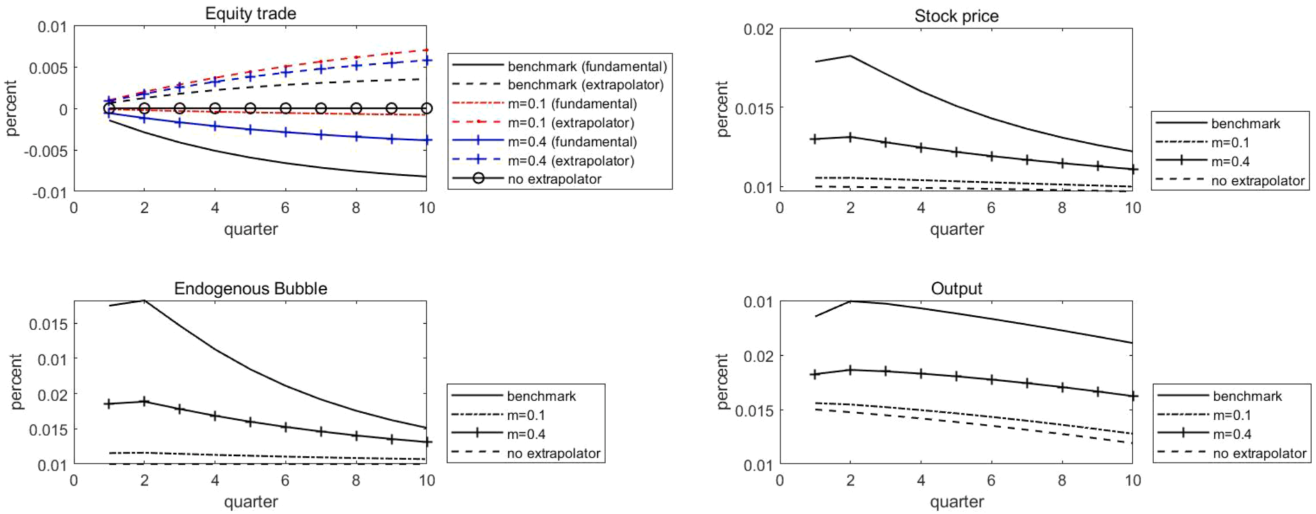

Fig. 6. Robustness check: *m*.

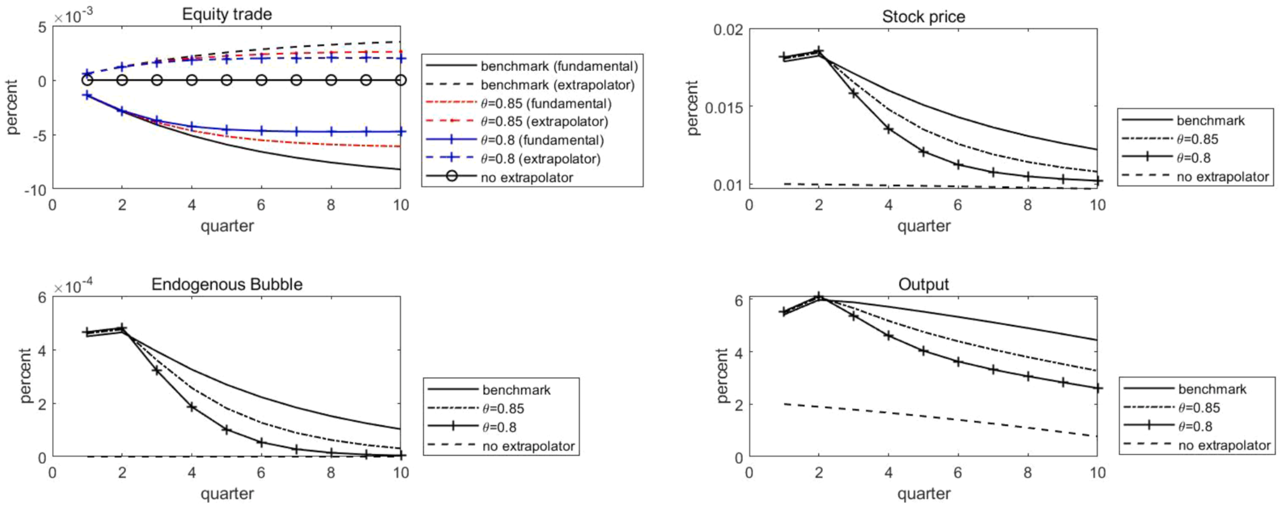

Fig. 7. Robustness check: θ.

Table 2
The asymmetric pattern of bubble I.

		Mean	Std. Dev.	Min	Max	Std. Err.	*P*-value
Output	+	0.0309	0.0781	−0.2088	0.3035	0.00128	0.0000***
	–	−0.0254	0.0756	−0.2426	0.2752	0.00126	
Investment	+	0.0448	0.0806	−0.2081	0.3306	0.00132	0.0000***
	–	−0.0394	0.0782	−0.2803	0.2739	0.00130	
Labor demand	+	0.0034	0.0022	4.90e-06	0.0126	0.00222	0.0000***
	–	−0.0034	0.0023	−0.0149	−2.63e-06	0.00232	
Bubble	+	0.0009	0.0006	1.29e-06	0.0033	9.57e-06	0.0000***
	–	−0.0009	0.0006	−0.0039	−6.93e-07	0.0000102	

Note: * Sig. < 0.1, ** Sig. < 0.05, *** Sig. < 0.01.

Table 3
The asymmetric pattern of bubble II.

		Mean	Std. Dev.	Min	Max	Std. Err.	P-value
Output	↑	0.0312	0.0685	−0.1337	0.1820	0.0061	0.0016***
	↓	−0.0034	0.0726	−0.1806	0.0912	0.0089	
Investment	↑	0.0463	0.0739	−0.1304	0.2029	0.0065	0.0000***
	↓	−0.0023	0.0821	−0.2026	0.1222	0.0100	
Labor demand	↑	0.0037	0.0030	−0.0033	0.0105	0.0003	0.0000***
	↓	0.0003	0.0041	−0.0062	0.0077	0.0005	
Bubble	↑	0.0010	0.0008	−0.0009	0.0028	0.00007	0.0000***
	↓	0.0001	0.0011	−0.0016	0.0020	0.00013	

Note: * Sig. < 0.1, ** Sig. < 0.05, *** Sig. < 0.01.

shown in Fig. 2, are presented. If removing the heterogeneous traders in the stock market, the model in this paper will go back to the standard DSGE model. As shown in Fig. 2, unlike previous macro studies, the stock bubble is endogenous in this paper rather than exogenous, which is caused by the trading behaviors of heterogeneous traders in the stock market. As a result, the endogenous bubble shows an inverted-U shape in Fig. 2 instead of a linear path. Second, the decreasing impact of the TFP shock still causes an inverted U-shaped output. In the standard DSGE model, both the fluctuations of the output and the investment depend on the exogenous TFP shock. However, this paper argues that with a positive TFP shock, the speculator's behavior of chasing the rising prices stimulates the stock price to further rise (i.e., against the decline of the TFP shock). The inverted U-shaped bubble thus relaxes firm's borrowing constraint, increases the investment and promotes the output to rise against the decline of TFP. Third, according to the extrapolator's trading rule in Eq. (11), this bubble can't continue to go up all the time. When the stock price rises slowly, the bubble slowly deflates.

Fig. 3 shows that with equity loan channel, a positive one standard deviation TFP shock causes stock price fluctuations, and an endogenous stock bubble and the inverted U-shaped stock price are generated by heterogeneous trading behaviors. This relaxes firm's borrowing constraint and increases the investment and the output correspondingly (rising against the decline of the TFP shock and deflating very slowly). However, if there is no equity loan, the direct link between the stock market and the real economy is removed. As a result, the output declines with the decreasing TFP shock. Because the firm value equals to the discounted value of future dividends, so the firm value is smaller than the benchmark model as the output decreases much faster. But as the stock price changes relatively smaller, the bubble becomes a litter bigger than the benchmark model.

In Fig. 4, both channels are shut down and it can be seen that there is no endogenous bubble and inverted-U shaped stock price. And similarly, the output declines with the decreasing TFP shock. Hence, Figs. 2, 3 and 4 imply that both the heterogeneous traders and the equity loan channels are effective and important.

3.3.2. *Comparison with different key parameters*

In this part, three robustness checks are shown in Figs. 5, 6 and 7 respectively. In Fig. 5, different capital share α are chosen to show the robustness of mechanism. The endogenous inverted-U shaped bubble and output still exist. When α=0.6, the inverted-U shaped output lasts longer, because in this case the output elasticity of capital is higher. As a result, the investment and capital increase more with increasing stock price. Similarly in Figs. 6 and 7, the main mechanism in Section 3.2 still exists. If the fraction of extrapolator m and the rule parameter θ are smaller, the fluctuations of the stock price, stock bubble and output are more minor.

4. The asymmetric bubbles and the real economy

4.1. *Positive and negative bubbles*

In this section, I study the impacts of the endogenous bubble caused by heterogeneous trading on output in different cases. It is common sense that bubbles refer to large, sustained mispricing of assets, and as a result bubbles are accompanied by business cycles. In the stock market, when a stock price is higher than the firm value, that is called a positive bubble; and if the stock price is lower than the firm value, that is called a negative bubble. According to the definition of the Schumpeter Cycle, the period of a short cycle is about

40 months.[4]

Here, a bubble is first divided into positive and negative as shown in Table 2, in which "+" indicates the positive bubble and "-" means the negative bubble. Following Miao et al. (2015b), the model moments are computed using the simulated data (10,000) periods. The four sets of data are significant in Table 2. The simulation shows that in the 10,000 periods (quarters), there are 264 positive-bubble time intervals and 260 negative-bubble time intervals respectively.[5] In detail, there are 3726 quarters in the positive bubble and 3612 quarters in the negative bubble. Table 2 shows that the positive and negative bubbles are asymmetric, thus the number of quarters of the negative bubble is smaller, so the positive bubble dominates. Especially, positive bubble plays a greater role in output and investment fluctuations. Table 2 shows that the mean and the standard deviation of output and investment in the positive bubble interval are larger than those in the negative bubble interval. That is to say, the positive bubble can promote the real economy more than the negative one.

4.2. Heterogeneous trading patterns

The cycle can also be divided into "continuous stock price rise" and "continuous stock price decline" intervals according to the rising or falling trend of the stock price. In the previous interval, extrapolators continue to buy equity while fundamental traders sell out. In the latter interval, the transaction direction for the two counterparties switches. Table 3 therefore shows how the heterogeneous trading patterns affect output and investment. Based on the definition of the Schumpeter Cycle, the ranges in which stock prices rise or fall for seven consecutive quarters are calculated. I use "↑" and "↓" to denote the rise or decline of stock prices for seven consecutive quarters, respectively. The model moments are also computed using the simulated data (10,000) periods. The four sets of data are significant in Table 3.

The results show that in the 10,000 periods (quarters), there are 17 rising-stock-price time intervals (including 128 quarters) and only 9 declining-stock-price time intervals (including 67 quarters). They are asymmetric. In particular, Table 3 shows that the increasing bubble interval plays a greater role in variables' fluctuations than the decreasing one. Although the standard deviations of output, investment, labor demand and bubble are slightly lower in the increasing bubble interval, the means are all significantly greater than in the decreasing interval. Among which, the means of output, labor demand and bubble are ten times greater, and investment is about twenty times greater than the other side. This implies that the x0027 rising-stock-price intervals affect the real economy more than the declining one.

5. Conclusion

This paper establishes a specific micro-foundation for the standard macro DSGE model by introducing heterogeneous transactions and studies how heterogeneous traders' behaviors affect the stock bubble cycles, as well as how the endogenous stock bubble cycles influence the real economy. This paper argues an entire mechanism from micro to macro and a mutual influence channel between the stock price and the real economy. The main results find that, first, heterogeneous trading behaviors cause an endogenous stock bubble. Second, the endogenous stock bubble affects the real economy as the endogenous inverted U-shaped bubble relaxes firm's borrowing constraint, which causes an inverted U-shaped output and promotes a rise in output against the decline of TFP shock. Third, by studying the patterns of stock bubble cycles, the results indicate that positive and increasing bubbles dominate in promoting the output and investment of the real economy.

Author statement

This manuscript has not been published or presented elsewhere in part or in entirety and is not under consideration by another journal. I have read and understood your journal's policies, and I believe that neither the manuscript nor the study violates any of these. There are no conflicts of interest to declare.

Declarations of Competing Interest

None.

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[4] Economic cycles have different lengths and types, for example, the Juguera cycle (9-10 years) and the Kantladiev cycle (50-60 years). This paper only focuses on a short cycle as it is more suitable for assessing stock market fluctuations.

[5] As the Schumpeter Cycle denotes that the period of a short cycle is about 40 months, so the simulated data in which every positive/negative bubble lasting for ≥ 7 quarters (about 21 months) are counted.

Appendix

Fig. A1

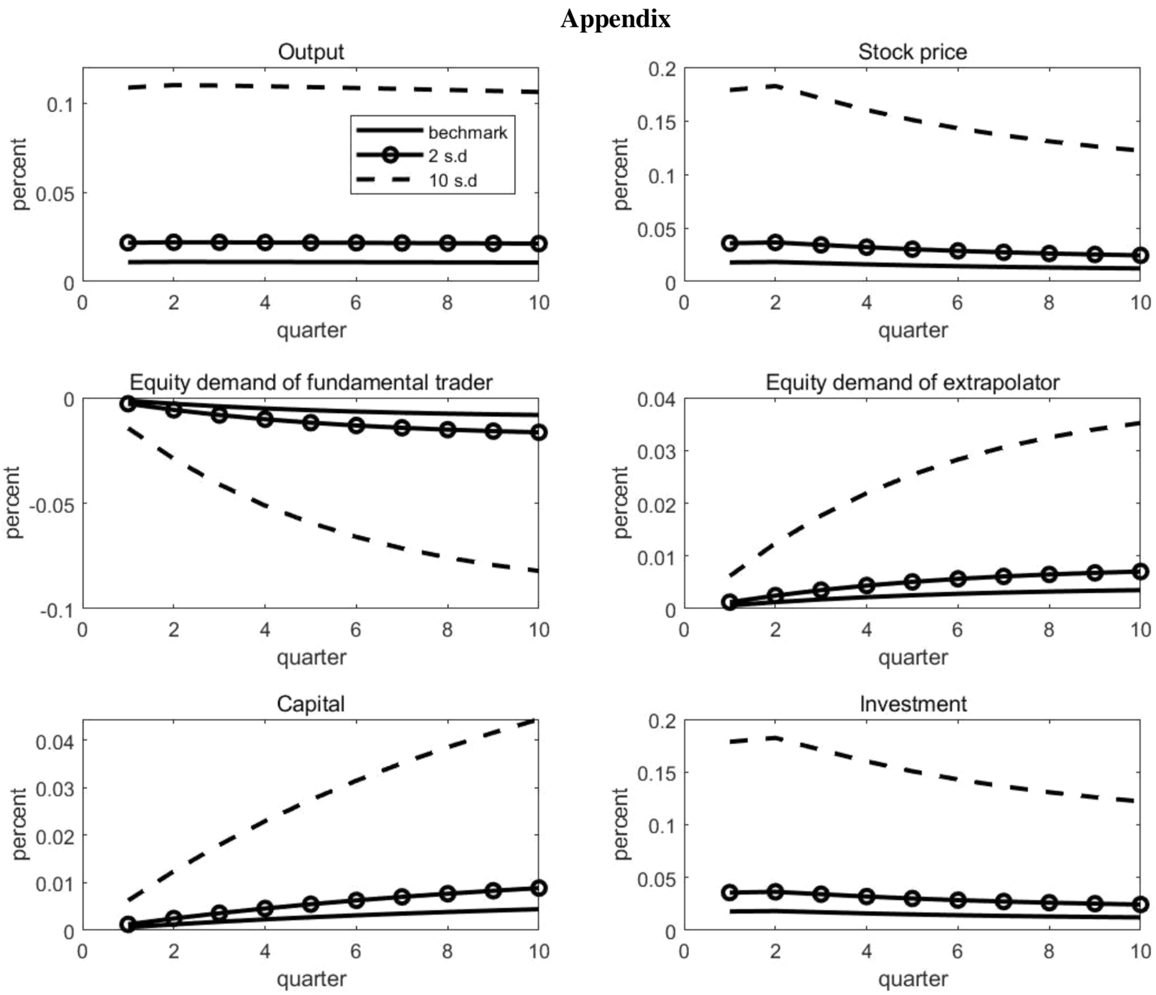

Fig. A1. Robustness check.

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