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САНХҮҮГИЙН ХУРДАСГАГЧТАЙ ДИНАМИК СТОХАСТИК ЕРӨНХИЙ ТЭНЦВЭРИЙН ЗАГВАР

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Хураангуй

Ben S.Bernanke, Mark Gertler and Simon Gilchrist (BGG) нар санхүүгийн хурдасгагч бүхий динамик стохастик шинж чанартай ерөнхий тэнцвэрийн загвар DSGE-р зээлийн зах зээл дээр гарсан өөрчлөлтүүд нь эдийн засгийн хэлбэлзэлд хэрхэн нөлөөлж байгааг судалсан. Энэхүү загварт эдийн засагт оролцогч өрх, аж ахуйн нэгж, жижиглэн худалдаачид, капитал бүтээгчдийг тус тусад нь тодорхойлсон бөгөөд зээлийн зах зээлд оролцогчдын хувьд мэдээлэл тэгш бус (asymmetric) байх, жижиглэн худалдаачид нь бараа бүтээгдэхүүний үнийг богино хугацаанд өөрчлөх боломжгүй (sticky price setting) байх гэсэн нөхцөлүүдийг тавьсан байдаг. Энэ ажлаар онолын хүрээнд тодорхойлсон DSGE загварын үр дүнг нарийвчлан тооцохын тулд загварыг санхүүгийн хурдасгагчтай болон санхүүгийн хурдасгагчгүй байдлаар симуляци хийж үр дүнгүүдийг харьцуулж дүгнэлт гаргасан. Симуляцийн үр дүнгээс харахад DSGE загварын үндсэн үр дүнтэй тохирч байгаа бөгөөд загварын параметерүүдийн утгыг үндэслэл сайтай, зөв сонгож чадвал санхүүгийн хурдасгагч нь эдийн засгийн динамикт үзүүлэх нөлөө нь ач холбогдолтой байна. Симуляциар аль нэг шокын эдийн засагт үзүүлэх нөлөөлөл нь их эсвэл бага байх нь тухайн шокын төрлөөс хамаарч байгаа нь харагдсан. Санхүүгийн хурдасгагчтай загварын хувьд, технологийн шокын үед түүний эдийн засагт нөлөөлөх нөлөөллийг гадаад санхүүжилт(external finance premium)-ийн үзүүлэлт нь бууруулна; харин засгийн газрын хэрэглээнд огцом өөрчлөлт ороход санхүүгийн хурдасгагч нь энэ шокын нөлөөллийн хүчийг нэмэгдүүлж, гүнзгийрүүлэх ба мөнгөний нийлүүлэлтийн шок бий болоход санхүүгийн

хурдасгагч нь эдийн засгийн динамикийн өөрчлөлтөд нөлөөлөхгүй гэсэн үр дүн гарсан.
Цаашдын судалгаагаар загварт авч үзэж буй гадаад санхүүжилтийн үзүүлэлт болон бусад параметерүүдийг эдийн засгийн тоо мэдээг ашиглан үнэлэх, зохимжит утгыг тооцож эдийн засгийн динамикт үзүүлэх нөлөөг тодорхой болгохыг зорьж байна.

Abstract

This paper considers the dynamic stochastic general equilibrium model with financial accelerator which is presented by Ben S.Bernanke, Mark Gertler and Simon Gilchrist in 1999 (hereafter BGG). They develops a dynamic stochastic general equilibrium model, hereafter DSGE, that is intended to help clarify the role of credit market frictions in business fluctuations. BGG model is characterized by sticky price setting, asymmetric information and agency problems. Here, I simulate BGG model with and without financial accelerator mechanism. Simulations results and BGG results are similar so that, under reasonable parametrizations of the model, the financial accelerator has a significant influence on business cycle dynamics. The results show that whether the presence of financial accelerator mechanism, as proposed by Bernanke et al(1999), significantly amplifies and propagates the impact of shocks depends on the shock type. As for the responses of monetary policy shock, financial accelerator has no significant effects on the dynamics; when the technology shock occurs the external finance premium dampens the effects of the shock. If there is a government spending shock in the economy, the presence of financial accelerator amplifies and propagates the effects of the shock in some extend.

1. Introduction

This paper considers the dynamic stochastic general equilibrium model with financial accelerator which is presented by Ben S.Bernanke, Mark Gertler and Simon Gilchrist in 1999. They develops a dynamic stochastic general equilibrium model, hereafter DSGE, that is intended to help clarify the role of credit market frictions in business fluctuations.

In the standard DSGE models, conditions in financial and credit markets do not affect the real economy which means standard frameworks for macroeconomic analysis adopt the assumptions underlying the Modigliani-Miller(1958)(MM) theorem. This theorem implies that financial structure is both indeterminate and irrelevant to real economic outcomes.

The idea that financial conditions may amplify and propagate shocks to the economy, presented in classic texts such as Fisher (1933) and Gurley and Shaw (1955) but long ignored by macroeconomists due to the influence of MM theorem, has aroused by Bernanke (1983).

Breakthroughs in the economics of incomplete and asymmetric information [beginning with Akerlof(1970)] and the extensive adoption of these ideas in corporate finance and other applied fields [e.g., Jensen and Meckling (1976)], have made possible more formal theoretical analysis of credit market imperfections and it is now well understood that asymmetries of information play a key role in borrower-lender relationships. In short, when credit markets are characterized by asymmetric information and agency problems, MM irrelevance theorem no longer applies.

Bernanke and Gertler (1989) shows that the presence of asymmetric information in credit markets between lenders and borrowers gives rise to agency costs that translate into an 'external finance premium' – i.e. an extra cost to firms' investment projects financed with external funds, as opposed to retained earnings; and such agency costs depend negatively on borrowers' financial health, and therefore behave counter-cyclically. As a result, shocks that positively affect economic activity, increasing firms' cash flow and net worth, tend to be accompanied by lower premia on external finance, and therefore better financing conditions in credit markets and higher investment, which reinforces the shock's initial expansionary effects; and conversely for contractionary shocks. This link has come to be known as the "financial accelerator."

Bernanke et al. (1999) and others, including Kiyotaki and Moore (1997) and Carlstrom and Fuerst (1997), demonstrate that financial frictions may significantly amplify the magnitude and the persistence of fluctuations in economic activity. Carlstrom and Fuerst (1997) first demonstrated the quantitative importance of the Bernanke and Gertler (1989) mechanism, finding that it could produce a hump-shaped output response to shocks in an otherwise standard real business cycle model. The propagation brought about by the financial friction allows the model to better match this key feature of the data, but it did not amplify the response of output. Using a sticky-price model calibrated to postwar US data, Bernanke et al. (1999) show that a different setup for the financial-accelerator mechanism both amplifies the impact of shocks and provides a quantitatively important mechanism that propagates shocks at business cycle frequencies.

Bernanke et al. (1999) considers a simple rule, to study the effects of monetary policy in an economy with credit-market frictions and the simple rule is known as standard Taylor rule, in which the central bank adjusts the current nominal interest rate in response to the lagged inflation rate and the lagged interest rate.

Bernanke et al. (1999) allowed heterogeneity among firms to capture the real-world fact that borrowers have differential access to capital markets and investment delay. But in this paper we will follow the baseline model.

The rest of this paper is as follows. Section 2 explains the model analyzed in Bernanke et al.(1999). The model embeds the credit market frictions in dynamic general equilibrium model with Calvo (1983) price setting. Section3 presents model simulations and results. Section 4 gives the conclusion of the whole work and future directions for research.

2. The model

The model is based on the closed economy Dynamic New Keynesian framework with sticky prices, such as that of Calvo(1983), and the financial accelerator mechanism, such as that of BGG [Bernanke,B., Gertler,M., Gilchrist,S.,1999. The financial accelerator in a quantitative business cycle framework. In Handbook of Macroeconomics. North Holland, Amsterdam]. The BGG model embeds the partial equilibrium contracting problem between the lender and entrepreneur within DSGE.

The economy consists of representative households, the monetary authority, government, and three types of producers: entrepreneurs, capital producers, and retailers.

Households consume and supply labor to the market and make deposits in the financial intermediaries, which becomes the external fund for entrepreneurs.

Entrepreneurs finance their capital investment by their own net worth and because they cannot fully finance their investment, they borrow funds from financial intermediaries for the excess of net worth. In this situation, entrepreneurs will face an external finance premium that rises when their leverage increases. Entrepreneurial net worth is accelerated depending on the leverage ratio. Entrepreneurs produce wholesale goods and their surviving rate to the next period is γ.

Capital producers build new capital goods and sell it to the entrepreneurs.

Retailers buy wholesale goods and sell them to households as final good and the monopoly power of retailers provides the source of nominal stickiness in the economy; otherwise, retailers play no role. They set nominal prices as in Calvo(1983).

The monetary authority follows a standard Taylor rule to adjust interest rate in response to output and inflation.

2.1. Households

Infinitely living representative household works, consumes, holds money, and invests its savings in a financial intermediary that pays the riskless rate of return. Household is seeking to maximize utility, which is defined by the period utility, $U(c_t, \frac{M_t}{p_t}, h_t)$. The expected lifetime utility function is as follows

$$E_t \sum_{k=0}^{\infty} \beta^k U(c_{t+k}, \frac{M_{t+k}}{p_{t+k}}, h_{t+k}),$$

where $\beta \in (0,1)$ is the discount factor, c_t is a consumption index, M_t is holdings of nominal money balances, p_t is price of the consumption good, and h_t denotes hours of work or employment. The consumption index is given by

$$c_t \equiv \left(\int_0^1 c_t(i)^{1-\frac{1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}},$$

where $c_t(i)$ is a quantity of good i consumed by the household in period t and ε is demand elasticity of substitution.

Assume that the single period separable utility function takes the form

$$U(c_{t+k}, m_{t+k}, h_{t+k}) = \ln c_{t+k} + \sigma \ln m_{t+k} + \nu \ln(1-h_{t+k}) \ .$$

Households allocate its consumption expenditures among different goods and this requires consumption index c_t must be maximized for any level of expenditures $\int_0^1 p_t(i)c_t(i)di$, where $p_t(i)$ is the price of good i. This yields a set of demand equations

$$c_t(i) = \left(\frac{p_t(i)}{p_t} \right)^{-\varepsilon} c_t \qquad \text{for } i \in [0,1],$$

where $p_t = \left[\int_0^1 p_t(i)^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}$ is an aggregate price index. Furthermore this leads to

$$\int_0^1 p_t(i)c_t(i)di = p_t c_t,$$

which means that total consumption expenditures can be written as the product of the price and quantity indexes.

At period t, each household works, consumes, holds money and deposits its savings in a financial intermediary that pays the riskless rate of return. The period budget constraint takes the form

$$\int_0^1 p_t(i)c_t(i)di + M_t + D_{t+1} \le W_t h_t - T_t + R_t^n D_t + M_{t-1} + \boldsymbol{\Theta_t} \qquad \text{for } t = 0,1,2,...$$

with letters in caps representing the nominal variables. Households divide their revenue among the expenditure of consumption $\int_0^1 p_t(i)c_t(i)di$, money holdings , M_t, and deposits, D_{t+1}. They earn W_t nominal wage for h_t hours of working, and R_t riskless rate of return from D_t, which is deposited in financial intermediary at t-1. R_t^n is gross nominal interest rate. Households receive dividend, Θ, from ownership of firms and T_t is the lump sum taxes. Budget constraints in real terms can be written as follows, specifying the total consumption index as the product of price and quantity indexes

$$c_t + m_t + \frac{D_{t+1}}{P_t} \le w_t h_t - \frac{T_t}{P_t} + R_t^n \frac{D_t}{P_t} + m_{t-1}\frac{P_{t-1}}{P_t} + \frac{\Theta_t}{P_t} \qquad \text{for } t = 0,1,2,...$$

where all small letters are for real variables.

Household chooses $\{c_t, m_t, h_t, D_{t+1}\}$ to maximize the expected lifetime utility subject to the budget constraints. The first-order conditions for optimality are

$$w_t = \nu \cdot c_t \frac{1}{1-h_t}, \qquad (1)$$

$$\frac{1}{c_t} = E_t\left\{\beta \frac{1}{c_{t+1}}\right\} R_{t+1},, \qquad (2)$$

$$m_t = \sigma \cdot c_t \left(\frac{R^n_{t+1} - 1}{R^n_{t+1}}\right)^{-1}, \qquad (3)$$

where R^n_t is the gross nominal interest rate, i.e.,

$$R_{t+1} = R^n_{t+1} (\frac{P_{t+1}}{P_t})^{-1} \text{ and}$$

$m_t = M_t / P_t$, $w_t = W_t / P_t$, are real money balance and real wage respectively.

Log-linear equations of the optimality conditions are:

$$\hat{w}_t - \hat{c}_t = \hat{h}_t \cdot \frac{h}{1-h}, \qquad (1a)$$

$$\hat{c}_t = -\hat{r}_{t+1} + E_t\{\hat{c}_{t+1}\}, \qquad (2a)$$

$$\hat{m}_t = \hat{c}_t - \hat{r}^n_{t+1} \cdot \frac{1}{R-1}, \qquad (3a)$$

where all letters in hats are log deviations of the variables from its steady state values.

2.2. Production sectors

2.2.1. Entrepreneurs

As in Bernanke et al. (1999), entrepreneurs produce wholesale goods and borrow to finance the capital used in the production process. They purchase capital in each period for use in subsequent period thus the net worth and return on holding capital are determined on a period ahead.

(1). Optimum Production

Entrepreneurs produce y_t wholesale goods using household and entrepreneurial labor h_t, h^e_t and capital k_t. Here, assume that the production is constant returns to scale and impose that the entrepreneurial labor is fixed at unity. This allows to write the production function as an aggregate relationship. The aggregate production function is specified as

$$y_t = A_t k^{\alpha}_t (h^{\Omega}_t (h^e_t)^{1-\Omega})^{1-\alpha}$$

where aggregate output of wholesale goods, y_t, household labor, h_t, entrepreneurial labor, h_t^e, aggregate amount of capital purchased by entrepreneurs in period t-1, k_t, are all in real terms. A_t is a technology shock common to all entrepreneurs. It follows a stationary first-order autoregressive process

$$\log A_t = (1-\rho_a)\log A + \rho_a \log A_{t-1} + \varepsilon_t^a \qquad (4)$$

where $\rho_a \in (-1,1), A > 0$ is a constant, and ε_t^a is normally distributed with zero mean and standard deviation σ_a. Ω is the share of the income going to the household labor and in simulations, set Ω, equal to 0.99, therefore the modification of the standard production function has no significant effect on the result.

Each entrepreneur sells its output to retailers in a competitive market for a price that equals its nominal marginal cost $MC_t = p^w$. The relative price between wholesale and retail goods is the inverse of markup of retail goods over wholesale goods. Denoting the markup as x_t, the relative price of wholesale goods is $\frac{1}{x_t} = \frac{p_t^{wholesale}}{p_t} = \frac{MC_t}{p_t} = mc_t$, which implies that the relative price between wholesale and retail goods is equal to real marginal cost.

Entrepreneurs maximize their profits by choosing household labor, h_t, entrepreneurial labor, h_t^e ($h_t^e = 1$), and capital k_t subject to the production function. The first-order conditions for the optimization problem are:

$$mpc_t = \alpha mc_t \frac{y_t}{k_t} \qquad (5)$$

$$w_t = \Omega(1-\alpha) mc_t \frac{y_t}{h_t} \qquad (6)$$

$$y_t = A_t k_t^{\alpha} (h_t^{\Omega} (h_t^e)^{1-\Omega})^{1-\alpha} \qquad (7)$$

$$w_t^e = (1-\Omega)(1-\alpha) mc_t \frac{y_t}{h_t^e} \qquad (8)$$

where mpc_t is real marginal productivity of capital, mc_t is real marginal cost, w_t is real wage for household labor, w_t^e is real wage for entrepreneurial labor.

Related log-linear forms of the equations are:

$$\hat{mpc}_t = \hat{mc}_t + \hat{y}_t - \hat{k}_t \qquad (5a)$$

$$\hat{w}_t = \hat{mc}_t + \hat{y}_t - \hat{h}_t \qquad (6a)$$

$$\hat{y}_t = \hat{a}_t + \alpha \hat{k}_t + \Omega(1-\alpha)\hat{h}_t \qquad (7a)$$

$$\hat{w}_t^e = \hat{mc}_t + \hat{y}_t \qquad (8a)$$

(2). Financial accelerator mechanism

Entrepreneurs are assumed to be risk neutral and have a finite horizon for planning. Specifically each entrepreneur has a constant probability γ of surviving to the next period so his expected lifetime is $1/(1-\gamma)$. The assumption of finite horizons for entrepreneurs is intended to capture the phenomenon of ongoing births and deaths of firms, as well as to preclude the possibility that the entrepreneurial sector will ultimately accumulate enough wealth to be fully self financing. Entrepreneurs issue debt contracts to finance their desired capital stock in excess of net worth.

At period t, entrepreneurs purchase k_{t+1} capital to use in the next period t+1 at price q_t. Thus the cost of the purchased capital is $q_t k_{t+1}$. The capital acquisition is financed partly by their net worth, n_{t+1}, and by borrowing, $q_t k_{t+1} - n_{t+1}$ from financial intermediary. The financial intermediary obtains its funds from households deposits and faces an opportunity cost of funds between t and t+1 equal to the economy's riskless gross rate of return, R_t.

Bernanke et al (1999) assume the existence of an agency problem that makes external finance more expensive than internal funds as in the Townsend (1979). The financial intermediaries must pay a cost if they wish to observe an individual entrepreneurs' realized return on capital. This "auditing cost" is interpretable as the cost of bankruptcy including for example, auditing, accounting, and legal costs, as well as losses associated with asset liquidation and interruption of business. The entrepreneurs costlessly observe their output, which is subject to random outcome. Depending on the observed outcome, the entrepreneurs pay their debt or default. If they default, the financial intermediaries audit the loan and recover the project outcome, less monitoring cost. The monitoring cost is assumed to equal a proportion μ of the realized gross payoff to the firm's capital, $\omega^j R_{t+1}^k q_t k_{t+1}^j$ where ω^j is an idiosyncratic disturbance to firm j's return and it is a random variable, i.i.d across time and firms, with c.d.f, $F(\omega)$; and R_{t+1}^k is the ex post aggregate return to capital.

Bernanke et al (1999) solve a financial contract that maximizes the payoff of the entrepreneur, subject to the lender earning the required rate of return. Bernanke et al showed that- given parameter values associated with the cost of the monitoring the borrower, characteristics of the distribution of entrepreneurial returns, and the expected life span of firms- their contract implies an external finance premium $s(.)$, that depends on the entrepreneur's leverage ratio. The underlying parameter values determine the elasticity of the external finance premium with respect to the firm leverage.

The demand for capital:

As derived before, Cobb Douglas production implies that the rent paid to a unit of capital (=real marginal productivity of capital) in t+1 for wholesale good is:

$$mpc_{t+1} = \alpha mc_{t+1} \frac{y_{t+1}}{k_{t+1}}$$

The entrepreneurs' expected gross return to holding a unit of capital from t to t+1 can be written

$$E\left\{R_{t+1}^{k}\right\} = E\left\{\frac{mpc_{t+1} + q_{t+1}(1-\delta)}{q_t}\right\} \qquad (9)$$

where δ is the capital depreciation rate and $q_{t+1}(1-\delta)$ is the value of one unit of capital used in production at t+1 and the right hand side of the equation expresses the expected marginal return of capital.

Log-linear equation for expected return to capital is

$$E_t\{\hat{r}_{t+1}^{k}\} = (1-\eta)\, E_t\{\widehat{mpc}_{t+1}\} + \eta E_t\{\hat{q}_{t+1}\} - \hat{q}_t \qquad (9a)$$

where $\eta \equiv \dfrac{1-\delta}{1-\delta+\alpha \cdot mc \cdot y/k}$.

The supply of investment finance: Leverage ratio and the premium on external funds

From optimal contracting problem, as proven in BGG, there is a positive relationship between capital/wealth ratio, $\frac{qk}{n}$ and premium on external funds, R^k/R (see BGG (1999), AppendixA.3, Aggregate risk for more details). Denoting by $s_t = E\left\{R_{t+1}^{k}/R_{t+1}\right\}$ expected discounted return to capital (or can be called external finance premium: it is because in equilibrium the return to capital will be equated to the marginal cost of external finance), the relation for optimal capital purchases can be written in the form:

$$\frac{q_t k_{t+1}}{n_{t+1}} = \Psi(s_t) \qquad \text{where } \Psi(1)=1, \Psi'(.)>0.$$

Here, $s_t \geq 1$ is taken as given, because entrepreneurs purchase capital in competitive market in this case. This equation is the key relationship of the financial accelerator mechanism and it shows that capital expenditures by a firm are proportional to the net worth of the owner/entrepreneur, with a proportionality factor that is increasing in the expected discounted return to capital, s_t. From above, one can say that the external finance premium depends inversely on the share of the firm's capital investment that is financed by the entrepreneurs own net worth. Thus, the equation for expected return to capital can be written:

$$E\left\{\frac{R_{t+1}^{k}}{R_{t+1}}\right\} = s\left(\frac{n_{t+1}}{q_t k_{t+1}}\right), \text{ where } s_t = s\left(\frac{n_{t+1}}{q_t k_{t+1}}\right) \qquad (10)$$

Log-linear equation for the supply for investment is

$$E_t\left\{\hat{r}^k_{t+1}-\hat{R}_{t+1}\right\}=\psi E_t\left\{\hat{q}_t+\hat{k}_{t+1}-\hat{n}_{t+1}\right\},\ \text{where}\ \psi\equiv\frac{\Psi(\frac{R^k}{R})}{\frac{R^k}{R}\Psi'(\frac{R^k}{R})} \qquad (10a)$$

where ψ represents the elasticity of the external finance premium with respect to a change in the leverage ratio of entrepreneurs.

The external finance premium depends on the size of the borrower's leverage ratio. As $\frac{n_{t+1}}{q_t k_{t+1}}$ falls the borrower relies on uncollateralized borrowing to a larger extent to fund the project. Since this increases the incentive to misreport the outcome of the project, the loan becomes riskier and the cost of borrowing rises.

(3). Net worth

Aggregate entrepreneurial net worth evolves according to
reflects the premium for external finance. When the entrepreneurs fail, their net worth will be consumed.

$$(1-\gamma)v_t=c^e_t, \qquad (12)$$

Combining the above equations with (7) and imposing the condition that entrepreneurial labor is fixed at unity, yields a difference equation for net worth:

$$n_{t+1}=\gamma\left[R^k_t q_{t-1}k_t-\left(R_t+\frac{\mu\int_0^{\bar{\omega}_t}\omega dF(\omega)E_{t-1}R^k_t q_{t-1}k_t}{q_{t-1}k_t-n_t}\right)(q_{t-1}k_t-n_t)\right]+w^e_t;$$

$$n_{t+1}=\gamma v_t+w^e_t, \qquad (11)$$

where v_t denotes the entrepreneurial equity (wealth accumulated by entrepreneurs from operating firms) so that γv_t is equity held by entrepreneurs at t-1 who are still in business at t and w^e_t be the entrepreneurial wage. v_t is given by

$$v_t=R^k_t q_{t-1}k_t-\left(R_t+\frac{\mu\int_0^{\bar{\omega}_t}\omega dF(\omega)\cdot E_{t-1}R^k_t q_{t-1}k_t}{q_{t-1}k_t-n_t}\right)(q_{t-1}k_t-n_t).$$

Entrepreneurial equity equals gross earnings on holdings of equity from t-1 to t less repayment of borrowings. The ratio of default costs to quantity borrowed:

$$\frac{\mu\int_0^{\bar{\omega}_t}\omega dF(\omega)\cdot E_{t-1}R^k_t q_{t-1}k_t}{q_{t-1}k_t-n_{t-1}}$$

Log-linear equation for the net worth is

$$\hat{n}_{t+1} = \gamma R\left[\frac{k}{n}(\hat{r}_t^k - \hat{R}_t) + \hat{n}_t + \hat{R}_t + \frac{k}{n}(\frac{R^k}{R} - 1)(\hat{r}_t^k + \hat{q}_{t-1} + \hat{k}_t) - \frac{R^k}{R}\frac{k}{n}(E_{t-1}\hat{r}_t^k + \hat{q}_{t-1} + \hat{k}_t) \bullet D\right]$$
$$+ \frac{1}{n}(1-\Omega)(1-\alpha) y \cdot mc(\hat{mc}_t + \hat{y}_t); \qquad (11a)$$

where $D = \mu \int_0^{\bar{\omega}_t} \omega dF(\omega)$ is the steady-state ratio of monitoring cost.

For entrepreneurial consumption log-linearization yields

$$\hat{c}_t^e = \hat{n}_{t+1} + \frac{w^e}{n - w^e}(\hat{n}_{t+1} - \hat{w}_t^e) \qquad (12a)$$

Because the last term of the equation has a little effect on the equation, this implies that entrepreneurial consumption evolves proportionally to the net worth.

2.2.2. Capital Producers

(1). Aggregate capital stock

Let i_t denote the aggregate investment expenditure. Bernanke et al (1999) assumes that aggregate investment expenditure i_t yields a gross output of new capital goods $\Phi(\frac{i_t}{k_t})k_t$. Thus aggregate capital evolves according to

$$k_{t+1} = \Phi(\frac{i_t}{k_t})k_t + (1-\delta)k_t \qquad (13)$$

The log-linear equation for capital evolution is

$$\hat{k}_{t+1} = \delta\hat{i}_t + (1-\delta)\hat{k}_t \qquad (13a)$$

[Investment expenditure at steady state is $i = \Phi(\frac{i}{k})k = \delta k \Rightarrow \frac{i}{k} = \delta$]

(2). Optimization of capital producers

Assuming that there are increasing marginal adjustment costs in the production of capital, competitive capital producing firms produce new capital goods, $\Phi(\frac{i_t}{k_t})k_t$ with expenditures of investment, i_t and existing capital stock k_t. The adjustment cost is included to permit a variable capital price. Given the adjustment cost function, the price of a unit of capital in terms of the numeraire good, q_t, is given by

$$q_t = \left[\Phi'(\frac{i_t}{k_t})\right]^{-1} \qquad (14)$$

Log-linearization of capital adjustment cost equation is

$$\hat{q}_t = \chi(\hat{i}_t - \hat{k}_t), \qquad \text{where } \chi = -\frac{\Phi''(\frac{i}{k})}{\Phi'(\frac{i}{k})}\frac{i}{k} \qquad (14a)$$

Normalizing the adjustment cost function, the price of capital goods becomes unity in the steady state.

The quantity and the price of capital are determined in the market for capital. In the production sector, the entrepreneurial demand curve for capital is determined by the equation (8) and the first-order condition for the capital producer's profit maximization problem (13) gives the market's supply of capital.

2.3. Retailers and price setting:

To motivate sticky prices BGG modify the model to allow for monopolistic competition and costs of adjusting nominal prices. Assuming that the monopolistic competition occurs at the 'retail' level, let $y_t(i)$ be the quantity of output sold by retailer (i), measured in units of wholesale goods, and let $p_t(i)$ be the nominal price. Total final usable goods y_t are the following composite of individual retail goods

$$y_t \equiv \left(\int_0^1 y_t(i)^{1-\frac{1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

Corresponding price index is

$$p_t = \left[\int_0^1 p_t(i)^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}$$

With y_t given above, in the monopolistic framework, the demand curve facing each retailer is:

$$y_t(i) = \left(\frac{p_t(i)}{p_t} \right)^{-\varepsilon} y_t, \qquad (a)$$

where ε is a demand elasticity of goods. Retailer chooses the price $p_t(i)$, taking as given the demand curve (a) and the price of wholesale good p_t^w ($p_t^{wholesale} = \frac{p_t}{x_t}$).

They can change their prices only with probability of $(1-\theta)$ as in Calvo(1983). p_t^* is the price set by retailers and the retailer (i) chooses his prices to maximize expected discounted profits, which is given by:

$$\max_{\{p_t^*(i)\}} \sum_{k=0}^{\infty} \theta^k E_t \{ z_{t+k} D_{t+k}(i) / p_{t+k} \}$$

subject to: $y_{t+k}(i) = \left(\frac{p_t^*(i)}{p_{t+k}} \right)^{-\varepsilon} y_{t+k}$, (Demand function)

where retailers' nominal profit function is

$D_{t+k}(i) = (p_t^*(i) - MC_{t+k}^n) y_{t+k}(i)$, and $z_{t+k} = \beta^k (C_{t+k} / C_t)^{-\sigma} (p_t / p_{t+k})$

is stochastic discount factor for nominal payoffs. So, the first-order condition leads to

$$p_t^*(i) = \frac{\varepsilon}{\varepsilon - 1} \frac{\sum_{k=0}^{\infty} \theta^k E_t \left\{ z_{t,k} y_{t+k}(i) MC_{t+k} / p_{t+k} \right\}}{\sum_{k=0}^{\infty} \theta^k E_t \left\{ z_{t,k} y_{t+k}(i) / p_{t+k} \right\}} \quad (15)$$

Log-linearization for the first-order condition is

$$\hat{p}_t^*(i) - \hat{p}_{t-1} = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left\{ \hat{mc}_{t+k} + \hat{p}_{t+k} - \hat{p}_{t-1} \right\} \quad (15a)$$

Then aggregate price evolves according to

$$p_t = [\theta p_{t-1}^{1-\varepsilon} + (1-\theta)(p_t^*)^{1-\varepsilon}]^{1/1-\varepsilon} \quad (16)$$

Log-linearization around zero steady state is

$$\hat{\pi}_t = (1-\theta)(\hat{p}_t^*(i) - \hat{p}_{t-1}) \quad (16a)$$

New Keynesian Phillips Curve derives from the two equations above

$$\begin{cases} \hat{p}_t^*(i) - \hat{p}_{t-1} = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left\{ \hat{mc}_{t+k} + \hat{p}_{t+k} - \hat{p}_{t-1} \right\} \\ \hat{\pi}_t = (1-\theta)(\hat{p}_t^*(i) - \hat{p}_{t-1}) \end{cases} \Rightarrow \hat{\pi}_t = \beta E_t \{\hat{\pi}_{t+1}\} + \kappa \hat{mc}_t \quad (15b)$$

where $\kappa \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}$.

2.4. Completing the model

Resource constraint

General equilibrium resource constraint is given by

$$y_t = c_t + c_t^e + i_t + g_t + E_{t-1} R_t^k q_{t-1} k_t \cdot \mu \int_0^{\varpi} \omega dF(\omega) \quad (17)$$

where c_t^e is entrepreneurial consumption. Denoting the steady state ratio of monitoring cost as D,

$$E_{t-1} R_t^k q_{t-1} k_t \cdot \mu \int_0^{\bar{\omega}_t} \omega dF(\omega) = E_{t-1} R_t^k q_{t-1} k_t \cdot D$$

reflects aggregate monitoring costs.

Log-linear equation of the economy wide resource constraint is

$$\hat{y}_t = \frac{c}{y} \hat{c}_t + \frac{c^e}{y} \hat{c}_t^e + \frac{i}{y} \hat{i}_t + \frac{g}{y} \hat{g}_t + \frac{R^k k}{y} D(E_{t-1} \hat{r}_t^k + \hat{q}_{t-1} + \hat{k}_t) \quad (17a)$$

Government

Assume that the government expenditure follows simple first-order autoregressive process

$$\hat{g}_t = \rho_g \hat{g}_{t-1} + \varepsilon_t^g \qquad \text{where } \rho_g \in [0,1] \qquad (18a)$$

Monetary policy rule

A standard Taylor rule is as follows

$$\hat{r}_t^n = \rho \hat{r}_{t-1}^n + \rho_\pi \hat{\pi}_{t-1} + \varepsilon_t^{rn}, \qquad (19a)$$

All log linearized equations are summarized in Appendix1.

3. Model simulations

3.1. Model parametrization

In Bernanke et al. (1999) discount rate β is set equal to 0.99, implying the steady state quarterly riskless rate of $R = 1/\beta$, which equals to 1.01. Household labor supply elasticity, $\frac{1-h}{h}$, set equal to 3. The capital share, α, is 0.35, and household labor share, $(1-\alpha)(1-\Omega)$, is 0.64. Thus, the share of income accruing to entrepreneurs' labor, $1-\Omega$, is equal to 0.01. The parameter ε that measures the degree of retailers' monopoly power is set equal to 6, implying steady state price markup of 20%, a common value used in the literature. The quarterly depreciation rate, δ is assigned the commonly used values of 0.025. Retailers' index of price stickiness (probability that a firm does not change its price within a given period), θ, is equal to 0.75, implying that the average period between price adjustments is four quarters. Finally, the survival rate of entrepreneurs, γ, is set to be 0.9728. The steady-state share of government expenditures in total output, g/y, is 0.2, the approximate historical average. At steady state gross inflation rate, π, is equal to 1 which matches the historical average over the sample period in estimation and a ratio of capital to net worth, k/n, is 2 or leverage ratio defined as the ratio of debt to assets of 0.5. The steady-state values of a risk spread, $r^k - R$, equal to two hundred basis points(0.02), implying the steady-state external finance premium, $s(.)$, is equal to 1.0198. Table1 reports the parameter values and Table2 shows the steady-state values of some variables. The serial correlation parameters for the technology and government expenditure shocks, ρ^a and ρ^g, are assumed to be 1.0 and 0.95, respectively. Autoregressive parameter, ρ, to 0.9 and the coefficient on inflation equal to 0.11(implying a long-run rise in the nominal interest rate of one hundred and ten basis points in response to a permanent one hundred basis point increase in inflation.).

As in Bernanke et al (1999), values of the elasticity of external finance premium, ψ, and capital adjustment cost parameter, χ are set to 0.05 and to 0.25, respectively as in the literatures.

Table1. Parameters

	Parameters	Definition	Values
1	β	Discount factor	0.99
2	Ω	Share of income for household labor	0.99
3	α	Capital share of production	0.35
4	ε	Demand elasticity of substitution	6
5	γ	Survival rate of entrepreneurs	0.9728
6	δ	Capital depreciation rate	0.025
7	θ	Index of price stickiness	0.75
8	χ	Capital adjustment parameter	0.25

Table 2.Steady state values

	Variables	Definition	Values
1	g / y	Share of government expenditures in total output	0.2
2	π	Gross inflation rate	1
3	k / n	Capital/ net worth ratio	2
4	$r^k - R$	Risk spread	0.02
5	$\left(\frac{h}{1-h}\right)^{-1}$	Elasticity of labor supply	3

3.2. Results

Simulations are performed in Dynare. There are 3 types of aggregate shocks.

1. A monetary policy shock
2. A technology shock
3. A government expenditure shock

Impulse responses of the variables to these shocks are considered in two ways, by including and excluding financial accelerator mechanism to have the answer of do the financial accelerator mechanism has a role in the dynamics of the macro economic variables. Inclusion and exclusion of the financial accelerator mechanism is implemented by switching on ($\psi = 0.05$) and off ($\psi = 0$) the elasticity of external finance premium. BGG considers a monetary policy shock, specifically an unanticipated exogenous movement in the short term interest rate. The responses of all variables are similar in the versions of the model with financial accelerator and without financial accelerator and their plots virtually coincide when monetary policy shock occurs. Following this shock, the nominal interest rate rises and output, consumption, hours fall sharply on impact in the three models. Inflation fall leads the real interest rate to rise and risk premium, net worth, investment and capital price to fall sharply.

Figure1 shows impulse responses of variables to a technology shock. When technology shock is present, leads output and consumption to rise sharply and then to decline slowly to the steady state. An increase in output leads the Fed to raise the nominal interest rate and inflation, in instance net worth and risk premium rises but soon fall sharply. Because of the excess of output (product) in the economy, hours, investment and capital price first to rise and decline. The financial accelerator mechanism dampens the responses of capital price, investment and output but amplifies net worth.

Figure2 plots the impulse response to a 1% positive shock in government spending. There is a little impact of the financial accelerator on output, consumption, hours, interest rate, risk premium. In contrast, the presence of financial accelerator has the effects on net worth, investment and capital price. The financial accelerator amplifies the effects of government spending shock to investment, capital price and net worth.

Figure1. Shock to a technology

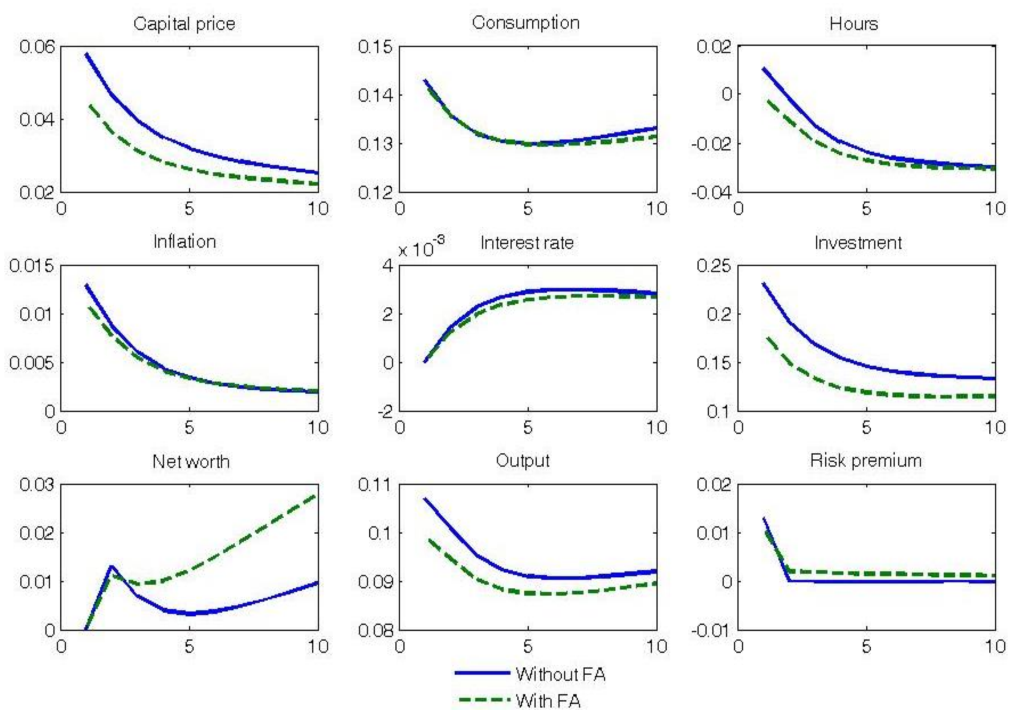
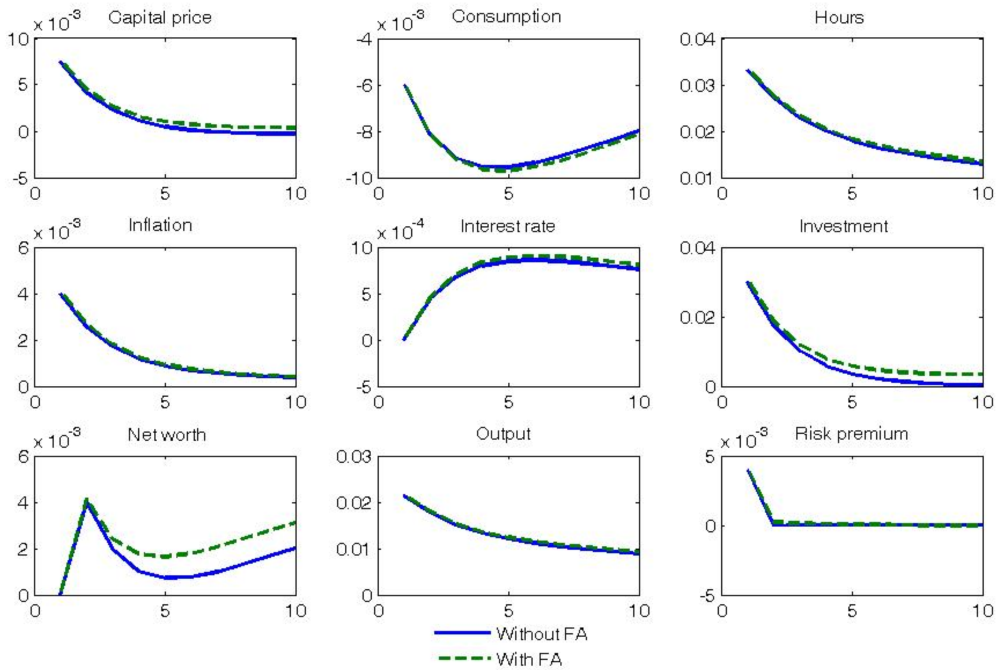


Figure2. Government shock



4. Conclusion

In this thesis, I simulated DSGE model with financial accelerator as in BGG to affirm that financial accelerator mechanism has an effect to the macroeconomic variables' dynamics and thus the economy as whole. In the studies of dynamic models considering credit market frictions and choosing its variables were some kind of complicated. So that, investigations including credit market frictions are long ignored in consequence of the fact of simplification as well as the Modigliani-Miller theorem. Bernanke, Gertler, Gilshricht (1999) (BGG) has demonstrated that financial frictions may significantly amplify the magnitude and the persistence of fluctuations in economic activity.

The results show that whether the presence of financial accelerator mechanism, as proposed by Bernanke et al(1999), significantly amplifies and propagates the impact of shocks depends on the shock type. As for the responses of monetary policy shock, financial accelerator has no significant effects on the dynamics; when the technology shock occurs the external finance premium dampens the effects of the shock. If there is a government spending shock in the economy, the presence of financial accelerator amplifies and propagates the effects of the shock in some extend.

The later investigation should be the estimation of the parameters, especially the external finance premium and capital adjustment, are of interest.

AppendixA: Loglinear equilibrium system

1. $\hat{w}_t - \hat{c}_t = \hat{h}_t \cdot \frac{h}{1-h}$,

2. $\hat{c}_t = -\hat{r}_{t+1} + E_t\{\hat{c}_{t+1}\}$,

3. $\hat{m}_t = \hat{c}_t - \hat{r}^n_{t+1} \cdot \frac{1}{R-1}$,

4. $\hat{mpc}_t = \hat{mc}_t + \hat{y}_t - \hat{k}_t$;

5. $\hat{w}_t = \hat{mc}_t + \hat{y}_t - \hat{h}_t$

6. $\hat{y}_t = \hat{a}_t + \alpha \hat{k}_t + \Omega(1-\alpha)\hat{h}_t$; when $(h_t^e)^\Omega = 1$

7. $\hat{w}_t^e = \hat{mc}_t + \hat{y}_t$; when $(h_t^e)^\Omega = 1$

8. $\hat{a}_t = \rho_a \hat{a}_{t-1} + \varepsilon_t^a$,

9. $E_t \hat{r}^k_{t+1} = (1-\eta)E_t \hat{mpc}_{t+1} + \eta E_t \hat{q}_{t+1} - \hat{q}_t$ where $\eta \equiv \frac{1-\delta}{1-\delta+\alpha \cdot mc \cdot y/k}$

10. $E_t\left\{\hat{r}^k_{t+1} - \hat{R}_{t+1}\right\} = \psi E_t\left\{\hat{q}_t + \hat{k}_{t+1} - \hat{n}_{t+1}\right\}$ where $\psi \equiv \frac{\Psi(\frac{R^k}{R})}{\frac{R^k}{R}\Psi'(\frac{R^k}{R})}$;

11.

$$\hat{n}_{t+1} = \gamma R\left[\frac{k}{n}(\hat{r}^k_t - \hat{R}_t) + \hat{n}_t + \hat{R}_t + \frac{k}{n}(\frac{R^k}{R} - 1)(\hat{r}^k_t + \hat{q}_{t-1} + \hat{k}_t) - \frac{R^k}{R}\frac{k}{n}(E_{t-1}\hat{r}^k_t + \hat{q}_{t-1} + \hat{k}_t) \bullet D\right]$$

$$+\frac{1}{n}(1-\Omega)(1-\alpha)ymc(\hat{mc}_t + \hat{y}_t); \qquad D = \mu\int_0^{\bar{\omega}_t} \omega dF(\omega)$$

12. $\hat{c}^e_t = \hat{n}_{t+1} + \frac{w^e}{n-w^e}(\hat{n}_{t+1} - \hat{w}^e_t)$

13. $\hat{k}_{t+1} = \delta\hat{i}_t + (1-\delta)\hat{k}_t$

14. $\hat{q}_t = \chi(\hat{i}_t - \hat{k}_t)$

15. $\hat{\pi}_t = \beta E_t\{\hat{\pi}_{t+1}\} + \kappa \hat{mc}_t$ where $\kappa \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}$

16. $\hat{y}_t = \frac{c}{y}\hat{c}_t + \frac{c^e}{y}\hat{c}_t^e + \frac{i}{y}\hat{i}_t + \frac{g}{y}\hat{g}_t + \frac{R^k k}{y} D(E_{t-1}\hat{r}_t^k + \hat{q}_{t-1} + \hat{k}_t)$

17. $\hat{g}_t = \rho_g \hat{g}_{t-1} + \varepsilon_t^g$

18. $\hat{r}_t^n = \rho \hat{r}_{t-1}^n + \rho_\pi \hat{\pi}_{t-1} + \varepsilon_t^{rn}$,

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