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Research Report

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Credit Constraints and Aggregate Economic Activity Over the Business Cycles

Tamar Giorgadze and Aleksandar Vasilev

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Abstract

The paper examines that imperfections in financial markets are themselves a source of macroeconomic fluctuations. Small, temporary shocks to technology or income distribution can generate large fluctuations in output and asset prices and spill over to other sectors. The work is based on the original model by Kiyotaki and Moore (1997). This paper will simulate a one-unit technology shock and study the propagation through the credit channel, evaluating its quantitative impact. While in the Kiyotaki – Moore model there is a linear production function used, I will try to do the derivation using the non-linear function and analyze how it changes the previously obtained result.

Key words: Credit cycles; business cycles; collateralized debt; borrowing constraint; aggregate fluctuations.

1 Introduction and Motivation

The credit cycle is the expansion and contraction of access to credit over the time. Some economists regard credit cycles as the fundamental process driving the business cycle and economic development. The literature on the interaction between financial structure and aggregate fluctuations goes back to the time of the Great Depression. The simultaneous collapse of the financial system and the destruction of the real economic activity attracted the attention of economists. One of the determinants of credit cycles is risk – the higher the risk, the lower the borrowing and investment. Banks then tighten lending requirements and raise interest rates. This is due to the higher risk of borrower default. Ultimately, this cuts down the available credit pool, which brings the credit cycle to the low access point.

There are some good reasons why the researcher should be interested in the theories of credit cycles (Semerak, 2001).

Some of the researchers suggest that business cycle models typically rely on large exogenous shocks to explain fluctuations in aggregate output. This approach is often criticized because shocks of the required magnitude are hard to find in the data (Summers 1986, Cochrane 1994). As Kiyotaki and Moore (1997) and Kiyotaki (1998) suggest in their work, when debts need to be fully secured by collateral, say land, and the collateral is also an input in production, then a small shock to the economy can be largely amplified. For example, if at time t the productivity shock causes a decrease of constrained firms' net worth, therefore they decrease investment in land in period t and in the following periods (Kiyotaki 1998). In order to restore land market equilibrium, the unconstrained firms user cost is anticipated to fall in each period, this event causes a decrease in the land price in period t . The fall in land prices causes the constrained firms' net worth to decrease further. As a result of this research, the overall effect can

be dramatic.

The goal of this project is to follow closely and extend the original model derived by Kiyotaki and Moore (1997), but perform additional diagnostics of the model, what happens when one of the agents have non-linear production function and how is it different from the result obtained in the original model.

2 The Basic Model

The result I am expecting to get is to show that small shocks to the economy might be increased by credit restrictions, giving rise to large output fluctuations, assuming the borrowers cannot be forced to repay unless the debt is collateralized. In order to obtain the desirable result, I will estimate the linearized version of Kiyotaki and Moore's (1997) credit cycle model. It illustrates the role of debt, net worth and asset price fluctuations on equilibrium output (Kasa, 1998).

There are two sectors in the model – farmers (productive) and gatherers (unproductive), both of them are risk neutral and they discount the future differently (discount factor for gatherers is bigger than the one for farmers). This assumption guarantees that in equilibrium farmers will not want to postpone production because they are relatively impatient (Kiyotaki, 1997). “ One sector is subject to borrowing constraints, i.e., investment must be fully backed by the collateral. The other sector is unconstrained and acts as a buffer, i. e., it provides an alternative use for the collateralized asset” (Kasa, 1998). The amount farmers can borrow is restricted. The idea behind it is that if farmers cannot repay their debt back, it needs to be backed by the collateral, the price of which determines the amount borrowed. The greater the value of collateral land, the greater the amount they can borrow.

The model represents discrete time economy with two goods, a durable asset and nondurable commodity:

Land – is used as a durable asset, with a fixed total supply and does not depreciate with time. And since the total land supply is fixed, aggregate investment is automatically zero.

Fruit – is used as an “outcome” of land, a nondurable commodity, which cannot be stored.

Several assumptions make the model simple: As it was mentioned above, dis-

count factor for gatherers is bigger than the one for farmers. Second assumption ensures that in equilibrium the farmer will not want to consume more than the bruised fruit: the return from farming, is high enough that all tradable output is used to invest (Kiyotaki and Moore also state in their work that removing those two assumptions and modeling the economy in an OLG framework does not change the final result).

Both of the agents in the model are risk neutral. c_t denotes their consumption, q_t is the price of land and E_t is their expected utility at time t . The production functions are given by the following formula: $y_t = A_t h_{t-1}^\nu$ for productive agents and $y'_t = A'_t h_{t-1}^{\mu'}$ for unproductive. First thing that needs to be done is to maximize utilities of both agents at time t , assuming that the discount factor for farmers - γ is less than the one for gatherers - β .

Gatherers

$$\max E_0(\sum_{t=0}^{\infty} \beta^t c'_t)$$

$$\text{s.t. } c'_t + q_t h'_t + R b'_{t-1} = y'_t + q_t h'_{t-1} + b_t$$

Expressing c'_t from the constraint $c'_t = y'_t + q_t h'_t + b'_t - q_t h'_{t-1} - R b'_{t-1}$ and plugging it into the utility formula I get:

$$L = E_0 \sum_{t=0}^{\infty} \beta^t (y'_t + q_t h'_{t-1} + b'_t - q_t h'_{t-1} - R b'_{t-1})$$

I take the first order derivatives with respect to b_t and h_t .

$$E_{t+1} \beta^{t+1} (y'_{t+1} + q_{t+1} h'_t + b'_{t+1} - q_{t+1} h'_{t+1} - R b'_t) + E_t \beta^t (y'_t + q_t h'_{t-1} + b'_t - q_t h'_{t-1} - R b'_{t-1})$$

With respect to h'_t :

$$-E_t \beta^t q_t + E_t \beta^{t+1} (q_{t+1} + \mu \frac{y'_{t+1}}{h'_t}) \text{ where } \frac{y'_{t+1}}{h'_t} = A'_{t+1} h'_t{}^{\mu-1}$$

$$q_t = E_t \beta (q_{t+1} + \mu \frac{y'_{t+1}}{h'_t})$$

With respect to b_t :

$$E_t \beta^t - E_t \beta^{t+1} R = 0$$

$$\beta^t = \beta^{t+1} R$$

$$1 = \beta R$$

Farmers

$$\max E_0 \left(\sum_{t=0}^{\infty} \gamma^t c_t \right)$$

$$\text{s.t } c_t + q_t h_t + R b_{t-1} = y_t + q_t h_{t-1} + b_t, R b_t \leq m E_t (q_{t+1} h_t)$$

$$c_t = y_t + q_t h_{t-1} + b_t - q_t h_t - R b_{t-1}$$

$$L = E_0 \sum_{t=0}^{\infty} \gamma^t (y_t + q_t h_{t-1} + b_t - q_t h_t - R b_{t-1}) - \lambda_t (R b_t - m q_{t+1} h_t)$$

FOC with respect to b_t :

$$E_{t+1} \gamma^{t+1} (y_{t+1} + q_{t+1} h_t + b_{t+1} - q_{t+1} h_{t+1} - R b_t) - \lambda_{t+1} (R b_{t+1} - m q_{t+2} h_{t+1}) +$$

$$E_t \gamma^t (y_t + q_t h_t + b_t - q_t h_t - R b_{t-1}) - \lambda_t (R b_t - m q_{t+1} h_t)$$

$$- E_{t+1} \gamma^{t+1} R + E_t \gamma^t - \lambda_t R$$

$$- \gamma^{t+1} R + \gamma^t - \lambda_t R$$

$$\gamma^t = \gamma^{t+1} R + \lambda_t R$$

$$1 = \gamma R + \lambda_t R$$

With respect to h_t :

$$\gamma^{t+1} E_{t+1} A_{t+1} \nu h_t^{\nu-1} + E_{t+1} q_{t+1} + \lambda_t m q_{t+1}$$

$$\gamma^t E_t q_t = \gamma^{t+1} E_{t+1} \frac{y_{t+1}}{h_t} \nu + \gamma^{t+1} E_{t+1} q_{t+1} + \lambda_t m q_{t+1}$$

$$q_t = \gamma E_t \left(\frac{y_{t+1}}{h_t} \nu + q_{t+1} \right) + E_t (\lambda_t m q_{t+1})$$

The last equation can be transformed as follows:

$$q_t = \gamma E_t q_{t+1} + E_t \lambda_t m q_{t+1} + \gamma E_t \nu \frac{y_{t+1}}{h_t}$$

$$q_t = E_t q_{t+1} (\gamma + \lambda_t m) + \gamma E_t \nu \frac{y_{t+1}}{h_t}, \quad 1 = \gamma R + \lambda_t R, \quad \lambda_t R = 1 - \gamma R, \quad \lambda = \frac{1 - \gamma R}{R} =$$

$$\frac{1}{R} - \gamma = \beta - \gamma$$

$$q_t = E_t q_{t+1} (\gamma(1 - m) + m\beta) + \gamma \nu E_t \frac{y_{t+1}}{h_t}$$

Collecting all the equations we get the following system:

$$c'_t + q_t h'_t + Rb'_{t-1} = y'_t + q_t h'_{t-1} + b'_t \quad (1)$$

$$c_t + q_t h_t + Rb_{t-1} = y_t + q_t h_{t-1} + b_t \quad (2)$$

$$q_t = E_t q_{t+1} (\gamma(1-m) + m\beta) + \gamma\nu E_t \frac{y_{t+1}}{h_t} \quad (3)$$

$$q_t = \beta E_t (q_{t+1} + \mu \frac{y'_{t+1}}{h'_t}) \quad (4)$$

$$Rb_t = m E_t (q_{t+1} h_t) \quad (5)$$

Together with the market clearing conditions we can solve it for the steady state values of all the parameters.

$$h_t + h'_t = 1 \quad (6)$$

$$b_t + b'_t = 0 \quad (7)$$

$$y_t = A_t h_{t-1}^\nu \quad (8)$$

$$y'_t = A'_t h'_{t-1} \quad (9)$$

Setting $\phi = m\beta + (1-m)\gamma$ we can transform equation (3) as follows:

$$q_t = \phi E_t q_{t+1} + \gamma\nu E_t A_{t+1} h_t^{\nu-1}$$

Since, in this case $\nu = 1$, $h_t^{\nu-1}$ also equals 1 and we simplify the equation for q_t as follows:

$$q_t = \phi E_t q_{t+1} + \gamma E_t A_{t+1} \quad (3)$$

$$q = \phi q + \gamma A$$

$$q = \frac{\gamma A}{(1-\phi)} \quad (\text{SS value of } q)$$

Modifying equation (4):

$$q_t = \beta E_t q_{t+1} + \beta \mu E_t A'_{t+1} (1 - h_t)^{\mu-1} \text{ using the property (6).}$$

Obtaining the SS value for h from (4):

$$\begin{aligned} q_t - \beta E_t q_{t+1} &= \beta \mu E_t \frac{A'_{t+1}}{(1-h_t)^{1-\mu}} \\ q(1-\beta) &= \frac{\beta \mu A'}{(1-h)^{1-\mu}} \\ (1-h)^{1-\mu} &= \frac{\beta \mu A'}{q(1-\beta)}, \text{ where } q = \frac{\gamma A}{1-\phi} \\ (1-h)^{1-\mu} &= \frac{\beta \mu A' (1-\phi)}{\gamma A (1-\beta)} \\ 1-h &= \left(\frac{\beta \mu A' (1-\phi)}{\gamma A (1-\beta)} \right)^{\frac{1}{1-\mu}} = h' \end{aligned}$$

Next step is to define marginal product of land used in both sectors, MPK.

In farming sector it is simply equal to A , but in the gatherer's sector it is:

$$\begin{aligned} q &= \beta q + \beta MPK \\ q(1-\beta) &= \beta MPK \\ MPK &= \frac{q(1-\beta)}{\beta} = \frac{\gamma A (1-\beta)}{\beta (1-\phi)} \end{aligned}$$

Obtaining SS value for b :

$$\begin{aligned} Rb_t &= m E_t q_{t+1} h_t \\ b &= \frac{m q h}{R} = \frac{m q h}{\frac{1}{\beta}} = \beta m q h \end{aligned}$$

SS value for c :

$$\begin{aligned} c_t + q_t h_t + Rb_{t-1} &= y_t + q_t h_{t-1} + b_t \\ c + qh + Rb &= y + qh + b \\ c &= y + b - Rb = y + b(1-R) = y - b(R-1) = Ah - (R-1)mqh = \\ Ah - (1-\beta)mh \frac{\gamma A}{1-\phi} &= Ah \left(1 - \frac{m\gamma(1-\beta)}{1-\phi} \right) \end{aligned}$$

SS value for c' :

$$\begin{aligned} c'_t + q'_t h'_t + Rb'_{t-1} &= y'_t + q'_t h'_t + b'_t \\ c' + qh' + Rb' &= y' + qh' + b' \\ c' &= y' + b' - Rb' = y' + b'(1-R) = y' - b'(R-1) = y' + b(R-1) \text{ using} \end{aligned}$$

that $b + b' = 0$

Linearizing the equations:

(5)

$$Rb_t = mE_t q_{t+1} h_t$$

$$\ln R + \ln b_t = \ln m + \ln E_t q_{t+1} + \ln h_t$$

$$\frac{d \ln b_t}{dt} = \frac{d \ln E_t q_{t+1}}{dt} + \frac{d \ln h_t}{dt}$$

$$\frac{1}{b_t} \frac{db_t}{dt} = E_t \frac{1}{q_{t+1}} \frac{dq_{t+1}}{dt} + \frac{1}{h_t} \frac{dh_t}{dt}$$

$$\hat{b}_t = E_t \hat{q}_{t+1} + \hat{h}_t$$

(1)

$$c_t + q_t h_t + Rb_{t-1} = y_t + q_t h_{t-1} + b_t$$

$$\frac{d \ln}{dt} (c_t + q_t h_t + Rb_{t-1}) = \frac{d \ln}{dt} (y_t + q_t h_{t-1} + b_t)$$

$$\frac{1}{c_t + q_t h_t + Rb_{t-1}} \frac{d(c_t + q_t h_t + Rb_{t-1})}{dt} = \frac{1}{y_t + q_t h_{t-1} + b_t} \frac{d(y_t + q_t h_{t-1} + b_t)}{dt}$$

$$\frac{dc_t}{dt} + \frac{dq_t}{dt} h_t + \frac{dh_t}{dt} q_t + R \frac{db_{t-1}}{dt} = \frac{dy_t}{dt} + \frac{dq_t}{dt} h_{t-1} + \frac{dh_{t-1}}{dt} q_t + \frac{db_t}{dt}$$

$$c \hat{c}_t + q h \hat{q}_t + q h \hat{h}_t + R b \hat{b}_{t-1} = y \hat{y}_t + q h \hat{q}_t + q h \hat{h}_{t-1} + b \hat{b}_t$$

$$c \hat{c}_t = y \hat{y}_t + q h (\hat{h}_{t-1} - \hat{h}_t) + b (\hat{b}_t - R \hat{b}_{t-1})$$

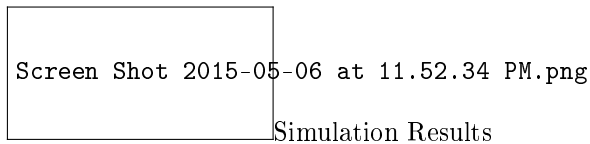
(3)

$$q_t = \phi E_t q_{t+1} + \gamma E_t A_{t+1}$$

$$\ln q_t = \ln \phi E_t q_{t+1} + \ln \gamma E_t A_{t+1}$$

$$\frac{1}{q_t} \frac{dq_t}{dt} = \phi E_t \frac{1}{q_{t+1}} \frac{dq_{t+1}}{dt} + \gamma E_t \frac{1}{A_{t+1}} \frac{dA_{t+1}}{dt}$$

$$\hat{q}_t = \phi E_t \hat{q}_{t+1} + \gamma E_t \hat{A}_{t+1}$$



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Figure 1: Simulation Results

3 Conclusion

The idea is to show that credit market imperfections might amplify the effects of given shocks to the economy. The model demonstrates that an increase in the asset prices implies that the creditor will be able to recover more from selling the asset whenever the debtor defaults, therefore for each asset price increase he is willing to supply more credit (Iakoviello, 41). This model says that when a shock hits, it is late to renegotiate therefore repayments are the same, but current borrowing increases.

As a result, if we plot the graph for the cycles following the code by Kato, it is easy to see that the price of the land hits its peak at the time of the shock.

4 Literature Review

The major guiding paper for the thesis is “Credit Cycles” by Kiyotaki and Moore (1997). This paper is a theoretical study of how credit constraints interact with aggregate economic activity over the business cycles. The model determines how small, temporary shocks to technology might generate large fluctuations in output and income distribution. The model is constructed based on the following assumption: credit constraints arise naturally because lenders cannot force the borrowers to repay their debt unless the debt is collateralized. The authors discuss two types of multiplier effect – static and dynamic. Throughout the paper, they make some unorthodox assumptions about preferences and technologies. As a result, it is shown that the land price hits its peak at the time of shock. Their model itself is based on the original work of Bernanke and Gertler (1989) who constructed the overlapping generation model in which financial market imperfections cause temporary shocks in net worth.

The paper “Borrowing Constraints and Asset Market Dynamics” by Kenneth Kasa estimates the linearized, stochastic version of Kiyotaki and Moore’s model, using the land price data from Japan and Korea. His model features two sectors. In one sector, investment is fully backed up by the collateral. The other one is unconstrained and is provides alternative use for the collateralized asset (Kasa, 17). It suggests that the cost of borrowing constraints are positively related to the persistence of land price fluctuations. He models trends and cycles simultaneously. As a result, he suggests that factors causing growth can have important cyclical consequences and the land price can be approximated by an AR(1) process, where the AR coefficient depends positively on the importance of borrowing constraints.

Another major paper used for my research is “Endogenous Credit Cycles” by Alberto Martin. He states that absent any type of shocks, imperfections

in financial markets are themselves a source of macroeconomic fluctuations. And as a main result, he obtains that despite the absence of exogenous shocks; the economy can exhibit fluctuations that are purely generated by changes in lending standards. Differently from the existing literature, his environment can be consistent with two widely accepted empirical regularities: greater net worth of borrowers leads on average to greater investment, and net worth is pro-cyclical.

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