SONG, XUETAO. Three Essays in Macroeconomics and Finance. (Under the direction of Dr. Ivan Kandilov and Dr. Douglas Pearce.)

In Chapter 1, we construct a DSGE model consistent with China’s local government’s “land sale–debt financing–infrastructure investment” cycles. Policy triggered land price changes drive reallocation of capital and lands between private and public sectors, which are heterogeneous in TFP and financial frictions. Credit policies in this model are implemented as shocks to borrowing constraints for borrowers and lending constraints for lenders. Collateral constraints amplify the responses to policy shocks and resource reallocations between sectors. This paper finds that if local government debt is restricted by land collateral, fiscal stimuli of government spending on public goods (e.g. infrastructure investment) has little impact on land price, but crowds in the private sector output. If local government debt is not constrained, fiscal stimuli would lead to resource misallocation, capital overcapacity, and a negative fiscal multiplier. Moreover, given asymmetric TFP and financial frictions in two sectors, a relaxation in private borrowing constraint contributes more to growth in output and investment than a same percentage of relaxation in public borrowing constraint. If a bank looses lending constraints (i.e. required reserve ratio), the private sector would be crowded out by the public and would result with an overcapacity of capital.

In Chapter 2, we observe that after the recent financial crisis, employment and wages recovered slowly, and working hours were extended. We construct a model with labor market search and financial frictions to study the importance of the financial market to labor market fluctuations and to account for the observed slow recovery in the labor market after the credit crunch. In the model, wages and employment are determined at both intensive and extensive margins. The model shows why the post-2009 recovery has greater joblessness than the previous two recoveries and reproduces jobless recovery after a credit crunch. Quantitative results match the stylized facts in the labor market and reproduce important labor market properties over the business cycle.

In Chapter 3, we document facts about China’s outward foreign direct investment in the last decade (2004-2013): diverging growth in inward and outward FDI; faster growth of China’s outward FDI to developed economies than to developing economies during the post-crisis period; and the asymmetric effect of international business cycles on outward FDI before and after the crisis. These facts challenge the existing literature that focused on the link between the development and FDI but ignored how international business cycles can change the pattern of FDI flows. By adopting an empirical approach, this paper attempts to bridge the study of inward and outward FDI with the study of international business cycles. In this paper, we investigate
the link between flow of FDI and international business cycles using panel estimation with data on bilateral FDI and macroeconomic conditions. The empirical evidence suggests that China’s pattern of FDI flow is changing remarkably after the crisis and is a result of not only Chinese but also international business cycles.
Three Essays in Macroeconomics and Finance

by

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APPROVED BY:

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Dr. Ivan Kandilov              Dr. Douglas Pearce
Co-chair of Advisory Committee Co-chair of Advisory Committee
DEDICATION

To my wife and my parents.
BIOGRAPHY

The author was born in 1989 in Xi’an, China. He graduated from Xi’an Jiaotong University with a B.A. in economics in 2011, then entered into North Carolina State University for Ph.D. in economics in the same year. During the last year, he worked as a visiting scholar for the People’s Bank of China, a macroeconomist for Huatai Securities Corporation and for Tianfeng Securities Corporation. He is also a special invited researcher for the China Financial 40 Forum.
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Chapter 1

Slowdown, Stimuli and Real Estate Cycles of China

1.1 Introduction

The analysis of China’s 2014 GDP data that was released in the first quarter of 2015 focused on the slowdown which experienced the weakest growth rate in the past 24 years (7.4%) and is the first time in this century that China has ever failed to reach its official growth target (7.5%). This weaker growth rate should not cause concern. China’s economic size has remained large enough such that a slower growth now will generate more additional output than before. However, after a long-term boom (2003-2009 and 2011-2013) in the housing markets, China’s economy experienced a slump in fixed-asset investment and a decline in land prices (Figure 1.3 and Figure 1.4).

Land is developed and sold by the local government to finance off-budget infrastructure investments. As stated by Zhang and Barnett (2014)[85], infrastructure investment has become local government’s main strategy for improving the economy and has also become a countercyclical policy tool. Local infrastructure spending has been primarily financed either through land sales or Local Government Financing Vehicle (LGFV) borrowings, which is an implicit local government debt. Since land is a major input of infrastructure investment, the land sales-investment-growth cycle supports economy directly and causes land prices to fluctuate. Figure 1.3 shows that the time series of GDP, land price and public expenditure have moved together during the last decade. A cross correlation test in Figure 1.5 shows that land price leads real estate development, local government investment and comoves with output and public expenditure.

These facts and observations have raised questions to be answered:

(i) What impacts do local government land financing and debt financing models have on
Chinese economy?

(ii) Does local government’s spending on infrastructure investment help explain the Chinese real estate cycles and business cycles?

(iii) What effects do credit policies, i.e. changes in lending constraint and borrowing constraint, have on the real estate market, government finance, and macroeconomic dynamics?

This paper aims to answer the questions above by understanding the interplay between land market, local government policies and macroeconomic structure in China. Figure ?? displays the market structures and relationships between agents in the model. This paper builds a general equilibrium model in a closed economy with two production sectors which are heterogeneous in TFP and financial frictions. To match the model to reality, the public sector includes state owned enterprises (SOE) and infrastructure projects, which have lower TFP levels and easier access to financing resources. By contrast, the private sector is composed primarily of domestic
private enterprises (DPE), which have higher TFP levels and less access to the financial market. The explanation for these assumptions in heterogeneity of technology and financial frictions is provided in Chapter 3.

The local governments invest in public sector production e.g. infrastructure investment, and finance government spending through land sale and government debt. The local governments refinance their debt by issuing a local government bond $B_{g,t}$ at a discounted rate $R_t$, and repurchasing this bond issued in the last period at its par value $B_{g,t-1}$. Both capitalists and local governments face limited contract enforcement. Their debt is bound by a Kiyotaki-Moore type of collateral constraint. Land, capital and labor can be reallocated between the two sectors as land prices change. The collateral constraints of borrowing could amplify the model dynamics to shocks and the resource reallocations between sectors. To explicitly describe the transmission of fiscal stimuli to real estate price and output, Figure 1.2 displays the mechanism of the model.

The model is log-linearized near the deterministic steady states and calibrated to the annual Chinese data. Then the simulation of the model takes first-order approximation and is HP-filtered to be comparable with the data.

The paper has several important findings as follows:

(i) If the local government debt is constrained by the collateral value of its land holdings, an expansion in government spending on infrastructure would have little effect on the land
price, crowd out the private sector in the short run and crowd in the private sector in the long run.

(ii) A relaxation in private borrowing constraints contributes more to the output and investment than then a same percentage of relaxation in public borrowing constraint.

(iii) An increase in the reserve requirement ratio would drive up the borrowing cost of both private and public sectors. But the private sector would benefit from a lower land price that is driven by the tightening lending constraint shock. If the lending constraints are loosened, the private sector would be crowded out by the public sector because the local government has greater capacity to borrow and invest in infrastructure. There would also be an overcapacity of capital.

(iv) If local government debt is not constrained, an expansion in government expenditure will cause private sector crowd out in the short run and long run, as well as resource misallocation, capital overcapacity and losses in GDP.

The structure of this paper is organized as follows: Chapter 2 surveys the related literature; Chapter 3 introduces the backgrounds and empirical evidences of Chinese local government land financing and debt financing model; Chapter 4 constructs a baseline model and its equilibrium conditions; Chapter 5 includes the calibration of parameters and simulation method; Chapter 6 reports the impulse response results and Chapter 7 extends the model to solve several issues; Chapter 8 concludes the paper. The Appendix includes data source, the log-linearized system and the steady state system of the model.

1.2 Literature

This paper is related to several strands of literature that covers topics on the housing market and macroeconomy, monetary and fiscal stimulus, and capital misallocation and business cycles. The recent housing boom and bust and financial crisis have renewed the curiosity of economists of all stripes about the interplay of housing, finance and macroeconomics. A booming literature has been produced on these topics to jointly explain business cycle facts and real estate prices during the great housing boom and bust of the 2000-2010 decade. This list includes Davis and Heathcote (2005) [30], Iacoviello (2005) [49], Kiyotaki, Michaelides and Nikolov (2011) [53], and Liu, Wang and Zha (2013) [62]. Davis and Heathcote (2005) modeled shocks hitting the production of housing in the spirit of a simple two-sector model. Iacoviello (2005) followed the production section in Davis and Heathcote (2005) but featured a standard new Keynesian framework with an emphasis on the monetary policy transmission to housing markets. Liu, Wang and Zha (2013) captured the co-movement between land price and business investments
using a DSGE model with the constraint of a firm’s land collateral. Kiyotaki, Michaelides and Nikolov (2011) studied the interaction between borrowing constraints, housing prices and economic activity. They used a general equilibrium life-cycle model to study the implications of an unexpected increase in land’s share of housing in an environment where interest rates are set outside of the model. Davis and Nieuwerburgh (2014) [31] have created a very good survey of the recent literature in housing, finance and macroeconomics.

The second strand of literature analyzes the impacts of financial frictions on the TFP. This list includes Jermann and Quadrini (2007) [51], Buera, Kaboski and Shin (2011) [22], Miao and Wang (2012) [66], and Liu and Wang (2014) [61]. Buera, Kaboski and Shin (2011) assumed two production sectors with heterogeneous fixed costs and scales of operation in production. They discovered that financial frictions distort the allocation of capital across heterogeneous production units and also their entry/exit decisions, lowering aggregate and sector-level TFP. Miao and Wang (2012) assumed that idiosyncratic productivity shocks are attached to aggregate productivity level. They discovered that bubbles allow firms to relax credit constraints and more capital is allocated to more productive firms, leading to a rise in total factor productivity (TFP). The collapse of bubbles tightens the credit constraints and worsens investment efficiency, leading to a recession and a fall of TFP. Liu and Wang (2014) studied a model with productive and unproductive firms, the former of which face binding credit constraints. Thus, a drop in equity value tightens credit constraints and reallocates resources from productive to unproductive firms, generating a financial multiplier and self-fulfilling business cycles.

The third strand of literature analyzes government investment and fiscal multipliers. For example, Leeper, Walker and Yang (2010) [60] studied the effect of government investment as a fiscal stimulus by modeling the government investment as building public capital in production technology. They found that the implementation delays in a time-to-build model and the fiscal adjustment cost could result in government investment contraction in the long run. Traum and Yang (2013) [83] used an estimated New Keynesian model with monetary and fiscal policy interactions to examine when government debt crowds out investment. They found that higher debt can crowd in investment by cutting capital tax rates or increasing government investment. Therefore, whether investment is crowded in or out by government debt depends on which policy shock triggers the debt expansions.

The last strand of literature studies the housing market of China after the financial crisis in the U.S.. For example, Deng et al (2011) [32] studied the impacts of monetary and fiscal stimuli on the housing market in China. Their data analysis found that much of the public investment that was operated by SOEs was highly leveraged purchases of real estate. They argue that China’s stimulus package may well have fueled a real estate bubble and induced costly resource misallocation. Zhang and Barnett (2014) constructed the augmented fiscal deficit and debt data of China. They claim that the practice of local governments financing infrastructure investment
from their off-balance land sales would increase fiscal vulnerabilities and risks. General equilibrium quantitative analysis in this field is scarce. Chang, Chen, Waggoner and Zha (2015) [23] constructed a set of core macroeconomic time series for China to be as consistent with the NIPA as possible. Their econometric analysis shows that monetary aggregates such as M2, as well as required reserves and the deposit rate, play a substantive role in both fluctuations and growth of aggregate output.

1.3 Background and Empirical Evidences

1.3.1 China’s Fiscal Stimulus

Although the recent financial crisis has generated substantial interest in understanding the links between the real estate market and the macroeconomy in the U.S., studies in terms of China have been scant. One possible reason is that right after the breakdown of the U.S. financial crisis in 2008 Q4, the Chinese central government reacted with an active fiscal stimulus package of 4 trillion-yuan ($586 billion) and a passive transformation in monetary policy from moderately tight to moderately loose. As a response, China’s annualized growth rate of fixed-asset investment increased from 20.3% in 2008 Q4 to 29.4% and 38% in Q1 and Q2 of 2009. Its annualized GDP growth rate reached 6.2%, 7.9%, 9.1% and 10.7% in the four quarters of 2009.
respectively and 11.9% in 2010 Q1.\(^1\) The annualized growth rate of land price increased from -0.2% in 2008 Q4 to 14.9%, -11.1%, 65.7%, and 35.9% in the four quarters of 2009 and 23.6% and 71.1% in 2010 Q1 and Q2. Therefore, the booms in the housing market and fixed-asset investment by fiscal stimuli might beg the question to what extent are these housing market boom-and-bust cycles consistent with fundamental conditions in China.

1.3.2 Chinese Local Government Land Financing Model

Land in China is initially developed by the local government. \(^2\) The revenue of sales of land use rights belongs to the local government and has become a key source of revenue for the local government as urbanization advances. For example, according to estimates of Zhang and Barnett (2014)[85], the local government earned a gross land sale revenue of 3.3 trillion Yuan ($520 billion) out of the 3.8 trillion Yuan in government managed funds revenue. The land sales revenues were then used to finance infrastructure investment to further support the urbanization process. However, as land is a major input of infrastructure investment, higher infrastructure spending supported investment directly and propagated land price indirectly. Thus, the land sales-investment-growth cycle not only bolstered the economy but also raised concerns about whether infrastructure investments crowd out other investments that use land as an input.

1.3.3 Local Government Debt Financing Model

As stated by Zhang and Barnett (2014)[85], Chinese local governments are not allowed to issue bonds directly unless approved by the State Council. Thus, in order to finance the off-budget government spending, local governments make recourse to local government financing vehicles (LGFVs) which are government-related entities to borrow from banks and corporate bond markets. Local governments inject land or property to provide capital to LGFVs, which is used as collateral for borrowing. Lu and Sun (2013)[63] discuss the function and risks of the local government financing vehicles in China. They found that local governments transfer land as collateral to help LGFVs to secure loans. Land could also provide future operating revenue for LGFVs when the land use rights are sold in the future.

1.3.4 Heterogeneity in Productivity and Borrowing Constraints

Extensive literature documents a higher TFP in domestic private enterprises (DPE) than in state owned enterprises (SOE). For example, Song, Storesletten and Zilibotti (2011)[82] estimate

\(^1\)The numbers of growth rate are from the estimates in Deng et al (2011)[32].

\(^2\)A land user obtains the land using right only, not the land or any resources in or below the land. Source: Land Administrative Law of the People’s Republic of China: Chapter II Article 8. To obtain the land use right, land user must sign a land grant contract with the land administration department of the state. Source: China Real Estate Law: Part 1: Land Use Right.
a small average TFP gap between DPE and SOE of about 9% per year. Hsieh and Klenow (2009)[47] estimate a gap of 1.42, which is similar to the estimate of 1.4952 in this paper. Brandt and Zhu (2010)[19] document persistent differences in returns to capital and labor between the state and the non-state sectors. Brandt, Tombe and Zhu (2013)[18] examine the effect of resource misallocation in China. They found that TFP losses associated with factor market distortions are still high in China and have increased sharply since the mid-1990s. The rising TFP losses are primarily due to capital misallocation between the SOE and non-SOE sectors.

Financial frictions are also documented in China where private firms are subject to strong discrimination in credit markets. The commercial banks, most of which are state owned, tend to offer easier credit to SOE (Genevieve Boyreau-Debray and Wei, 2005[17]). Song, Storesletten and Zilibotti (2011)[82] showed that SOE finance more than 30% of their investments through bank loans compared to less than 10% for DPE. Dollar and Wei (2007)[34] and Riedel, Jin and Gao (2007)[78] report that DPE rely less on bank loans and more on retained earnings and other sources to finance investments. In the case of Egypt and Turkey where government investments take large shares in some industries, private TFP is twice as large as government TFP (Schmitz, 2001[80]).

1.3.5 Macroeconomic Dynamics

Table 1.1 displays the data moments of land market variables, fiscal variables and macroeconomic variables. All series are hp-filtered. Columns 1 to 3 of the upper panel are standard deviation, relative standard deviation to GDP, and first-order autocorrelation. Figure 1.3 displays the output, public expenditure and land price from 2004 to 2014. These time series data are hp-filtered.

Figure 1.4 displays the land market variables and government investments. All time series data are hp-filtered. Figure 1.4c is the average price of land sale derived from 1.4a and 1.4b. The land price in China experienced a slump in 2011, then a rebound in 2012. Figures 1.4d and 1.4g display fixed-asset investment and investment of real estate development enterprise, both of which display a contraction after 2011. Figures 1.4e and 1.4f display investment by state-owned enterprises (SOEs) and local government. It is noticeable that local government investment (1.4f) co-moves with fixed-asset investment (1.4d). This is because a large portion of local government investment is on fixed assets. Also, the real estate development investment (1.4g) co-moves with land price.
Table 1.1: Moments of Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Std.Dev.</th>
<th>Rel.Std.Dev. to GDP</th>
<th>ACF(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Sale Volume</td>
<td>0.089</td>
<td>2.164</td>
<td>-0.244</td>
</tr>
<tr>
<td>Land Price</td>
<td>0.099</td>
<td>2.401</td>
<td>0.723</td>
</tr>
<tr>
<td>Fixed-asset Investment</td>
<td>0.039</td>
<td>0.935</td>
<td>0.740</td>
</tr>
<tr>
<td>Real Estate Development</td>
<td>0.047</td>
<td>1.127</td>
<td>0.751</td>
</tr>
<tr>
<td>Local Government Investment</td>
<td>0.039</td>
<td>0.934</td>
<td>0.743</td>
</tr>
<tr>
<td>Tax</td>
<td>0.046</td>
<td>1.115</td>
<td>0.732</td>
</tr>
<tr>
<td>GDP</td>
<td>0.041</td>
<td>1.000</td>
<td>0.741</td>
</tr>
<tr>
<td>Public Expenditure</td>
<td>0.107</td>
<td>2.584</td>
<td>0.686</td>
</tr>
<tr>
<td>RRR</td>
<td>0.139</td>
<td>3.359</td>
<td>0.759</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.132</td>
<td>3.202</td>
<td>0.582</td>
</tr>
<tr>
<td>LTV: public</td>
<td>0.037</td>
<td>0.899</td>
<td>0.696</td>
</tr>
<tr>
<td>LTV: private</td>
<td>0.078</td>
<td>1.883</td>
<td>0.751</td>
</tr>
</tbody>
</table>

Correlation with Land Price

<table>
<thead>
<tr>
<th>Correlation with Land Price</th>
<th>contemp. corr</th>
<th>corr with $Q_{l,t-1}$</th>
<th>corr with $Q_{l,t+1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corr($Q_t$,fix inv)</td>
<td>0.560</td>
<td>0.693</td>
<td>0.149</td>
</tr>
<tr>
<td>Corr($Q_t$,SOE inv)</td>
<td>0.496</td>
<td>0.777</td>
<td>0.090</td>
</tr>
<tr>
<td>Corr($Q_t$,real estate develop)</td>
<td>0.276</td>
<td>0.305</td>
<td>0.063</td>
</tr>
<tr>
<td>Corr($Q_t$,local gov inv)</td>
<td>0.428</td>
<td>0.697</td>
<td>0.007</td>
</tr>
<tr>
<td>Corr($Q_t$,funds)</td>
<td>0.326</td>
<td>-0.279</td>
<td>0.174</td>
</tr>
<tr>
<td>Corr($Q_t$,gdp)</td>
<td>0.630</td>
<td>0.264</td>
<td>0.480</td>
</tr>
<tr>
<td>Corr($Q_t$,public exp)</td>
<td>0.718</td>
<td>0.265</td>
<td>0.567</td>
</tr>
</tbody>
</table>

Note: The data is detrended using the Hodrick-Prescott filter with smoothing parameter $\lambda = 100$. The data source is in Table A.1.

Volatility

As shown in Table 1.1, the public expenditure is more volatile than output. Also, the investment variables are less volatile than output, which is not the case for the U.S. data. The land variables such as land sale volume, land sale revenue, and land prices are about twice as volatile as the output. In the model matching, how the observed large volatility in government expenditure and lands market variables are generated is key to the model.

Co-movement

The lower panel of Table 1.1 reports the variables’ contemporaneous correlation with land price and their cross correlation with one lead and one lag in land price. There is a high positive correlation between land price and public expenditure (0.718), which is consistent with observation in Figure 1.4. For example, a fall in public expenditure since 2008 is followed by a fall in land price since 2008. An expansionary public expenditure in 2010 is followed by an
Figure 1.4: Time Series of Land Market Variables and Investment Variables

Note: Data is hp-filtered with smoothing parameter $\lambda = 100$. The annual data is constructed from the accumulated monthly data by the National Bureau of Statistics of China.

increase in land price in 2010. Also, land price and GDP are positively correlated in Table 1.1. We also find that the land prices lead fixed asset investment, real estate development and local government investment. Figure 1.5 displays the cross correlations between land price and other variables.

1.4 Model

The economy is populated by two agents: workers and capitalists, two production sectors: private and public, and a local government who is not an optimizing agent but also a “player” in the model. The capitalists own private sector firms, and the government owns public sector firms. All firms are equipped with technology that uses land, capital and labor to produce. Land is initially developed by the government and part of the land is sold to the capitalists. Both capitalists and government use the land as collateral for an external bond financing. The imperfect contract enforcement implies that the amount of the bond is constrained by
the value of collateral. Monetary policy is represented by an exogenous credit injection into the loanable funds market. Fiscal policies are fiscal rules of government bond financing, government consumption, land development and taxes.

1.4.1 Agents: Capitalists and Workers

The agents are composed of capitalists and workers.

Workers

The representative worker has the utility function

$$E \sum_{t=0}^{\infty} \beta^t_h (\ln c_{h,t} - \psi \ln N_{h,t})$$ (1.1)

where $\beta^t_h$ is the worker’s discount factor, $c_{h,t}$ is the worker’s consumption, $\psi$ is a parameter for disutility of labor, and $N_{h,t}$ is the worker’s labor supply.

The representative workers maximize utility subject to

$$c_{h,t} + \frac{B_{h,t}}{R_t} + T_t = B_{h,t-1} + w_t N_{h,t}$$ (1.2)

where $w_t$ is wage and $T_t$ is a personal tax on the workers. The workers purchase a one-period bond $B_{h,t}$ from the financial intermediary at time $t$. $\frac{1}{R_t}$ is the bond price at time $t$. $B_{h,t-1}$ is the repayment of matured bond that workers purchased at time $t - 1$. The bond price at maturity is 1. The workers are free to work in either sector; therefore, $N_{h,t}$ is the total supply of labor.

Capitalists

The capitalists own all capital and the (non-residential) land they bought from the government. The capitalists receive a rent of capital from both sectors and a rent of land from the private sector. The representative capitalist owns all private sector firms and retains the profit. The capitalist finances his or her consumption, investment, and land acquisition through internal and external financing.

The representative capitalist has the utility function

$$E \sum_{t=0}^{\infty} \beta^t_c \ln c_{c,t}$$ (1.3)

where $\beta^t_c$ is the capitalist’s discount factor and $c_{c,t}$ is the capitalist’s consumption. $\beta^t_c < \beta^t_h$ is assumed to ensure that the borrowing constraint of the capitalist binds in a neighborhood of
the deterministic steady state.

The representative capitalist maximizes the utility subject to:

\[ c_{c,t} + Q_{t,t}(L_{c,t} - L_{c,t-1}) + I_t + \Psi(e_t)K_{t-1} + B_{c,t-1} = \frac{B_{c,t}}{R_t} + R_{k,t}e_tK_{t-1} + R_{l,t}L_{c,t-1} + \Pi_t \quad (1.4) \]

where \( Q_{t,t} \) is land price, \( L_{c,t} \) is land holding of capitalist, \( I_t \) is capital investment, \( e_t \) and \( \Psi(e_t) \) are capacity utilization and its adjustment cost, \( R_{k,t} \) and \( R_{l,t} \) are rental prices of capital and land. \( \Pi_t \) is the private sector firms’ profit which is retained by capitalists. For the simplicity of the model, the capitalists do not pay taxes. \( L_{c,t} - L_{c,t-1} \) represents the investment of land by capitalists and the volume of land sold by the local governments. The capitalists sell a one-period bond \( B_{c,t} \) to the financial intermediary at time \( t \). The bond price at time \( t \) is \( \frac{1}{R_t} \) and the bond price at maturity is 1. \( B_{c,t-1} \) is the repayment of matured bonds that capitalists sold at time \( t - 1 \). The cost of capital capacity utilization \( \Psi(e_t) \) is an increasing and convex function.

\[ \Psi(e_t) = \gamma_1(e_t - 1) + \frac{\gamma_2}{2}(e_t - 1)^2 \quad (1.5) \]

The law of motion for capital evolves as:

\[ K_t = (1 - \delta)K_{t-1} + \Omega(I_t) \quad (1.6) \]

where \( \Omega(I_t) \) is investment with adjustment cost of capital.

\[ \Omega(I_t) = \left[ 1 - \frac{\Omega}{2}(I_t - \gamma_t)^2 \right] I_t \quad (1.7) \]

1.4.2 Production and the Firm’s Problem

The economy has two production sectors: a public production sector with a larger share of land in production and a lower productivity, a private production sector with a smaller share of land in production and a higher productivity. Examples of the public production sector include low-rent housing, infrastructures, as well as roads, railways and airports, which constitute a major part of fiscal investment in China and are mainly operated by the state-owned enterprises (SOEs). Examples of the private production sector are manufacturing, commercial and residential housing contractors, etc.

Each firm employs workers and operates a constant-returns-to-scale technology that transforms labor, land, capital, and infrastructure stock into final consumption goods. Empirical evidences justify the positive spillover effects of infrastructure investment on the private production (Aschauer, 1989 [7]; Otto and Voss, 1994 [71]; Lau and Sin, 1997 [59]; Ramey, 2011 [76]). Related theoretical literature on the spillovers of productive government spending date back to

Therefore, the representative private sector firm’s production is presented as:

\[
y_t = A_t(L_t^\phi k_t^{1-\phi} n_t^{1-\alpha} Y_t^{\gamma'})
\]  

(1.8)

where \( y_t \) is private sector output, \( A_t \) is total factor productivity of the private sector, \( \phi \) is land input elasticity, \( 1 - \alpha \) is the share of labor input in production, \( Y_t' \) is infrastructure stock, and \( \gamma' \) is elasticity of private output with regard to the infrastructure stock. The \( A_t \) follows the AR(1) process:

\[
\log(A_t) = \rho_A \log(A_{t-1}) + (1 - \rho_A) \log(A) + \epsilon_{A,t}
\]  

(1.9)

where \( \rho_A \) is the degree of persistence, and \( \epsilon_{A,t} \) is i.i.d. with a zero-mean and a normal process of standard deviation \( \sigma_A \). The log(\(A\)) is the steady state level of log(\(A\)). In the part of calibration, \( A \) is calibrated according to the data mean of total factor productivity growth rate.

The law of motion of infrastructure stock \( Y_t' \) is:

\[
Y_t' = (1 - \delta_y)Y_{t-1}' + y_t'
\]  

(1.10)

Similar with the capital stock, the value of infrastructure stock could depreciate over time. \( \delta_y \) is the depreciation rate of infrastructure stock.

The representative public sector firm’s production is:

\[
y_t' = A_t'(L_{t-1}^{'\phi'} (k_t')^{1-\phi'} (n_t')^{1-\alpha})
\]  

(1.11)

where \( t \) represents that the parameter is specific to the public sector.\(^3\) The \( A_t' \) follows the AR(1) process:

\[
\log(A_t') = \rho_A' \log(A_{t-1}') + (1 - \rho_A') \log(A') + \epsilon_{A',t}
\]  

(1.12)

where \( \rho_A' \) is the degree of persistence and \( \epsilon_{A',t} \) is i.i.d. with zero-mean and a normal process of the standard deviation \( \sigma_A' \).

As reviewed in literature, empirical evidence suggests \( A \geq A' \) which imply that private sector has a higher productivity than that of public sector (Brandt and Zhu, 2000; Hsieh and Klenow, 2009; Song, Storesletten and Zilibotti, 2011).

Both production sectors are perfectly competitive; therefore, profit of firms in both sectors

\(^3\)The stock of infrastructure is left out of the public sector production function for simplicity.
is zero.

The representative private sector firm maximizes the profit by solving the firm’s problem:

\[ \Pi_t = \max_{k_t, L_{c,t}, n_t} y_t - R_{k,t}k_t - R_{l,t}L_{c,t-1} - w_t n_t \]  

(1.13)

where the rental price \( R_{k,t} \) and \( R_{l,t} \) and the wage \( w_t \) are given.

The government owns the public sector firms (e.g. SOEs and public investment projects) and their lands. The government leases land \( L_t' \) to the public sector firms’ production and retains their profits. The representative public sector firm maximizes the profit

\[ \Pi'_t = \max_{k'_t, n'_t} p_t^G y'_t - R_{k,t}k'_t - R_{l,t}L_{t-1}' - w_t n'_t \]  

(1.14)

where \( p_t^G \) is the relative price of public goods.

### 1.4.3 Local Government

Land is initially developed by the local government. The local government sells part of the developed land to raise revenue. The government spends on consumption of public goods and land development. The government finances spending through land sale revenue, personal taxes, profits in public sector, and local government bond from financial market. The government budget constraint is:

\[ Q_{l,t}(L_{c,t} - L_{c,t-1}) + T_t + R_{l,t}L_{t-1}' + \frac{B_{g,t}}{p_t^G} = B_{g,t-1} + p_t^G G_t^c + G_t^I + \Pi'_t \]  

(1.15)

where \( p_t^G G_t^c \) and \( G_t^I \) denote government consumption of public goods and investment in land development, respectively. \( \Pi'_t \) is the public sector firms’ profit that is retained by the local government. The local governments sell a one-period local government bond \( B_{g,t} \) to the financial intermediary at time \( t \). The government bond price at time \( t \) is \( \frac{1}{p_t^G} \) and the bond price at maturity is 1. \( B_{g,t-1} \) is the repurchase of matured government bond that local governments sold at time \( t - 1 \).

There is a fiscal policy shock, \( \{\epsilon_{g,t}\} \), to government purchase of public goods.

Assume that the government consumption of goods \( G_t^c \) follows AR(1) processes and the fiscal policy shock \( \epsilon_{g,t} \) is i.i.d. with a zero-mean and a normal process of standard deviation.

\[ \log G_t^c = \rho_{g,c} \log G_{t-1}^c + (1 - \rho_{g,c}) \log G^c + \epsilon_{g,t}^c \]  

(1.16)

The tax-output ratio follows a fiscal rule to keep the local government debt from continuously
where \( \tau_t = T_t / Y_t \) is the personal tax-output ratio, and \( \tau^* \) is the targeting tax ratio. The shock to the personal tax-output ratio \( \epsilon_{\tau,t} \) is i.i.d. with a zero-mean and a normal process of standard deviation.

In this model, government investment targets land development to be used in the process of production or sold. The government investment expands the stock of land

\[
F(G^I_t) = Q^I_t(L_t - (1 - \delta_L)L_{t-1})
\]

where \( F(\cdot) \) is a linear function such as \( F(x) = \eta x \) with \( \eta \in (0, 1) \). \( \delta_L \) is the land depreciation rate which is consistent with the tenure of land property using right in China. The land depreciation rate is to keep the total land stock from continuously growing if there is a sufficiently large land price rise. Since land market clears, the government investment of land development \( G^I_t \) is an endogenous variable of land demand and land price.

### 1.4.4 Borrowing Constraint

Both production sectors use land as collateral for external financing to invest and to pay wage bills. For this study, I assumed an imperfect contract enforcement that limits the amount of loans by capitalists and governments’ land value (Kiyotaki and Moore, 1997[54]; Iacoviello, 2005[49]; Liu, Wang and Zha, 2013[62]). Because capitalists and governments face collateral constraints, they can only borrow a limited amount of their land collateral value.

The collateral constraint for representative capitalists is:

\[
B_{c,t} \leq \theta_t Q_{l,t} L_{c,t}
\]

where \( \theta_t \) is the loan-to-value ratio for the capitalist. The imperfect contract enforcement implies that the lender can recoup up to a fraction \( \theta_t \) of the value of collateral assets if the borrower fails to repay the loan. Although \( \theta_t \) might be considered varieties of borrowing constraint, in this paper, I am especially concerned with the effect of shocks to \( \theta_t \), which is identified as a collateral shock. As in Kiyotaki and Moore (2012)[56], I have taken \( \theta_t \) as exogenous, which follows an AR(1) process

\[
\ln \theta_t = \rho \ln \theta_{t-1} + (1 - \rho) \ln \theta + \epsilon_{\theta,t}
\]

where \( \epsilon_{\theta,t} \) denotes the collateral shock which is i.i.d. with a zero-mean and a normal process of standard deviation.
The collateral constraint for local government is:

\[ B_{g,t} \leq \theta_t' Q_{l,t} L_t' \]  \hspace{1cm} (1.21)

where \( \theta_t' \) is the loan-to-value ratio for projects in the public sector. \( \theta_t' \) follows an AR(1) process where \( \epsilon_{\theta,t} \) represents the collateral shock to the public sector.

\[ \ln \theta_t' = \rho_{\theta} \ln \theta_{t-1}' + (1 - \rho_{\theta}) \ln \theta' + \epsilon_{\theta,t} \]  \hspace{1cm} (1.22)

### 1.4.5 Bank and Lending Constraint

The financial intermediary in the model is a bank, which finances loans from workers’ bond purchase \( B_{h,t} \) minus an exogenous monetary reserve \( X_t \). The financial market is perfectly competitive; therefore, the profit of financial intermediary is zero. The FI’s balance sheet implies that its liabilities cannot be more than its assets. Therefore, \( B_{h,t} \) minus the required reserve (liabilities) cannot be more than \( B_{c,t} + B_{g,t} \) (assets). The FI’s balance sheet constraint is:

\[ B_{h,t}(1 - X_t) \leq B_{c,t} + B_{g,t} \]  \hspace{1cm} (1.23)

where \( X_t \) is the RRR required by the central bank.

The credit policy of lending constraints in this model is implemented by a reserve requirement ratio (RRR) policy. He and Wang (2012)[44] showed that deposit rates and RRR are policy tools most frequently used by the People’s Bank of China (PBOC). Because bond price is determined by the bond market equilibrium, credit policy in this model is implemented by exogenous injections of liquidity into the financial intermediary through RRR policy; therefore, the central bank is nothing more than a liquidity provider. 4

The RRR \( X_t \) follows an AR(1) process:

\[ \ln X_t = \rho_x \ln X_{t-1} + (1 - \rho_x) \ln X + \epsilon_{x,t} \]  \hspace{1cm} (1.24)

where \( \epsilon_{x,t} \) is an exogenous credit policy shock that directs to injection (withdrawal) of liquidity into (from) the financial system.

---

4The central bank in the model is a liquidity provider. The credit policy is specified as a stochastic process of the required reserve ratio (RRR) in the banks. By adjusting the required reserve ratio (RRR), the central bank can change the money multiplier; thus, inject (or withdraw) liquidity to the system. This RRR credit policy, as a money-supply target policy in China, has been working effectively in China since 1994 (the year PBOC was created as the central bank) because the giant state-owned commercial banks were highly regulated by the central bank (PBOC) and bank’s regulatory commission (CBRC). Therefore, from the model’s perspective, the central bank could affect the system’s liquidity via an exogenous shock to the level of RRR.
1.4.6 Equilibrium

Given the initial conditions and a sequence of exogenous variables, an equilibrium consists of a sequence of state-contingent allocations and prices such that (1) the allocations solve the first order problems of agents and firms; (2) the capital market, goods market, lands market, and labor market all clear; (3) government constraints and financial market constraints are balanced.

Optimal Conditions

The optimal conditions are first order conditions of workers’, capitalists’, private and public production sectors’ problems. Both private sector and public sector are perfectly competitive, so their profits are zero at the equilibrium.

Workers

The workers maximize their expected lifetime utility subject to their budget constraint.

\[ \frac{\partial}{\partial c_{h,t}} : \quad \frac{1}{c_{h,t}} = \lambda_{h,t} \]  
\[ \frac{\partial}{\partial B_{h,t}} : \quad \lambda_{h,t} \frac{R_t}{\gamma_{h,t}} = \beta_h \lambda_{h,t+1} \]  
\[ \frac{\partial}{\partial N_{h,t}} : \quad \psi_{N_{h,t}} = \lambda_{h,t} w_t \]  

where \( \lambda_{h,t} \) is multiplier to budget constraint.

Capitalists

The capitalists maximize their expected lifetime utility subject to their constraints.

\[ \frac{\partial}{\partial c_{c,t}} : \quad \frac{1}{c_{c,t}} = \lambda_{c,t} \]  
\[ \frac{\partial}{\partial I_t} : \quad \lambda_{c,t} = \mu_{c,t} - \beta_c \mu_{c,t+1} \frac{\partial \Omega(I_t)}{\partial I_t} + \beta_c \mu_{c,t+1} \frac{\partial \Omega(I_{t+1})}{\partial I_t} \]  
\[ \frac{\partial}{\partial K_t} : \quad -\mu_{c,t} + \beta_c (\mu_{c,t+1} (1 - \delta) + \lambda_{c,t+1} (R_{k,t+1} + e_{t+1} - \Psi(e_{t+1}))) = 0 \]  
\[ \frac{\partial}{\partial e_t} : \quad \Psi'(e_t) = R_{k,t} \]  
\[ \frac{\partial}{\partial L_c,t} : \quad -\lambda_{c,t} Q_l,t + \nu_{c,t} Q_{t,t} + \beta_c \lambda_{c,t+1} Q_{l,t+1} + Q_{l,t+1} = 0 \]  
\[ \frac{\partial}{\partial B_{c,t}} : \quad \frac{\lambda_{c,t}}{R_t} = \nu_{c,t} + \beta_c \lambda_{c,t+1} \]  

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where \( \{\lambda_{c,t}, \mu_{c,t}, \nu_{c,t}\} \) are multipliers to budget constraint, capital accumulation and collateral constraint, respectively. The \( \frac{\partial \Omega(I_t)}{\partial I_t} \) and \( \frac{\partial \Omega(I_{t+1})}{\partial I_t} \) in the first order condition of \( I_t \) are as below:

\[
\frac{\partial \Omega(I_t)}{\partial I_t} = 1 - \frac{\Omega}{2} \left(2\left(\frac{I_t}{I_{t-1}} - \gamma_I\right)\frac{I_t}{I_{t-1}} + \left(\frac{I_t}{I_{t-1}} - \gamma_I\right)^2\right) \tag{1.34}
\]

\[
\frac{\partial \Omega(I_{t+1})}{\partial I_t} = \frac{\Omega}{2} \left(2\left(\frac{I_{t+1}}{I_t} - \gamma_I\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right) \tag{1.35}
\]

**Private Sector**

The land input in private sector is provided by capitalists so that \( l_t = L_{c,t} \). The optimal conditions for private sector firms are as below

\[
\frac{\partial}{\partial l_t} : \quad \frac{\alpha \phi y_t}{L_{c,t-1}} = R_{l,t} \tag{1.36}
\]

\[
\frac{\partial}{\partial k_t} : \quad \frac{\alpha (1 - \phi) y_t}{k_t} = R_{k,t} \tag{1.37}
\]

\[
\frac{\partial}{\partial n_t} : \quad \frac{(1 - \alpha) y_t}{n_t} = w_t \tag{1.38}
\]

**Public Sector**

The public sector receives land input from the governments so that \( L_t' = L_{c,t} \) is given.

\[
\frac{\partial}{\partial L_t'} : \quad \frac{\alpha \phi' p_t^G y_t'}{L_{t-1}'} = R_{l,t} \tag{1.39}
\]

\[
\frac{\partial}{\partial k_t'} : \quad \frac{\alpha (1 - \phi') p_t^G y_t'}{k_t'} = R_{k,t} \tag{1.40}
\]

\[
\frac{\partial}{\partial n_t'} : \quad \frac{(1 - \alpha) p_t^G y_t'}{n_t'} = w_t \tag{1.41}
\]

where \( p_t^G \) is relative price of public goods to private goods.

**Market Clearing Conditions**

The aggregate resource constraint clears the private goods market and public goods market:

\[
c_{h,t} + c_{c,t} + \Omega(I_t) + \Psi(\epsilon_t) K_{t-1} + G_t' = y_t \tag{1.42}
\]

\[
G_t' = y_t' \tag{1.43}
\]
The land market clearing condition is:

\[ L_{c,t} + L_t' = L_t \quad (1.44) \]

The capital market clearing condition is:

\[ k_t + k_t' = e_t K_{t-1} \quad (1.45) \]

The labor market clearing condition is:

\[ n_t + n_t' = N_t \quad (1.46) \]

**GDP**

The aggregate output of the two sectors is:

\[ Y_t = y_t + p_t^G y_t' \quad (1.47) \]

### 1.5 Calibration and Simulation

To solve the model and fit it to the data, I first log linearized the stationary equilibrium conditions around the deterministic steady state in which the collateral constraints of private and public sectors are binding. There are seven exogenous shocks in the baseline model: productivity shocks to \( \{ A_t, A_t' \} \), fiscal policy shocks to \( \{ G^c_t, T_t \} \), and credit policy shocks to \( \{ \theta_t, \theta_t', X_t \} \).

First, I calibrated the parameters to the data and existing literature. Then, I simulated the model to obtain the theoretical impulse response functions and simulated moments. The standard convention of model evaluation is to compare moments from the data with ones from the model based on the same transformation.

#### 1.5.1 Calibration

The parameters are categorized into two groups. The parameters in the first group are standard so that they are calibrated from the literature. The parameters in the second group are model specific so that they are determined by the moments of data. Table 2.1 summarizes the first and second groups of parameters. The calibration table is based on the annual data in China from 2004 to 2014. Data source is in Table A.1.

The labor supply aversion \( \psi \) is calibrated to \( wNybar/chybar \) where \( wNybar \) and \( chybar \) are the labor income-output ratio and consumption-output ratio.\(^5\) The annual capital depreciation

---

\(^5\)This steady state representation is in Appendix.
Table 1.2: Calibrated Parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preference:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker’s discount factor</td>
<td>$\beta_h$</td>
<td>0.99</td>
</tr>
<tr>
<td>Capitalist’s discount factor</td>
<td>$\beta_c$</td>
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</tr>
<tr>
<td>Labor supply aversion</td>
<td>$\psi$</td>
<td>1.10</td>
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<tr>
<td><strong>Capital:</strong></td>
<td></td>
<td></td>
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<tr>
<td>Capital depreciation rate</td>
<td>$\delta$</td>
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<td>Investment adjustment cost</td>
<td>$\Omega_1$</td>
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</tr>
<tr>
<td>Investment adjustment cost</td>
<td>$\gamma_1$</td>
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</tr>
<tr>
<td>Capital utilization (slope)</td>
<td>$\gamma_1$</td>
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</tr>
<tr>
<td>Capital utilization (curvature)</td>
<td>$\gamma_2$</td>
<td>1.01</td>
</tr>
<tr>
<td><strong>Technology:</strong></td>
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<td></td>
</tr>
<tr>
<td>Labor share</td>
<td>$1 - \alpha$</td>
<td>0.70</td>
</tr>
<tr>
<td>Land share in private sector</td>
<td>$\phi$</td>
<td>$1/3$</td>
</tr>
<tr>
<td>Land share in public sector</td>
<td>$\phi'$</td>
<td>$1/2$</td>
</tr>
<tr>
<td>Land value/development</td>
<td>$\eta$</td>
<td>0.578</td>
</tr>
<tr>
<td>Land depreciation rate</td>
<td>$\delta_L$</td>
<td>0.014</td>
</tr>
<tr>
<td>Productivity ratio</td>
<td>$A'/A$</td>
<td>0.68</td>
</tr>
<tr>
<td>Infrastructure stock elasticity to private output</td>
<td>$\gamma'$</td>
<td>0.10</td>
</tr>
<tr>
<td>Infrastructure depreciation rate</td>
<td>$\delta_y$</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Financial:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loan-to-value ratio for Private</td>
<td>$\theta$</td>
<td>0.60</td>
</tr>
<tr>
<td>Loan-to-value ratio for Public</td>
<td>$\theta'$</td>
<td>0.72</td>
</tr>
<tr>
<td>Mean of Required Reserve Ratio</td>
<td>$X$</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Fiscal:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parameter in Fiscal Rule</td>
<td>$a$</td>
<td>0.65</td>
</tr>
</tbody>
</table>

rate is 0.03 so that the quarterly rate is 0.0075. $\phi$ and $\phi'$, share of land input in the production of private and public sectors, are calibrated to ratio of the value of commercial real estate and the value of output in private (domestically private-owned enterprise) and public sectors (state-owned enterprise). These data are taken from the National Bureau of Statistics of China for the period 2004-2014. $\phi$, the share of land input to capital in the production for private sector is 1/3, which is calibrated to the steady state for private sector. It is approximated to the estimates in Iacoviello (2005) and Liu, Wang and Zha (2013), based on the ratio of steady state value of commercial real estate to output. $\phi'$, the share of land input in the production of public sector is 1/2, which is calibrated to the steady state for public sector.
The calibration suggests that the share of land input in the production in public sector $\phi'$ is greater than that in the private sector $\phi$. This makes sense because the public goods include infrastructures, roads, railways and airports, which consist larger share of land in production. The elasticity of infrastructure stock to private output is 0.10 in empirical studies of effects of public infrastructure investment on economic growth (Lau and Sin, 1997). The land development parameter $\eta$ is 0.578, derived from the steady state of land development equation (18) so that

$$\eta = \left(\bar{Q}L/y\right)\delta_{L}/\left(G^I/y\right)$$

where $Q^I L/y$ and $G^I/y$ are steady states and $\delta_L$ is the depreciation rate of land. The land depreciation rate is calibrated based on the 70-year tenure of land property using right in China. Therefore, land depreciation rate per year, $\delta_L$, is 0.014. Typically, the loan-to-value ratio in the land financing market of China ranges from 50% to 70%. Here we calibrate the loan-to-collateral value ratio from the sector-level leverage ratio data released by CASS (Chinese Academy of Social Science). The ratio of public sector productivity to private sector productivity is calibrated from production functions of two sectors given public goods clearing condition and $G^c/y$ at steady state.

The shock parameters are calibrated to data. Table 1.3 summarizes the shock parameters including persistence and volatility.

---

Table 1.3: Shock Parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autocorrelation of shocks:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity: private</td>
<td>$\rho_A$</td>
<td>0.582</td>
</tr>
<tr>
<td>Productivity: public</td>
<td>$\rho'_A$</td>
<td>0.582</td>
</tr>
<tr>
<td>Government consumption</td>
<td>$\rho_G$</td>
<td>0.686</td>
</tr>
<tr>
<td>Collateral constraint for private</td>
<td>$\rho_\theta$</td>
<td>0.751</td>
</tr>
<tr>
<td>Collateral constraint for public</td>
<td>$\rho'_\theta$</td>
<td>0.696</td>
</tr>
<tr>
<td>Credit policy</td>
<td>$\rho_X$</td>
<td>0.759</td>
</tr>
<tr>
<td>Standard deviation of shocks:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity: private</td>
<td>$\sigma_A$</td>
<td>0.132</td>
</tr>
<tr>
<td>Productivity: public</td>
<td>$\sigma'_A$</td>
<td>0.132</td>
</tr>
<tr>
<td>Government consumption</td>
<td>$\sigma_G$</td>
<td>0.107</td>
</tr>
<tr>
<td>Collateral constraint for private</td>
<td>$\sigma_\theta$</td>
<td>0.078</td>
</tr>
<tr>
<td>Collateral constraint for public</td>
<td>$\sigma'_\theta$</td>
<td>0.037</td>
</tr>
<tr>
<td>Credit policy</td>
<td>$\sigma_X$</td>
<td>0.139</td>
</tr>
</tbody>
</table>

---

6Though the land supply elasticity in the first-tier cities in China is low while in others cities is high due to differences in their land resource endowments, we assume that land supply elasticity is the same across country using the country-level land transaction data.
1.5.2 Simulation

The simulation takes first-order Taylor-approximation and is HP-filtered with the smoothing parameter $= 100$ to be comparable with the annual data. The simulation results use the average of 10000 times series, each of which has 100 periods and first 50 periods are burned in. The theoretical impulse responses are based on the comparison of simulated paths with and without an exogenous shock.

1.6 Impulse Responses and Economic Implications

In this section, I discuss the quantitative implications of model based on the theoretical impulse responses of key variables to various shocks.

1.6.1 Impacts of Government Spending Shock with Government Debt Constrained: Private Crowd-out in the Short Run, Crowd-in in the Long Run

Figure 1.6 displays the impulse responses of several variables to a positive government spending shock. An expansion in government spending on public goods (e.g. infrastructure) has little effect on the land price. This is because the increase in land demand is elastic thus an increase in land demand by public sector is offset by an increase in land supply by local government. Since government debt is constrained by land collateral value and cannot borrow beyond the limit, government has to sell part of land holdings to finance the expansion in purchase of public goods. Therefore, the impact of increase in public-sector land demand on land price is minor.

However, the government spending shock has a real effect on investment and output. A positive shock pushes up the rental price of land because of an increase in the demand of land in the public sector. Capital increases in response to a growing demand of capital. Wage increases as the marginal product of labor is increased by an increase in the public-sector capital input. As a result, the private sector is crowd out by a positive government spending shock in the short-run. The impulse responses of private output displays a hump shape. Public goods are productive to private production. With the accumulation of public goods, private sector is crowd-in in the long run.

Figure 1.6 shows a short-run crowd-out and long-run crowd-in effects of public spending on private sector output. The key issue is that the government debt must be constrained by their land collateral value. What if there is no imperfect contract enforcement on government debt? I will discuss this in the next chapter.
1.6.2 Impacts of Relaxation in Borrowing Constraints: Capitalist vs. Government

Figures 1.7 and 1.8 report the impulse responses of land and macroeconomic variables to relaxations in borrowing constraints for capitalists and the local government. Comparing impulse responses to a one-percent deviation change in the collateral constraint of capitalist and local government, relaxation in the capitalist’s collateral constraint has a greater effect on stimulating GDP, investment, and consumption than relaxing government debt constraints. Despite an increase in the portion of public sector output in total GDP, the borrowing constraint shock to the capitalist is still able to account for more fluctuation in output and investment.

Here is the mechanism. Since capitalist’s collateral constraint is directly related to their capital investment decision, a relaxation in the capitalist’s collateral constraint would have a direct effect on the investment. Because land is used as a collateral asset, a relaxation in the capitalist’s collateral constraint would increase their land demand, as well. Then, capitalists would invest their new adding land in the private sector, which has higher productivity. Therefore, the same percent change in the capitalist’s borrowing constraint has a greater effect on output.

1.6.3 Impacts of Tightening Lending Constraint: Private Benefits from Lower Land Price

Increasing the required reserve ratio (RRR) has complex yet interesting consequences. Figure 1.9 reports the impulse responses of model variables to a negative lending constraint shock, i.e. increase RRR. The model predicts that a tightening of lending constraints would increase the private-sector output. This is due to a reallocation of land between private and public sectors driven by land price changes. An increase in the reserve requirement ratio would drive up the interest rate. Because government debt is constrained by collateral value of land, a higher interest rate would increase the borrowing cost and push the government to sell part of land holdings to create alternative financing. This results in a lower land price. Though capitalists are facing a higher borrowing cost as well, instead of selling their land holdings, they would cut their capital investment and increase the capital utilization rate. Also, the capitalists would buy more land in response to a cheaper land price. Therefore, the private sector would benefit from a lower land price that is driven by the tightening lending constraint shock.
1.6.4 Impacts of Loosening Lending Constraint: Private Crowd-out and Capital Overcapacity

If lending constraints are loosened by reducing the required reserve ratio, the interest rate falls. Both capitalists and the government would have incentive to borrow more to finance investment in productions. However, since both parties face collateral constraints on their land holding, they have to acquire more land to borrow more. The demand of land increases; thus, land prices increase, as displayed in Figure 1.10. To acquire more land as collateral, government cuts the land sale to capitalists and inputs the land into public sector production. As a result, the private sector is facing a shortage of land input and a higher land price. In response to a shortage of land input, the capitalists have to reduce the capital utilization rate, which results in the overcapacity of capital. Therefore, the private sector output is crowded out by the public if lending constraint is loosened.

1.7 Key Issues

1.7.1 What if Local Government Bond is not Constrained by Land Collateral? Private Crowd-out in the Short Run and Long Run

From the last chapter, we can tell that the assumption that local government debt is constrained by collateral value of their land holdings is very important to the model dynamics. One may wonder what happens if there is no limited contract enforcement so that the government debt is not constrained by land collateral. Would there be crowd-out effect on the private sector if there is an expansion in government spending? To answer this question, I considered an alternative model in which local government debt is not constrained by land collateral.

Figure 1.11 reports the impulse responses of variables to an expansion in government spending if the government debt is not constrained by land collateral. The alternative model has shown two significant results.

First, when government debt is not constrained by their land collateral, the model generates smaller volatility of land price. This is because the collateral constraint on the local government bond would amplify the impact of an exogenous credit shock on the land price volatility.

Second, the alternative model predicts that an increase in the government expenditure on public goods would drive up land price and wage, then cause a reallocation of capital, land and labor between private and public sectors. As a result, the private sector is crowded out by the public sector after an expansion in public spending. This crowding out effect on private sector production further reduces capital investment, reduces consumption, and causes capital overcapacity. Therefore, if a local government debt is not constrained, an expansion in government expenditure reallocates resources from high-productive sector to low-productive...
sector, which causes resource misallocations and GDP losses.

### 1.7.2 What if Total Land Supply is Fixed: Stronger Private Crowd-in

The benchmark and analysis in the last chapter are based on an assumption that the land supply is elastic to the land price so that local government could determine land development in response to land price changes. This assumption secures relatively smooth land price fluctuations since any time that land prices are driven up by land demand, the land supply could increase to cancel off the demand side effect. The land development model is realistic for many urban cities in China. However, in some cities or rural areas where land is not completely developed and sold by the government or where there is a relatively high adjustment cost associated to the land supply, the effect of government investment in infrastructure on land price and other model dynamics may change. Therefore, to figure out the relationship between fiscal spending and real estate cycles and macroeconomic variables, I constructed an alternative model in which total land supply is fixed. Then, this model is consistent with the land supply assumption in Iacoviello (2005) and a series of following papers which assume fixed land supply in the model. Because total land supply is fixed, the local government cannot develop more land so that there is no government land development investment (\(G_L\)). Then, government land holding is determined by land price only (not by both land price and land rental price in an elastic land supply model).

Figure 1.12 shows the impulse response to government spending expansion if land is fixed and government debt is constrained by land collateral value. Comparing Figure 1.12 with Figure 1.6 in which land is elastic and government debt is constrained, land price drops faster and deeper but causes more crowding in private sector output if the total land supply is fixed. The logic of the land price drop is the same as in the previous chapter. Local government debt is constrained so that the government has to sell more land to finance the increase in public spending. Since land supply is fixed so that the government cannot adjust land development to smooth changes in land prices, the fluctuations of land price, investment and output are greater. The crowd in effect of government spending to private sector is stronger, and there is no hump-shape in the impulse responses of variables because land prices fluctuation driven by demand cannot be canceled off by the supply change.

### 1.7.3 What if Land Supply is Fixed and Local Government Bond is Unconstrained?

Figure 1.13 reports the impulse response to government spending expansion if land is fixed and local government debt is unconstrained. Comparing Figure 1.13 with Figure 1.12 in which land is fixed and government debt is constrained, we can see that unconstrained-debt government
spending would crowd out private investment and output and push up the land price. Comparing Figure 1.13 with Figure 1.11 in which government debt is unconstrained and land supply is elastic, fixing land supply (or increase land supply elasticity to infinity) would not only increase the fluctuations of land price, but also crowd out private investment and output more than the case with elastic land supply. Therefore, relaxing the local government debt from collateral constraint would crowd out private investment and output, increase land price, and cause GDP losses while fixing the land supply would increase the fluctuations of land price and other variables.

1.7.4 Matching the Model to the Data

Table 1.4 compares the simulated moments of the model with data based on the same transformation. We can see that the land price fluctuation is smaller than the data. This is not a surprise because land price is over-smoothed by a frictionless land development process. Otherwise, the baseline model matches well with the data. The model without collateral constraint generates more fluctuations in private output, land price and land sale, than those in baseline model. It is because the increase in land price driven by a positive demand-side shock would not necessarily cause an increase in land supply, if government debt is not constrained. The model with fixed land supply generates even more fluctuations than the other models. It is because land price is smoothed in a model with elastic land supply.

<table>
<thead>
<tr>
<th>Standard Deviation</th>
<th>Data</th>
<th>Baseline Model</th>
<th>No Collateral Constraint</th>
<th>Fix Land Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Output</td>
<td>0.041</td>
<td>0.031</td>
<td>0.046</td>
<td>0.082</td>
</tr>
<tr>
<td>Land Price</td>
<td>0.099</td>
<td>0.017</td>
<td>0.026</td>
<td>0.054</td>
</tr>
<tr>
<td>Land Sale Volume</td>
<td>0.089</td>
<td>0.028</td>
<td>0.044</td>
<td>0.131</td>
</tr>
<tr>
<td>Public Expenditure</td>
<td>0.107</td>
<td>0.119</td>
<td>0.101</td>
<td>0.119</td>
</tr>
<tr>
<td>RRR</td>
<td>0.139</td>
<td>0.117</td>
<td>0.130</td>
<td>0.117</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.132</td>
<td>0.137</td>
<td>0.121</td>
<td>0.137</td>
</tr>
<tr>
<td>LTV: public</td>
<td>0.037</td>
<td>0.046</td>
<td>N/A</td>
<td>0.046</td>
</tr>
<tr>
<td>LTV: private</td>
<td>0.078</td>
<td>0.056</td>
<td>0.073</td>
<td>0.056</td>
</tr>
</tbody>
</table>

Note: Both data and model have been detrended using the Hodrick-Prescott filter with smoothing parameter $\lambda = 100$. The frequency of data is annual. The data source is in Table A.1.
1.8 Sensitivity Analysis

1.8.1 Adjustment Cost

Figure 1.14 compares the impulse responses to expansion in government spending. Parameterization is with three different values of investment growth rate at steady state, $\gamma_I$: 1.01, 1.05, 1.10, while $\Omega = 2$. The impulse responses of investment, capital stock and capital utilization rate if $\gamma_I = 1.10$ are smaller than the case if $\gamma_I = 1.01, 1.05$. A higher steady state investment growth rate is associated with a higher adjustment cost of investment so that responses of a capitalist’s investment decision are smaller.

1.8.2 Land Share

Figure 1.15 compares the impulse responses between models with different private land input share, $\phi$: 1/10, 1/11, 1/12. If local government debt is constrained, higher land input share in the private sector would result in higher land price and land rental price. Because the private sector would benefit from the land price drop and land supply increase, higher private sector land input share would cause more crowd-in of the private output. Figure 1.16 compares the impulse responses between models with different public land input share, $\phi'$: 1/6, 1/5, 1/4. In contrast with Figure 1.15, as public sector land share increases, land would need to be inputted in public sector production and there would be less crowd-in effect on the private sector. Both Figure 1.15 and Figure 1.16 indicate that land share in private and public sector production would change the impacts of government spending on land market and output.

1.9 Conclusion

This paper contributes to the literature by studying the effects of Chinese local government land sales and infrastructure investment cycles on the real estate market and macroeconomy. This paper finds that if the local government debt is constrained, local government’s fiscal stimuli on infrastructure investment would crowd out the private sector in the short run and crowd in in the long run. Otherwise, similar fiscal stimuli would crowd out private sector in the short run and long run, as well as cause a resource misallocation, capital overcapacity and general losses in the total GDP.

This paper abstracts from several elements into the model. For example, the central bank in this paper is simplified as a liquidity provider conducting a single monetary policy target as the required reserve ratio. In future studies, I will discuss the impacts of local government debt financing on the economy in a nominal model in which monetary policy has multiple targets including real estate price.
Figure 1.5: Cross Correlation of Variables
Figure 1.6: IRF to government consumption shock (egc)
Figure 1.7: IRF to private borrowing constraint shock (eth)
Figure 1.8: IRF to public borrowing constraint shock (ethprime)
Figure 1.9: IRF to tightening lending constraint shock (ex)
Figure 1.10: IRF to loosening lending constraint shock (e-x)
Figure 1.11: IRF to government consumption shock if government debt is not constrained (egc)
Figure 1.12: IRF to government consumption shock if total land supply is fixed (egc)
Figure 1.13: IRF to government consumption shock if government debt is not constrained and total land supply is fixed (egc)
Figure 1.14: IRF to government consumption shock with different investment growth parameter (γ_I) in adjustment cost (egc)
Figure 1.15: IRF to government consumption shock with different private land share ($\phi$) (egc)
Figure 1.16: IRF to government consumption shock with different public land share ($\phi'$) (egc)
Chapter 2

Jobless Recovery After Credit Crunch: A Tale of Two Margins

2.1 Introduction

Recent financial turmoil has been associated with a severe increase in unemployment and a slow but significant decrease in the real wage rate. Though output growth has rebounded since the initial drop during the crisis, both employment and wages have displayed sluggish recoveries after the trough of output growth. For example, during the recent Great Recession, the unemployment rate grew from 5.0% to 9.5% in 18 months. However, after the recession, the unemployment rate dropped from 9.5% to 5.9% in 63 months.\(^1\) This pattern of sluggish recovery is similar to that of the annual percent change of the average hourly wage, which decreased after the end of recent recession until 2012:Q3.

In addition to an increase in unemployment and decrease in wages, working hours increased after the financial crisis. One explanation for this observation is that some firms were reluctant to add permanent employees since hiring new workers is associated with hiring and firing costs. They increased their labor input by increasing the workweeks of existing workers.\(^2\) Never had this feature of increased working hours been more true than in the recent recession. As shown in Figure 2.1, after the end of the recession, average weekly hours of all employees rose from 33.1 hours per week in 2009 to 33.7 hours per week in 2012. At the same time, the average weekly overtime hours of production rose from 2.8 hours to 4.4 hours.

Jobless recoveries following the recent Great Recession can be compared with the jobless recovery after 1991 and 2001. However, they are different in at least two aspects: recession

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duration and recovery speed. As shown in Figure 2.1, compared to the early 1990s and 2000s recession episodes, the recent recession was unusually long and featured a sharper increase in unemployment, as well as excess fluctuation in working hours.

Figure 2.2 displays the log-deviation of real GDP, average weekly hours, civilian employment and cyclical wage from the trough of the recessions. The 2009 recession was followed by a slower recovery in total employment and wage and a faster extension in working hours. What makes the post-2009 jobless recovery different from the previous two? Different from previous recessions in the early 1990s and early 2000s, the 2009 recession was associated with credit crunch and a financial deleveraging process afterward. As shown in Figure 2.3, the credit-to-GDP ratio dropped sharply after the recent recession, indicating deleveraging in the non-financial private sector. Therefore, the role of financial markets is important for understanding the jobless recovery after the recent recession.

The earlier labor search literature analyzed the role of search frictions with only an extensive margin. This simply ignores the role of the intensive margin in the determination of new employment. However, if the hiring and firing of workers is costly, then firms can extend or

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**Figure 2.1: Unemployment, Real Wage and Hours Followed by Three Recent Recessions**

Note: The unemployment rate used is the civilian unemployment rate, which is represented by the red solid line on the left scale. For the real wage, the annual percent change of average hourly earnings of all employees is used, which is shown in the blue dashed line on the left scale. Working hours is represented by the dotted gray line on the left scale, using the average weekly hours of all employees. Data frequency is quarterly and source is the Bureau of Labor Statistics. Shaded areas are the NBER recessions.

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3The cyclical wage is the real wage detrended by HP-filter.
shorten the working hours of each worker instead to adjust to exogenous shocks (Bachmann, 2012 [9]). In this way, the intensive margin of work could affect decision of employment and even exacerbate unemployment during and after recessions. Therefore, it is important to study jobless recovery in a model where wage and employment are determined at both intensive margin and extensive margin.

To study why the recent jobless recovery after the credit crunch is different from previous jobless recoveries, I constructed a model with three key elements: 1) search and match frictions in the labor market; 2) intensive and extensive margins determination; 3) financial frictions requiring that firms issue debt under limited enforcement.

The model of the labor market is built with search frictions and an intensive margin. In a model with search and match frictions, firms must post vacancies and search for unemployed workers. When a vacancy is matched, the wage is negotiated between the firms and existing
workforces given their surplus of employment and bargaining power. Given the firm’s value of
employment, firms determine the number of opening vacancies $v_t$ (extensive margin). In the
efficient bargaining scheme, hours and the wage are negotiated in one package. Working hours
per worker $h_t$ (intensive margin) is determined where the value of marginal product of the an
hour equals the marginal rate of substitution. In addition, the model discusses an alternative
bargaining scheme, right-to-manage bargaining, where the wage is determined unilaterally by
firms’ optimal choices in response to the wage bargaining. In this scheme, if the wage increases,
firms would extend the working hours of the existing workforce. As labor hours are extended,
firms would open fewer vacancies for the new matches.

The collateral constraint type of financial frictions popularized in Kiyotaki and Moore
(1997[54], 2005[55], KM hereafter) captures the indirect role of existing assets in the sacquisi-
tion of new capital. To be specific, in this model, the amount of debt issued by intermediate
firms is constrained by a fraction of the value of their capital stock. Such collateral constraints
allow one to examine the effects of the credit crunch in the recent recession on labor market
variables through a sudden constraint in firms’ borrowing capacity. In this model, financial
shocks are exogenous and stochastic. A credit expansion or crunch will generate positive or
negative liquidity which increases or decreases the equilibrium price of collateral asset prices.
The negative effect of a credit crunch on firms’ borrowing capacity is amplified and accelerated
with financial frictions. In the labor market, this amplification effect of a credit crunch causes

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Figure 2.3: Liquidity and Credit to GDP ratio in the United States, 1990-2011

Note: Liquidity is represented as Broad Money Supply (M3) to GDP of the United States. Credit is
represented as credit to nonfinancial private sector to GDP of the United States. Data is quarterly
frequency and from the Bureau of Economic Analysis.
labor market conditions to deteriorate quickly upon impact and recover slowly afterward.

When there is a credit crunch, firms have to cut their debt and investment projects and sell their working capital to reduce the debt. As a result, both working capital and labor demand fall following the credit crunch. The fall of collateral asset prices lowers firms’ borrowing limit. Thus, the impact on employment is amplified by the collateral constraint. This is the accelerator mechanism whereby financial frictions lead to a sharp increase in unemployment after a credit crunch.

In the right-to-manage bargaining scheme, firms would make each employee work for fewer hours and close new hires in recessions. In the following recoveries, firms would extend working hours of existing workforces instead of raising wages or adding new positions. Wage bargaining would not increase instantly even when credit conditions are improved in recoveries. Vacancy posting also rebounds slowly because the extension of working hours dampens firms’ motivation. In addition, if recessions are caused by severe credit crunches, financial frictions would act as a decelerator of jobless recoveries. Since the borrowing limit reduces the firms’ surplus of contracting employment, wage bargaining falls, and firms extend the working hours in job contracts for the existing workforce. As a result, firms open fewer vacancies for future matches, and new employment decreases further. This is the mechanism by which the interaction between the intensive margin and financial friction can explain a slower jobless recovery after a credit crunch.

The simulated moments of the model with the efficient bargaining scheme match the data moments on several dimensions, such as a positive correlation between hours and employment, a negative correlation between vacancy and unemployment rate (downward sloping Beveridge Curve), and a moderate volatility of hours to output. In addition, the simulated moments of the model with a right-to-manage bargaining scheme reproduces a negative correlation between wages and hours and a lower wage volatility. The impulse response of labor market variables to credit shocks implies that a greater credit crunch recession was featured with greater unemployment and jobless recovery.

The structure of this paper is organized as follows: Section 2 surveys the related literature; Section 3 includes timing of events, key ingredients of the model, and the transmission mechanism of financial shock to the labor market; Section 4 displays the optimal conditions of the model; Section 5 includes the calibration of parameters, steady states, and the simulation method; Section 6 reports the results of the model and Section 7 concludes the paper. To assess the quantitative consequences of the theory, a dynamic stochastic general equilibrium (DSGE) model is constructed and calibrated to quarterly U.S. data from 1990:01 to 2014:01, covering the three recent major economic recessions.
2.2 Literature

This paper builds upon two strands of literature.

There is a lengthy literature studies labor market dynamics by incorporating labor market frictions and wage rigidities into business cycle models. A major contribution to this field is a framework developed by Diamond (1982) [33], Mortensen (1982) [69], and Pissarides (1985) [74] (DMP hereafter). The DMP framework with labor market search provides strong micro foundations to analyze a broader set of labor market properties, but it does not match several business cycle facts. For example, the DMP framework fails to generate co-movements between hour and labor, the (high) volatility of unemployment, and the (negative) correlation between vacancies and unemployment. These drawbacks, also known as the wage/unemployment volatility puzzle, have been addressed in Shimer (2005) [81] and Hall (2005) [42]. Shimer (2005) argued that the search model is closed with a Nash bargain wage setting mechanism, allowing too much wage flexibility relative to the data. Shimer (2005) and Hall (2005) claimed that models with rigid or partially adjusting wages may be more successful than a flexible wage at explaining business cycle facts. Gertler, Sala, and Trigari (2008) [39] introduced wage rigidity through multi-period staggered Nash bargaining. To solve this puzzle of wage volatility, I introduce a right-to-manage bargaining scheme such as in Trigari (2006) [84], where wage is negotiated as Nash bargaining and hours are unilaterally determined by the firm. This provides a much lower volatility of the wage because both parties can adjust working hours instead of the wage in response to exogenous shocks. The right-to-manage bargaining scheme also provides a negative correlation between the wage and hours.

There are several papers close to this one that explain jobless recoveries with two margins. Bachmann (2012) [9] proposed a theory that firms can make workers on their payroll work longer, and the 1990s and 2000s jobless recovery may have been exacerbated by this reason. This helps to explain the mechanism in this paper for how the intensive margin with right-to-manage bargaining schemes work in a jobless recovery. However, this paper explains how the intensive margin can interact with financial frictions to exacerbate the recent jobless recovery after a credit crunch. Altug and Kabaca (2014) [3] incorporated the two-margin search model and financial frictions into a small open economy real business cycle model with shocks to TFP and interest rates.

Another related strand of literature attempts to integrate different sources of market incompleteness into labor market search models and find potential links between financial factors and unemployment fluctuations. Buera, Fattal-Jaef and Shin (2014) [21] constructed a financial friction model with heterogeneity in firm productivity. Their model shows that the reallocation of capital and labor from constrained-productive firms to unconstrained-nonproductive firm amplifies the impact of a credit crunch on unemployment. Liu, Miao and Zha (2013) [62] inves-
tigated the relationship between land price and unemployment and introduced land as a liquid asset to serve as collateral for debt financing. They included land price dynamics in a financial friction model and exhibit how interaction between the land market and the labor market can explain the labor market dynamics. Monacelli, Quadrini and Trigari (2012) [67] analyzed the relationship between the leverage ratio and the wage bargaining power of firms. In their model, a negative financial shock reduces the borrowing capacity of firms and increases the surplus being contracted between employer and employees. As a result, the increase in wages reduces the firm’s incentive to create vacancies, and the equilibrium of employment falls. Kiyotaki and Moore (hereafter KM, 1997) discovered that financial frictions due to collateral constraints can amplify and propagate small and temporary shocks into large and persistent effects on the macroeconomy. Their papers examine financial shocks with a collateral constraint, the amount a firm can borrow is proportional to the value of the firm’s holdings of resalable assets at the end of a period as in KM (2012) [56].

2.3 Model

The economy in this paper includes households, firms and government. There is an infinite number of households in the economy. The representative household consists of a large number of employed and unemployed members who pool their income and consumption no matter if they are employed or not. The representative firm determines its investment in capital and if it should open a vacancy. Firms finance investment by issuing debt backed by collateral on their capital stock with a limit, and firms’ debt is purchased by households. In the labor market with search, vacancies are matched with unemployed workers. The wages and hours are negotiated between employers and existing workforces in one package.

2.3.1 Timing

Timing in this model is important. Figure 2.4 displays the timing assumption in the baseline model, in which date t is divided into four sequential periods: (i) Employment; (ii) Realization of shocks; (iii) Search and match and wage bargaining; (iv) Production, investment, and job separation.

At the beginning of time t, the firm starts with stock of capital $k_t$, debt $B_t$ and matched workers $m_t$, which are predetermined at time $t - 1$. Then, exogenous shocks to productivity, credit, government spending and tax occur. The timing scheme in the baseline model assumes that the realization of the exogenous shocks and firms’ financial decisions are made before labor market search and wage bargaining with new matched workers. In response to the exogenous shocks, firms pay back the old debt and issue new debt with collateral based on the value of
their capital stock.

Firms would open or close vacancies at time $t$. Meanwhile, firms search for and match the vacancies with unemployed workers. The wage and hours are determined jointly by firm and workers at time $t$. The wage is negotiated based on the surpluses being contracted between the two parties. Hours are determined where the marginal product of hours equals the marginal rate of substitution. Since an employed worker is akin to a capital asset of the firm, an unemployed worker who finds a match at date $t$ will not work and produce until the next period. At time $t$, firms produce with existing workers $(1 - \rho)N_{t-1}$ and predetermined matches $m_t$. At the end of time $t$, firms produce and make a capital investment, and an exogenous job separation follows production.

I would like to clarify that the sequential timing of decisions is relevant for the dynamics of employment and other variables. As an alternative, I could assume that wage bargaining occurs prior to the realization of the financial shock, and I can alternate the time of realization of $\theta_t$ between the beginning of time $t$ and when the firm makes its financing decision. Thus, I have provided a robustness analysis in Appendix B.6 to determine if it matters for model dynamics: i) if the financial shock $\theta_t$ is realized prior to or subsequent to non-employed workers and firms engaged in labor market search; ii) if $\theta_t$ is realized at the beginning of date $t$ or when the firm makes its financing decision.
2.3.2 Household

This paper focused on a competitive equilibrium with complete risk sharing in the household, which is a decentralized economy with a social planner’s problem. Complete risk sharing in a representative household means that household members pool their income and consumption regardless of their employment status. By looking at the labor market with complete risk sharing in the household, we can understand how search frictions per se affect the behavior of aggregate labor market outcomes. This also makes it easy to describe the surplus splitting arrangement between a worker and a firm that have been matched (Hosios, 1990 [46]). Rather than modeling complete markets by specifying employment lotteries (Rogerson, 1988 [79]; Hansen, 1985), it is easier to assume that insurance takes place within a large household (Merz, 1995 [65]; Andolfatto, 1996 [5]).

Built on Merz (1995) [65], the representative household consists of a number of members who pool their income, and thus, provide each other with complete consumption insurance against unemployment. An aggregate household consists of $N_t$ proportion members who are employed and $1 - N_t$ proportion members who are unemployed. The household maximizes the lifetime utility with habit-consumption and elastic labor decision. Utility of the representative household is

$$\max_{C_t} E_t \sum_{t=0}^{\infty} \beta^t \left[ \ln(C_t - \zeta C_{t-1}) - N_t g(h_t) \right]$$ (2.1)

where $N_t$ denotes employment (extensive margin) and $h_t$ denotes the average working hours per worker (intensive margin).

$$g(h_t) = \frac{h_t^{1-\psi}}{1-\psi}$$

represents the disutility of labor. The two parameters $\zeta$ and $\psi$ measure the consumption habit behavior and the inverse of Frisch elasticity of labor. Habit formation helps to smooth consumption and amplify fluctuations in labor.

Households are aggregated and identical with the same proportion of employed and unemployed workers as in the aggregate economy. A representative household is subject to the following budget constraint:

$$C_t + B_{t+1} + \tau_t = R_t B_t + w_t h_t N_t + w_u t (1 - N_t)$$ (2.2)

where $B_t$ denotes the household’s lending to firms in the form of collateralized firm debt and $R_t$ denotes its real gross rate of return, $\tau_t$ denotes the lump-sum taxes or transfers to or from government, $w_t$ denotes the average wage per hour, and $w_u t$ denotes the unemployment benefit per member. Finally, $1 - N_t$ denotes the unemployment in the household.
2.3.3 Firm

Production

Firms choose capital and labor inputs to maximize the present value of dividends. Firms decide vacancies posting with regard to the financial market condition and their constraints. Firm has diminishing marginal productivity to each factor and constant returns to scale.

\[ y_t = A_t k_t^\alpha (N_t h_t)^{1-\alpha} \]  

(2.3)

where \( y_t \) is the production of consumption goods, \( k_t \) and \( h_t N_t \) are the physical capital and labor hours employed in production. The total factor productivity \( A_t \) follows an AR(1) process

\[ \ln A_t = \rho_A \ln A_{t-1} + (1 - \rho_A) \ln A + \epsilon^A_t \]  

(2.4)

where \( \epsilon^A_t \) denotes the productivity shock that is i.i.d. with zero mean and standard deviation \( \sigma_A \). The budget constraint for the firm is

\[ y_t + B_{t+1} = w_t N_t h_t + q_t I_t + R_t B_t + \kappa v_t \]  

(2.5)

where \( \kappa \) is the cost of vacancy posting and \( v_t \) is the number of vacancies. The firm owns and operates productive capital. The capital acquisition evolves as

\[ k_{t+1} = I_t + (1 - \delta) k_t \]  

(2.6)

where \( I_t \) denotes the investment and \( \delta \) denotes the depreciation rate. The firm retains the market value of nondepreciating capital \((1 - \delta) q_t k_t\), finances new funds by selling its debt to households \( B_{t+1} \), and pays existing debt with a gross real return of \( R_t \).

Financial Constraint

As in KM (1997, 2005, 2012), I assumed a limit on the obligations of the firm, which is motivated by the limited contract enforcement problem. Suppose that, if the firm fails to pay the loan, the lender can seize the collateral. Since liquidating the asset is costly, the lender can repossess up to a fraction of the value of the collateral, which is denoted by \( \theta_t \). In this case, the maximum amount of debt that a firm can borrow is bound by \( \theta_t q_t k_{t+1} \). The collateral constraint is given as

\[ B_{t+1} \leq \theta_t q_t k_{t+1} \]  

(2.7)

where \( \theta_t \) is the fraction of capital as collateral for a loan. The smaller is \( \theta_t \), and the tighter is the borrowing constraint that a firm faces. As in KM (2012), I take \( \theta_t \) as exogenous. Although
θ_t might be considered varieties of a borrowing constraint (KM, 1997; KM, 2005), in this paper, I am especially concerned with the effect of shocks to θ_t, which is identified as a credit shock (KM, 2012). As in KM, θ_t is assumed to follow an AR(1) process

\[ \ln \theta_t = \rho \ln \theta_{t-1} + (1 - \rho) \ln \theta + \epsilon_t^\theta \]  

(2.8)

where \( \epsilon_t^\theta \) is an i.i.d. white noise process.

**Firm’s Value of Employment**

There is an exogenous probability \( \rho \) that a match can break up before the production in the next period. In the next period, if this match survives, the firm continues with match value, \( J_{E+1}^F \). Otherwise, the firm receives the value of an open vacancy, \( V_{t+1} \). All other variables in the firm’s employment value function are deterministic except for \( B_t \) and \( w_t \). Since \( w_t \) is bargained and conditional on the firm’s debt level \( B_t \), its value function \( J_t^E \) is conditional on \( B_t \) as well.

Hereafter, \( J_t^F \) is written as \( J_t^F(B_t) \). The value of an employment for the firm is

\[ J_t^F(B_t) = (1 - \alpha) y_t - \tilde{w}_t h_t N_t + B_{t+1} - R_t B_t \frac{N_{t-1}}{N_t} + \mathbb{E}_t \left[ \frac{\beta \lambda_{t+1}^c}{\lambda_t^c} \right] [(1 - \rho) J_{t+1}^E(B_{t+1}) + \rho V_{t+1}] \]  

(2.9)

where \( \frac{\beta \lambda_{t+1}^c}{\lambda_t^c} \) denotes the stochastic discount factor and \( \tilde{w}_t \) denotes the expected wage level.

**2.3.4 Labor Market**

**Labor Flow**

As in the standard DMP framework, a worker matched at \( t \) will not go to work until \( t + 1 \) because each unit of labor is akin to capital which is predetermined. At \( t \), the workforce \( N_t \) is composed of non-separated labor \( (1 - \rho) N_{t-1} \) and predetermined matches \( m_t \). The wage is negotiated between firms and existing workforces, including the predetermined matches \( m_t \) at the same margin.

Figure 2.5 displays the flow of labor. The labor market begins with installation of \( w_0 \) and \( N_0 \) at \( t = 0 \). At the end of time \( t-1 \), a \( \rho \) portion of workers are separated from their positions, joining the unemployed workers group, and are compensated with unemployment benefits \( w^u \). The \( (1 - \rho) N_{t-1} \) non-separated workers are joined with the predetermined matches \( m_t \) to compose the workforce \( N_t \) at \( t \). A new wage \( w_t \) is negotiated between employers and the workforce at time \( t \). Meanwhile, unemployed workers \( u_t \) are searching for job positions. There are \( m_{t+1} \) of unemployed workers who finally match with vacancies with a probability \( p_t^u \). The new matches \( m_{t+1} \) will produce at time \( t + 1 \). The rest will keep the status of unemployed and receive the unemployment benefit at time \( t + 1 \). At the end of time \( t \), job separations are exogenous.
Search Frictions

There are two notions of unemployment in this paper: unemployed workers and unemployment rate. The unemployed workers $u_t$ is

$$u_t = 1 - (1 - \rho)N_{t-1} \quad (2.10)$$

which consists of existing unemployed and new separations at $t$. As indicated in the timing of events, unemployed workers $u_t$ is observed every period before match happens. The unemployment rate is

$$U_t = 1 - N_t \quad (2.11)$$

which is observed before separation happens and after match happens.

The firm must post vacancies to employ workers. At date $t$, the number of jobless workers who find jobs is $m_{t+1}$. The new matches $m_{t+1}$ is a predetermined forward looking variable. Since an employed worker is akin to a capital asset of the firm, the usual timing in the search model is that a date $t$ match only begins to work and produce during date $t+1$. The aggregate employment $N_t$ evolves as

$$N_t = (1 - \rho)N_{t-1} + m_t \quad (2.12)$$

where $m_t$ is predetermined at date $t-1$.

Following Merz (1995) and Andolfatto (1996), the matching process of unemployed workers and job vacancies is represented by a Cobb-Douglas function

$$m_{t+1} = \chi v_t^\gamma u_t^{1-\gamma} \quad (2.13)$$
where $v_t$ denotes the number of vacancies, $\gamma$ denotes the vacancy elasticity of job matching, and $0 < \gamma < 1$. $u_t$ is the number of workers who are involved in a job search. The efficient equilibrium condition requires that the worker’s bargain share $b$ is equal to the elasticity of matches with respect to the unemployed $1 - \gamma$, which is the Hosios condition for efficient vacancy creation.\(^4\)

To calibrate matching parameters, I introduced variables describing labor tightness and matching efficiency. Let $p^u_t \equiv m_{t+1}/u_t$ denote the job finding probability and $p^v_t \equiv m_{t+1}/v_t$ denote the matching rate of vacancy. Also, let $\phi_t \equiv v_t/u_t$ denote the labor market tightness, then

\[
\begin{align*}
m_{t+1} &= \chi \phi_t^\gamma u_t \quad \text{(2.14)} \\
p^u_t &= \chi \phi_t^\gamma \quad \text{(2.15)} \\
p^v_t &= \chi \phi_t^{\gamma - 1} \quad \text{(2.16)}
\end{align*}
\]

### 2.3.5 Wage Bargain

#### Efficient Bargaining Scheme

The bargaining scheme in this paper is that the bargaining agreement contracts both wage and hour in one package. This scheme is consistent with Andolfatto (1996), Cheron and Langot (2000) and most search and matching models with variable hours of work, which assumes that both the wage and hours are determined jointly by the firm and the worker. Wage is determined by negotiating between firms and workers through a Nash bargaining. The solution of hour is from the maximization of the joint surplus of employers and employees. Since this joint surplus maximization hour bargain is efficient for both parties, I refer to this joint bargaining scheme as “Efficient Bargaining (EB)”.

#### Bargain Solution

In this model, existing matched workers and new matches are homogeneous. Therefore, the wage is negotiated between the firm and all existing workforces including new matches at the same margin, as in most of the literature on labor market search. I define the value of employment for a new match worker as $W_t$ and denote the value of unemployment for an unemployed worker as $W_t^U$. The unemployment benefit $w_t^u$ is subject to $w_t^u = \mu w_t h_t$ where $\mu$ is the wage replacement ratio.

The vacancy value $V_t$ is zero given the free entry condition. A worker’s surplus of being employed is $W_t - W_t^U$, and a firm’s surplus of employment is $J^E_t$. Assuming that firms and

---

job searchers know the employment surplus of each other, the wage bargaining equilibrium is closed by a Nash equilibrium:

$$\max_{w_t} \left[(W_t - W_t^U)^b + (J_t^E)^{1-b}\right]$$

(2.17)

where $b$ is the workers’ bargaining power and $1 - b$ is of the firm’s bargaining power.

As derived in Appendix B.1, wage bargain is solved as

$$w_t h_t = \frac{b}{1 - b} J_t^E + g(h_t) + w_t^u - E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \left[(1 - \rho)(1 - p_t^u) (w_{t+1} h_{t+1} - w_{t+1}^u)\right]$$

(2.18)

If hour is jointly determined by firms and workers, the solution of efficient bargain hours is

$$\frac{-U_t'(h_t)}{\lambda_t} = \frac{\partial y_t}{\partial h_t}$$

(2.19)

which implies that the value of the marginal product of hours is equal to the marginal rate of substitution. It is exactly the same as in the neoclassical competitive labor market. This happens because under the efficient bargaining scheme the correct measure of the cost of hours to the firm is the marginal rate of substitution, rather than the wage. Thus, under an efficient bargaining scheme with hours, wage no longer plays an allocative role for hours due to the search and matching frictions (Barro’s critique). Therefore, hours at $t$ is

$$h_t = \left(\frac{(1 - \alpha) y_t}{N_t}\right)^{\frac{1}{1 - \psi}}$$

(2.20)

2.3.6 Government and Resource Constraint

The final feature of the economic environment is a balanced-budget unemployment insurance system. The government finances the nonproductive government spending and unemployment benefit payments through lump-sum taxes. The governmental budget constraint is

$$w_t^u (1 - N_t) + G_t = \tau_t$$

(2.21)

Standard practice assumes that government spending follows an AR(1) process. The lump-sum tax follows a fiscal rule

$$\ln \left(\frac{G_t}{Y_t}\right) = (1 - \rho_G) \ln \left(\frac{G}{Y}\right) + \rho_G \ln \left(\frac{G_{t-1}}{Y_{t-1}}\right) + \epsilon_t^G$$

(2.22)

$$\tau_t = \tau_s + a \left(\frac{G_t}{Y_t} - \frac{G}{Y}\right) + \epsilon_{\tau,t}$$

(2.23)
where $\epsilon^G_t$ and $\epsilon^\tau_{t}$ denote the fiscal policy shocks that are individually identically distributed with zero mean and standard deviation of $\sigma^G$ and $\sigma^\tau$ respectively. The aggregate resource constraint is

$$Y_t = C_t + I_t + G_t + \kappa v_t$$  \hspace{1cm} (2.24)$$

where $\kappa v_t$ is the total cost of vacancies.

### 2.4 Equilibrium and Economic Mechanisms

Given the initial conditions and a sequence of exogenous variables, a search equilibrium consists of a sequence of state-contingent allocations and prices such that (1) the allocations solve the first order problems of firms and households, (2) Nash bargaining solution is satisfied, (3) capital markets and goods markets clear.

#### 2.4.1 Optimal Conditions

Households maximize lifetime utility by optimally choosing consumption and leisure. Since households are not risk-neutral, they make savings against unemployment risks through bond purchase. Households can only choose their consumption $C_t$ and bond savings $B_{t+1}$. They cannot decide the labor hours $h_t$, new job match $m_t$, wage $w_t$, and employment $N_t$ unilaterally. The household’s optimal conditions are solved by maximizing their utility with regard to their budget constraint.

$$\tilde{\lambda}_t = \frac{1}{C_t - \zeta C_{t-1}} - \mathbb{E}_t \beta \frac{\zeta}{C_{t+1} - \zeta C_t} \hspace{1cm} \text{ (2.25)}$$

$$\lambda_t = \mathbb{E}_t \beta \lambda_{t+1} R_{t+1} \hspace{1cm} \text{ (2.26)}$$

where $\tilde{\lambda}_t$ is the Lagrangian multiplier of the household’s budget constraint, which represents the shadow price of household budget in terms of consumption.

The set of control variables that a firm chooses is $\{\tilde{v}_t, \tilde{k}_{t+1}, \tilde{B}_{t+1}\}$. At first, the firm decides the optimal level of capital stock $\tilde{k}_{t+1}$ in response to the productivity shock and the optimal level of debt $\tilde{B}_{t+1}$ in response to the financial shock. Then, in response to its labor demand and wage bargain $\tilde{w}_t$, the firm decides whether to open or close vacancies in the labor market $v_t$. The wage $w_t$ is negotiated between firms and workforces through bargaining. $R_t$ is the real gross rate of return on the firm’s debt. The optimal level of profit of the firm $\Pi_t$ is obtained by solving the firm’s optimal conditions with regard to collateral constraint and capital accumulation.

$$\Pi_t = \max_{\tilde{k}_{t+1}, \tilde{B}_{t+1}, h_t} \left( y_t - q_t I_t - w_t N_t h_t - R_t B_t + \tilde{B}_{t+1} \right) \hspace{1cm} \text{ (2.27)}$$
The firm’s optimal conditions are solved by maximizing the firm’s profits with regard to its collateral constraints. The equations below are the first-order conditions of the firm’s maximization problem with regard to the set of control variables \( \{k_{t+1}, B_{t+1}\} \).

\[
q_t = \frac{\mu_t}{\lambda_t} \theta_t \mathbb{E}_t q_{t+1} + \mathbb{E}_t \beta \lambda_{t+1} \left( \frac{\alpha q_{t+1}}{k_{t+1}} + (1 - \delta) q_{t+1} \right)
\]

(2.28)

\[
\mu_t = \lambda_t - \mathbb{E}_t \beta \lambda_{t+1} R_{t+1}
\]

(2.29)

where \( \mu_t \) denotes the Lagrangian multiplier with respect to the firm’s collateral constraint. The multiplier represents the shadow price for expanding the firm’s collateral constraint. The collateral constraint is always binding if \( \mu_t \) is greater than zero.

\( k_{t+1} \) is positively correlated with \( \theta_t \). This is obvious because as more debt is issued to finance investment projects, investment spending increases, and the firm accumulates more capital stock. The firm’s optimal choice of capital depends on how much the collateral constraint \( \theta_t \), price of current capital stock \( q_t \), and the expected price of the capital stock \( q_{t+1} \). But the \( B_{t+1} \) depends neither on \( w_t \) nor \( R_t \). It is only determined by the variables in the collateral constraint.

2.4.2 Equilibrium

Optimal Vacancy Posting

When a firm opens a vacancy, the vacancy is matched with a probability \( p^v_t \). Then the firm and newly matched employee obtain their employment matched value as \( J^E_t \) and \( w_t \) separately; otherwise, the firm continues with the expected value of a vacancy filled \( V_{t+1} \). Therefore, with no arbitrage condition, the value of the vacancy filled for the firm is:

\[
V_t = -\kappa + p^v_t [J^E_t(B_t)] + (1 - p^v_t) \mathbb{E}_t \beta \lambda_{t+1} \lambda^c_t V_{t+1}
\]

(2.30)

Free entry into the vacancy posting market condition drives the ex-ante value of a vacancy to zero in equilibrium. This implies that in equilibrium, the discounted match value of employment should equal the cost of posting a vacancy, i.e. \( p^v_t J^E_t = \kappa \) where \( p^v_t \) is the matching rate of vacancy, \( J^E_t \) is the value of a match employment, and \( \kappa \) is the cost of posting a vacancy.

The firm determines to open or to close a vacancy so that the optimal condition is that the current value of closing a vacancy equals the discounted expected value of holding a vacancy open and closing it in the next period. So the optimal vacancy posting of firm is

\[
\frac{\kappa}{p^v_t} = \frac{(1 - \alpha) y_t - \bar{w}_t h_t N_t + B_{t+1} - R_t B_t}{N_t} + \mathbb{E}_t \beta \lambda_{t+1} \lambda^c_t (1 - \rho) \frac{\kappa}{p^v_{t+1}}
\]

(2.31)

From this equation, it is obvious that an increase in working hours \( h_t \) increases the matching
rate of vacancy $p_t^v$, which implies that there are fewer vacancies opened for match. This is interpreted as the interaction of the extensive margin search and the intensive margin hours. The numerical interpretation of this interaction is

$$\frac{\partial m_{t+1}}{\partial h_t} = \frac{\partial m_{t+1}}{\partial p_t^v} J_t \frac{\partial J_t}{\partial h_t} = -\kappa v_t \alpha (J_t)^2 < 0 \quad (2.32)$$

**Implications from Wage Bargain Solution**

The wage bargain solution generates several important implications in this model.

First, the Nash bargaining wage $w_t$ is negatively correlated with the firm’s current debt level $B_t$, which derives from the solution of wage bargain.

$$\frac{\partial \tilde{w}_t}{\partial B_t} = \frac{\partial \tilde{w}_t}{\partial J_t} \frac{\partial J_t}{\partial B_t} < 0.$$  

This is because a higher level of debt reduces the firm’s surplus being contracted with employees. The smaller surplus allows employers to bargain for lower wages.

Second, the hour bargain solution $h_t$ reveals that there are two effects from hours on wage. First, an increase in hours will decrease the value of the marginal product of hour, and then decrease the wage. Second, an increase in hour will increase the disutility of working, which increases the household’s outside option and then increases the wage. Therefore, the Nash bargaining scheme of wage and hour cannot predict a negative correlation between wage and hours.

**2.4.3 Economic Mechanisms: Two Margins**

In this section, I explore the economic mechanism of sharp deterioration in the labor market and sluggish jobless recovery. The tale of two margins will explain: 1) how labor market frictions can explain a sharp increase in the unemployment rate after a credit crunch; 2) why the labor market recovers slowly even when credit conditions improve; 3) how financial frictions amplify the negative effect of a credit crunch on the labor market. These mechanisms will be displayed as model dynamics in the simulation results of this paper.

**Sharp Increase in Unemployment Rate**

The mechanism that shows why unemployment rates sharply increase after recessions led by a credit crunch should be clear by now. A credit crunch (negative collateral shock) restrains the borrowing limit of firms and forces firms to cut their loan $B_{t+1}$. The collateral constraint-bound firm has to sell its working capital and cut its investment projects in response to the tightening borrowing constraint $B_{t+1}$. In the wage bargaining solution (19), a smaller $B_{t+1}$ decreases the
expected wage bargain for existing workforces. In the hour bargaining solution (20), a decrease in capital level would decrease the marginal product of labor, thus increase the hours. In the optimal vacancy posting condition of the firm, an increase in hour would increase vacancy filling rate $p^v$, which implies that firms would open fewer vacancies $v_t$. As a result, the new match $m_{t+1}$ falls, and the unemployment rate $U_{t+1}$ increases.

In addition, the future wage bargain $w_{t+1}$ is higher because the lower future debt $B_{t+1}$ increases the surplus of employers, which allows workers to bargain for a higher wage. This drives the future unemployment rate $U_{t+1}$ even higher.

**The Financial Accelerator**

A credit crunch (negative collateral shock) restrains the borrowing limit of firms and forces firms to cut their debt $B_{t+1}$. The collateral constraint-bound firm has to sell its collateral capital to pay the debt or cut its investment project to reduce the debt in response to the tightening borrowing constraint $B_{t+1}$. As the capital market clears, the sale of capital lowers the price of collateral asset $q_t$. In addition, the cut of the investment project $I_t$ lowers the firm’s stock of capital $k_{t+1}$, which would decrease the firm’s future production $y_{t+1}$. The decrease in future production dampens the firm’s capacity to borrow and finance new investments. Thus, the negative effect of a credit crunch on the firm’s borrowing capacity is amplified and accelerated by the financial frictions.

2.5 Calibration and Simulation

2.5.1 Calibration

To solve the model, the stationary equilibrium conditions are log-linearized around the deterministic steady states. To fit the model to the data, all parameters are calibrated to moments of data based on the same transformation. Quantitative analysis is based on the numerical simulation of the model.

There are two groups of parameters: structural and shock parameters. The structural parameters are either calibrated to the model steady states or to their conventional values in the literature. The conventional parameters, such as preference and technology parameters, are calibrated as standard values in the literature. The model specific parameters, such as financial market and labor market frictions parameters, are calibrated to the model steady states. The model steady states used the entire data sample ranging from 1990:Q1 to 2014:Q1 (quarterly), which covered the recent three recessions.

The shock parameters were calibrated to the HP-filtered cycle components. The shock persistence and volatility parameters of each recovery are the same. The standard deviations to
Table 2.1: Values of Calibrated Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
<th>Value</th>
<th>Target/Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>Intertemporal discount rate</td>
<td>0.995</td>
<td>2% annual riskless interest rate</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Inverse of labor elasticity</td>
<td>-0.500</td>
<td>The steady state of hour</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>Habit parameter</td>
<td>0.750</td>
<td>Gali, Smets and Wouters (2011)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Capital share of production</td>
<td>0.333</td>
<td>Capital share in national income</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation rate</td>
<td>0.025</td>
<td>10% annual depreciation rate</td>
</tr>
<tr>
<td>$\chi$</td>
<td>Job matching parameter</td>
<td>0.500</td>
<td>Average job filling rate</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Vacancy match elasticity</td>
<td>0.500</td>
<td>Mean of $\log(m_{t+1}/u_t)/\log(\phi_t)$</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Wage replacement ratio</td>
<td>0.610</td>
<td>Unem. benefit-wage income ratio</td>
</tr>
<tr>
<td>$b$</td>
<td>Wage bargaining share</td>
<td>0.500</td>
<td>Hosios efficient condition</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Exogenous separation rate</td>
<td>0.033</td>
<td>Total separations/labor force</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Cost of vacancy posting</td>
<td>0.061</td>
<td>Solution in model steady states</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Loan-to-value ratio</td>
<td>0.400</td>
<td>(Debt/GDP)*(GDP/Capital)</td>
</tr>
<tr>
<td>$\rho_A$</td>
<td>Productivity</td>
<td>0.950</td>
<td>Total factor productivity in US</td>
</tr>
<tr>
<td>$\rho_G$</td>
<td>Government spending</td>
<td>0.970</td>
<td>Government spending-output ratio</td>
</tr>
<tr>
<td>$\rho_t$</td>
<td>Lump-sum taxes</td>
<td>0.900</td>
<td>Personal taxes receipts to GDP ratio</td>
</tr>
<tr>
<td>$\rho_b$</td>
<td>Collateral constraint</td>
<td>0.900</td>
<td>private sector debt to capital ratio</td>
</tr>
</tbody>
</table>

Input in the simulation for each recovery are specifically calibrated to data sample during each recovery period. The data sample of each recovery period contains the same length of 24 quarters after the trough of each recession.

Table 2.1 displays the calibration of all parameters. The shock parameters display significant differences in the standard deviations of productivity and the financial shock among the recent three recoveries.

The utility and technology parameters are conventional parameters, which are calibrated to standard values. $\beta$, the intertemporal discount rate, is set to 0.995. $\zeta$, the consumption habit parameter, is set to 0.75, as estimated in Gali, Smets and Wouters (2012) [52]. This is in the [0.0,0.9] range of calibrated values of habit persistence parameters in Boldrin, Christiano, and Fisher (2001) [16]. $\delta$, the depreciation rate, is calibrated to 0.025 which approximates to a 10 percent depreciation rate in the U.S. data. $\alpha$, the capital share of production, is set to 0.333 so that the equilibrium of the model matches the long run labor share of national income for the United States. $\psi$ is the inverse of negative Frisch elasticity of labor. $\psi$ is calibrated to the steady states of the model. 5 The job matching parameter $\chi$ is calibrated to the steady state of the average quarterly vacancy filling rate $p^v$.

The financial market and labor market parameters are model specific and are calibrated

---

5 From the efficient bargain solution of hour, we have $h = \left[ \frac{(1-\alpha)\lambda}{N} \right]^{1/(1-\psi)}$. Thus, $\psi = 1 - \frac{\log(1-\alpha) + \log(\phi) - \log(\bar{h})}{\log \bar{h}}$. 

---

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from data. $\rho$, the exogenous separation rate, is calibrated to 0.055, which is the mean of the U.S. quarterly data.\(^6\) $\gamma$, the elasticity of vacancy match, is calibrated to 0.291. Using data from JOLTS, I constructed quarterly data on labor market intensity and matching elasticity in match.\(^7\) $b$, the elasticity of the worker’s bargain surplus, is equal to the elasticity of matches with respect to the unemployed $1 - \gamma$. This applies to the Hosios condition for efficient vacancy creation.

$\mu$, the wage replacement ratio, is calibrated to 0.6095, which is the mean of the U.S. quarterly data.\(^8\) The steady state of vacancy posting cost $\kappa$ is solved from the firm employment value function, free entry condition, and wage bargain solution at a steady state. Given the first order moments of data, the vacancy cost $\kappa$ is calibrated to 0.061.\(^9\) The steady state of borrowing constraint $\theta$ is calibrated to the quarterly data of credit to nonfinancial private sector to the market value of capital. It is a product of two variables: the ratio of nonfinancial private sector debt to nonfinancial private sector GDP; GDP to capital ratio. The former variable is shown as blue solid line in Figure 2.3. The data mean of the nonfinancial private sector debt to nonfinancial private sector GDP ratio is 1.2 on average. The GDP to capital is 1/3 from the US data. Therefore, steady state of borrowing constraint $\theta$ is 0.4.

To make the simulation be comparable with data, the shock processes, i.e. persistence and volatility parameters, are the same across three recoveries; but different recovery has different shock size. The persistent parameters are calibrated to the first-order autocorrelation function of total factor productivity, government spending-output ratio, credit to nonfinancial private sector to GDP ratio, and personal taxes for the whole data sample. $\rho_A$, $\rho_G$, $\rho_\theta$, and $\rho_t$ in Table 2.1 are 0.95, 0.97, 0.90, 0.90 respectively.

The shock sizes are calibrated to the post-1991, post-2001, and post-2009 recoveries data. Each data sample has the equal length of 24 quarters. $S_A$, $S_G$, $S_\theta$ and $S_t$ in Figure 2.2 are the shock sizes of productivity, government spending, credit constraint, taxes for each recovery simulation. They are calibrated to the data of TFP, government spending, total nonfinancial private sector credit to market value of capital, and personal taxes to GDP ratio, separately.

---

\(^6\)The job separation rate is calculated from the ratio of Total Separations in Total Non-farm to Civilian Labor Force. Data is released by U.S. Department of Labor: Bureau of Labor Statistics. Frequency is quarterly.

\(^7\)Since $m_{t+1} = \phi^*_t u_t$, $\gamma$ is calibrated to $\log(m_{t+1}/u_t) / \log(\phi_t)$. In addition, there are higher estimates of $\gamma$ such as 0.5 in Hall and Milgrom (2008) [43], Gertler, Sala and Trigari (2008) [39], Gertler and Trigari (2006) [40], 0.7 in Petrongolo and Pissarides (2001) [72] and 0.765 in Hall (2005) [42].

\(^8\)The wage replacement is calculated from the ratio of unemployment insurance per unemployed to labor income per employed in quarterly frequency. $\mu$ ranges from 0.4 in Hall (2005) and 0.5 in Ravenna and Walsh (2008) [77] to 0.7 in Rogerson and Shimer (2012) and 0.75 in Christiano, Eichenbaum and Trabandt (2013) [27]. Based on a summary of the literature, Gertler, Sala and Trigari (2008) argue that a plausible range for the replacement ratio is 0.4 to 0.7.

\(^9\)The calibration of $\kappa$ is model specific. It ranges a lot in literatures, from 0.005 in Liu, Miao and Zha (2013) [62] to 0.298 in Monacelli, Quadrini and Trigari (2012) [67].
Table 2.2: Values of Shock Size in Each Recovery Simulation

<table>
<thead>
<tr>
<th>Shock</th>
<th>Description</th>
<th>Shock sizes</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{A,1991}$</td>
<td>Productivity shock</td>
<td>0.0064</td>
<td>S.D. of TFP, post-1991 recovery</td>
</tr>
<tr>
<td>$S_{θ,1991}$</td>
<td>Financial shock</td>
<td>0.0416</td>
<td>S.D. of Credit to GDP, post-1991 recovery</td>
</tr>
<tr>
<td>$S_{l,1991}$</td>
<td>Lump-sum taxes shock</td>
<td>0.0012</td>
<td>S.D. of tax-GDP ratio, post-1991 recovery</td>
</tr>
<tr>
<td>$S_{A,2001}$</td>
<td>Productivity shock</td>
<td>0.0042</td>
<td>S.D. of TFP, post-2001 recovery</td>
</tr>
<tr>
<td>$S_{G,2001}$</td>
<td>Government spend shock</td>
<td>0.0052</td>
<td>S.D. of G-Y ratio, post-2001 recovery</td>
</tr>
<tr>
<td>$S_{θ,2001}$</td>
<td>Financial shock</td>
<td>0.0508</td>
<td>S.D. of Credit to GDP, post-2001 recovery</td>
</tr>
<tr>
<td>$S_{l,2001}$</td>
<td>Lump-sum taxes shock</td>
<td>0.0025</td>
<td>S.D. of tax-GDP ratio, post-2001 recovery</td>
</tr>
<tr>
<td>$S_{A,2009}$</td>
<td>Technology shock</td>
<td>0.0052</td>
<td>S.D. of TFP, post-2009 recovery</td>
</tr>
<tr>
<td>$S_{G,2009}$</td>
<td>Government spend shock</td>
<td>0.0143</td>
<td>S.D. of G-Y ratio, post-2009 recovery</td>
</tr>
<tr>
<td>$S_{θ,2009}$</td>
<td>Financial shock</td>
<td>0.0955</td>
<td>S.D. of Credit to GDP, post-2009 recovery</td>
</tr>
<tr>
<td>$S_{l,2009}$</td>
<td>Lump-sum taxes shock</td>
<td>0.0053</td>
<td>S.D. of tax-GDP ratio, post-2009 recovery</td>
</tr>
</tbody>
</table>

2.5.2 Steady States

Table 2.3 displays the steady state values of some model specific variables. Data sample for the United States ranges from 1990:Q1 to 2014:Q1. At the beginning, the steady state unemployment rate is set to data mean. The steady state match is equal to steady state job separation, which is slightly lower than data mean. The steady state vacancy results from matching function. The data mean of labor market tightness results from the ratio of total number of unemployed workers to the total number of vacancies. Data mean of income-output ratio $whN/y$ uses the ratio of product of average hourly earnings of all employees ($w$), average weekly hours of all employees ($h$) and civilian employment ($N$) to GDP per week ($y$). $y$ is the US annual GDP divided by 52 weeks. The data mean of income-output ratio is smaller than the model mean because the earnings data could only explain part of the total labor cost in production.

Table 2.3: Implied Steady States of the Model

<table>
<thead>
<tr>
<th>Steady States of</th>
<th>Data Mean</th>
<th>Model Mean</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p^u$</td>
<td>0.5218</td>
<td>0.5036</td>
<td>Job finding rate</td>
</tr>
<tr>
<td>$u$</td>
<td>0.0615</td>
<td>0.0615</td>
<td>Unemployment rate</td>
</tr>
<tr>
<td>$m$</td>
<td>0.0554</td>
<td>0.0310</td>
<td>New match</td>
</tr>
<tr>
<td>$v$</td>
<td>0.0430</td>
<td>0.0625</td>
<td>Vacancy</td>
</tr>
<tr>
<td>$φ$</td>
<td>0.4098</td>
<td>0.9840</td>
<td>Labor market tightness</td>
</tr>
<tr>
<td>$c/y$</td>
<td>0.6397</td>
<td>0.4371</td>
<td>Consumption-output ratio</td>
</tr>
<tr>
<td>$I/y$</td>
<td>0.1504</td>
<td>0.1150</td>
<td>Investment-output ratio</td>
</tr>
<tr>
<td>$whN/y$</td>
<td>0.5142</td>
<td>0.4029</td>
<td>Labor income-output ratio</td>
</tr>
</tbody>
</table>
2.5.3 Simulation

The simulation takes a first-order Taylor approximation and is HP filtered with \( \lambda = 1600 \) as comparable with data moments. The simulation of each recovery uses the same structural parameters and has specific calibration of shock parameters. The simulation results use the average of 10,000 time series, each of which had 48 periods, and the first 24 periods were burned in. The sample size of each simulation is consistent with the size of recovery-specific data samples in calibration.

2.6 Results

In this section, I present quantitative results based on the numerical simulation of the model. I simulated the model using the same structural parameters and the recovery specific shock parameters. The size of each simulation is consistent with the size of recovery-specific data sample in calibration. I begin with a discussion of how labor market variables react to various exogenous shocks. Then, I analyze the role of financial frictions and intensive margins in the dynamics of labor market variables in response to shocks. I introduce a right-to-manage bargaining and show how this alternative bargaining scheme could solve the wage volatility and unemployment/vacancy co-movement puzzles stressed in Shimer (2005) [81] and Farmer (2006) [36].

2.6.1 Evaluating the Two-Margin Efficient Bargaining Model

Figures 2.6, 2.7, 2.8 and 2.9 report the impulse responses of labor market variables to one standard deviation of various shocks in the model using the Efficient Bargaining scheme.

- Figures 2.6 and 2.7 report that unemployment rates increased and wage decreased after a negative shock of productivity and credit constraint.

- Hours in Figure 2.6 displays a mixed effects of hour’s efficient bargain: a decrease in employment increases the marginal product of hour (hire less, work more), an increase in the wage decreases the marginal rate of substitution (earn more, work less). Therefore, hours would increase then decrease as a result of efficient bargaining solution of hours.

- A negative credit shock constrained firms’ ability to finance new employment and new investment. Firms had to cut employment and investment projects to meet tightening credit limits. Thus, the wage decreased in Figure 2.7 because firms would bargain for a lower wage for their financial budget. Hours decreased in Figure 2.7 as a result of mixed effects of credit constraint on hour bargain: a decrease in employment increases the
marginal product of hour (hire less, work more), a decrease in wage increases the marginal 
rate of substitution (earn less, work more).

- Figures 2.8 and 2.9 report impulse responses to fiscal policy shocks. From Figure 2.8, 
an increase in lump-sum tax would increase the unemployment rate and wage. Therefore, 
Ricardian equivalence does not hold. This is because a change in tax would cause a change 
in unemployment benefit, which causes endogenous variables to change on the margin. To 
be specific, an increase in lump-sum tax would increase the unemployment benefit, which 
increase the wage as the unemployed has a better outside option. The increase in wage 
reduces firm’s value of contracting an employment, thus firm opens less vacancies and the 
unemployment rate increases.

The impact of tax shock on hour is a mixture of two effects: a decrease in employment 
increases the marginal product of hour (hire less, work more), an increase in wage lowers 
the marginal rate of substitution (earn more, work less). Therefore, hours would increase 
them decrease as a result of efficient bargaining solution of hours.

Figure 2.9 reports that a positive fiscal spending shock could result in labor market 
conditions improvement. From the setup of the model, an increase in fiscal spending 
would increase the total demand of final goods and crowd out the unemployment benefits 
in the government budget constraint (Section 2.3.6). This positive demand shock would 
motivate new employment. Also, a decrease in unemployment benefit would decrease the 
price bargain (Section 2.3.5). The decrease in wage would increase the marginal rate of 
substitution, meaning that workers have to work for longer time to compensate wage 
decrease.

The impact of government spending on hour is a mixture of two effects: an increase in 
employment decreases the marginal product of hour (hire more, work less), a decrease in 
price increases the marginal rate of substitution (earn less, work more). Therefore, hours 
would decrease then increase as a result of efficient bargaining solution of hours.

To gauge the model with Efficient Bargaining scheme, Table 2.4 compares the simulated 
moments of model to the data moments. It displays the model-simulated moments of several 
key labor market variables. The historical data moments are separated in three samples with 

In sum, the model simulated moments match the data on several dimensions, such as a 
positive correlation between hours and employment, a negative correlation between vacancy 
and unemployment rate (downward sloping Beveridge Curve), and a moderate volatility of 
hours to output. However, the model-simulated moments contradict with data on two aspects, 
i.e. a positive correlation between wages and hours, and a greater volatility of wage.
Figure 2.6: Impulse Responses of Labor Market Variables to One Negative S.D. Productivity Shock in the EB Model
Figure 2.7: Impulse Responses of Labor Market Variables to One Negative S.D. Credit Shock in the EB Model
Figure 2.8: Impulse Responses of Labor Market Variables to One Positive S.D. Tax Shock in the EB Model
Figure 2.9: Impulse Responses of Labor Market Variables to One Positive S.D. Fiscal Spending Shock in the EB Model
First, the model predicts a positive wage-hours correlation because hours are determined by the marginal rate of substitution in the efficient bargaining scheme. Therefore, wage would increase with hours when productivity and/or labor market conditions improved.

Second, the model predicts a greater volatility in wage because the efficient bargain scheme gives too much flexibility to wage determination (Shimer, 2005). There are several ways to reduce the flexibility of wage determination. One way is to add extra adjustment cost to the wage determination, such as the rigid adjusting wage in Shimer (2005) and Hall (2005). Another way is to add extra frequency to wage bargain process, such as the staggered wage bargain in Gertler, Sala and Trigari (2008).

2.6.2 Alternative: Right-to-Manage Bargaining Scheme

To match the model-simulated moments (i.e., correlation and volatility) to the data, I consider an alternative bargaining scheme which is different from the efficient bargaining scheme (EB) in Section 2.6.1. The right-to-manage bargaining scheme (RTM) in Trigari (2006) could provide a negative correlation between wage and hours and explain a lower volatility of wage. The RTM bargaining refers to a model where the bargain agreement contracts hourly wage, but hours are unilaterally determined by employer ex-post to the wage bargain on the margin of per worker. As explained in Trigari (2006), the RTM scheme is motivated by the observed fact that hours are rarely an object in the bargaining agreement.

The solution of RTM hour is given by the optimal condition of employer

$$
\frac{\partial y_t}{\partial h_t} = w_t
$$

(2.33)

The RTM hours at $t$ are determined as

$$
\tilde{h}_t = \frac{(1 - \alpha)y_t}{w_tN_t}
$$

(2.34)
Implications from RTM Bargaining Solution: Slow Recovery

\[ \frac{\partial w_t}{\partial \theta_t} = \frac{\partial w_t}{\partial B_{t+1}} \frac{\partial B_{t+1}}{\partial \theta_t} > 0. \]

\[ \frac{\partial h_t}{\partial \theta_t} = \frac{\partial h_t}{\partial w_t} \frac{\partial w_t}{\partial \theta_t} < 0. \]

Consider a negative credit shock. A negative credit shock tightens the firm’s borrowing capacity and reduces the firm’s surplus of contracting employment. Because the borrowing limit reduces the firm’s surplus of contracting employment, the expected wage bargain falls. In response to a lower wage bargain, firms would extend the working hours in job contracts for the existing workforce instead of opening new vacancies during the recoveries. As investment projects were cut and the stock of working capital needed time to build, the demand of labor would not recover instantly. Even after the recession when the credit condition was easing and \( B_{t+1} \) increasing, \( w_t \) would not recover instantly because the working hours \( h_t \) is extending. Vacancy posting also rebounds slowly because the working hours extension dampens the firm’s motivation to create new jobs. This is the mechanism for how the interaction between intensive margin and financial friction can explain a slower jobless recovery after credit crunch.

Impulse Responses under RTM Bargaining Scheme

Figures 2.10, 2.11, 2.12 and 2.13 report the impulse responses of labor market variables to one standard deviation of various shocks in the model with RTM bargaining scheme.

- Figures 2.10 and 2.11 report that unemployment rates increased and new matches dropped after a negative shock of productivity and credit constraint.

- Wage decreased in Figure 2.10 because firms’ surplus was decreased by a negative productivity shock. This is consistent with the wage bargaining solution in Section 2.3.5. Hours increased in Figure 2.10 because wage decreased. This is consistent with the solution of RTM hours in Section 2.6.2.

- Figure 2.11 reveals that wage decreased and hours increased in response to a negative credit shock. A tightening credit limit would force firms to cut employment and investment projects. Thus, firms would bargain a lower wage for their financial budget (Section 2.3.5). Hours would increase as wage decreased (Section 2.6.2).

- The RTM bargaining model with the financial friction could explain why recessions after credit crunches are more jobless than others. A credit crunch decreases the wage bargaining. Firms would extend working hours of existing workforces as the wage decreased. In a recession after a severe credit crunch (such as the 2009-recession), employers could make
each employee would work longer and close new hires. Then in a recovery after the recession, the wage would not recover instantly because working hours would be extended. Employers could make each employee work longer and postpone new hires instead of raising wages or adding positions. This makes wage and employment recover slowly. This mechanism explains why the 2009-recession after the credit crunch featured greater unemployment and a jobless recovery. Bachmann (2012) [9] has a similar mechanism as this paper to explain the jobless recovery, but from the aspect of fixed cost of hiring and firing.

- Figures 2.12 and 2.13 report the impulse responses of labor market variables to fiscal policy shocks. Similar with Figure 2.8, an increase in lump-sum tax would cause endogenous variables to change, implying that Ricardian equivalence does not hold. This is because the shock to lump-sum transfers changed unemployment benefit in the government budget constraint. To be specific, an increase in lump-sum tax would increase the unemployment benefit to the unemployed, which increases the wage and decreases the working hours (Section 2.6.2). The increase in the wage reduces firm’s value of contracting an employment, thus firm opens less vacancies and the unemployment rate increases.

In Figure 2.13, an increase in government spending would decrease unemployment benefit, thus lower the motivation of unemployed workers to bargain a higher wage (Section 2.3.5). Firms would extend working hours as wage decreased. An increase in government spending would increase the total demand of consumption goods, thus motivates new employment and decreases unemployment rate.

Table 2.5: Comparing Moments of Data and Model, Using RTM Bargaining Scheme

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data</td>
<td>Model</td>
<td>Data</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \rho(w, h) )</td>
<td>-0.6234</td>
<td>-0.4342</td>
<td>-0.3970</td>
</tr>
<tr>
<td>( \rho(h, N) )</td>
<td>0.1047</td>
<td>0.8847</td>
<td>0.3039</td>
</tr>
<tr>
<td>( \rho(v, u) )</td>
<td>-0.9324</td>
<td>-0.8714</td>
<td>-0.9312</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \sigma(h)/\sigma(y) )</td>
<td>0.9057</td>
<td>0.8733</td>
<td>0.8000</td>
</tr>
<tr>
<td>( \sigma(w)/\sigma(y) )</td>
<td>0.6038</td>
<td>0.6424</td>
<td>0.7857</td>
</tr>
</tbody>
</table>

Table 2.5 displays simulated moments of model using the right-to-manage bargaining scheme. Compared to the Efficient Bargaining (EB) scheme in Table 2.4, the Right-to-Manage (RTM) bargaining scheme in Table 2.5 improved on at least two aspects. First, the RTM model repro-
Figure 2.10: Impulse Responses of Labor Market Variables to One Negative S.D. Productivity Shock in the RTM Model
Figure 2.11: Impulse Responses of Labor Market Variables to One Negative S.D. Credit Shock in the RTM Model
Figure 2.12: Impulse Responses of Labor Market Variables to One Positive S.D. Tax Shock in the RTM Model
Figure 2.13: Impulse Responses of Labor Market Variables to One Positive S.D. Fiscal Spending Shock in the RTM Model
duced a negative correlation between the wage rate and hours. This is consistent with employers' optimal condition of hours in the RTM bargaining scheme (Section 2.6.2).

Second, as seen in Table 2.5, the RTM model could reproduce a lower wage volatility in the search model. This is because in the RTM, the employer could adjust the working hours in addition to renegotiating the wage in response to exogenous shocks. When there is recession, the employer could make each employee work for longer time and close new hires instead of wage cutting or job separation. Then, when there is recovery, the employer could make each employee work longer and postpone new hires instead of raising wages or adding positions. This makes wages fluctuate less, and employment recovers slowly, especially after a recession followed by a severe credit crunch. The mechanism by which a right-to-manage bargaining scheme explains lower wage fluctuation and hours extension in the post-2009 recovery in this paper is similar to Bachmann (2012).

2.7 Conclusion

This paper constructs a model with labor market search and financial frictions to study the importance of the financial market to labor market fluctuations and to account for the observed jobless recovery after a credit crunch. Different from the earlier literature, the wage and employment are determined at both intensive and extensive margins in this paper. This paper also considers a right-to-manage bargaining scheme, which can explain two observed facts that the efficient bargaining scheme could not explain, i.e. lower wage volatility and negative correlation between the wage and hours.

The results of this paper reveal two main conclusions.

First, the model with financial frictions and two margins explain why unemployment in the 2009-recession was greater and the post-2009 jobless recovery was slower than the previous two. That is to say, a credit crunch in a recession and its amplification by financial frictions and the intensive margin could explain certain jobless recoveries. When there is a recession followed by a credit crunch, firms have to sell their working capital to reduce the debt; thus, both labor demand and asset prices fall in recession. The fall of collateral asset prices lowers firms' borrowing limits. Therefore, the impact of a credit crunch on employment is amplified.

Second, the model with a right-to-manage bargaining scheme can better explain hours extension and sluggish wage growth in post-2009 recovery. The model with a RTM bargaining scheme predicts that in a recovery firms would extend the working hours in job contracts for the existing workforce because wage recovers slowly and hours are unilaterally determined by the employer. This reduces the firms' surplus of contracting new employment. As a result, firms open fewer vacancies for future matches, and new employment recovers slowly.

The RTM bargain also predicts a lower fluctuation of wages. If hours are unilaterally deter-
mined by the employer, then when there is a recession, the employer could make each employee
work longer and close new hires instead of wage cutting or job separation. Then, when there
is a recovery, the employer could make each employee work longer and postpone new hires in-
stead of raise wages or add positions. This provides a much lower volatility in wage because the
employer could adjust the working hours in addition to renegotiating the wage in response to
exogenous shocks. This explains why the wage fluctuates less and employment recovers slowly,
especially after a recession followed by a severe credit crunch.

To make the findings and the mechanism transparent, the model abstracts from some di-
mensions that merit further study in the future. For example, it is a real model without money
which abstracts from impacts of monetary policy and its interactions with fiscal policy. In the
monetary history of the United States, in response to credit crunches and following recessions,
the central bank (The Federal Reserve) has introduced a variety of policy tools to foster eco-
nomic activity and to reduce the persistently high unemployment rate, including conventional
and unconventional policy tools. What are the impacts of these unconventional (monetary) pol-
icy tools on the recovery of the labor market? How do these policy tools interact with financial
market conditions? These are the topics to pursue in future study.
Chapter 3

The Macroeconomic Determinants of Outward FDI Flows: Evidence from China

3.1 Introduction

In the last few years, China’s outward foreign direct investment (OFDI) has soared and has begun to catch up with the inward foreign direct investment (IFDI). On the one hand, as shown in Figure 3.1, China had almost no outward flow of FDI until it joined the World Trade Organization in 2001. From 2002 to 2008, China’s outward FDI rose at a steady rate and then accelerated after the breakout of the global financial crisis in 2008. On the other hand, China’s inward foreign direct investment (IFDI) kept a steady growth rate before the crisis and then slowed down after the crisis. Figure 3.1 shows that China’s outward FDI has been rapidly catching up with the inward FDI after the financial crisis.

In section 2, we document several facts about China’s foreign direct investment after the financial crisis: diverging growth in outward FDI and inward FDI, and faster growth of China’s outward FDI into developed countries than into developing countries. These observations of China’s fast growing outward direct investment and its business cycles pose a broad set of questions to answer: What are the determinants of China’s outward direct investment? Why did China’s outward FDI surge after the financial crisis? What is the relationship between outward FDI and international business cycles? These are open questions.

The theoretical and empirical literature on China’s foreign direct investment typically focuses on the effects of inward FDI on domestic economic growth and the determinants of outward FDI; however, little attention has been paid to the impacts of domestic and international business cycles on the inward and outward flow of FDI, which is partly the focus of this
study.

To explain which macroeconomic factors are important to the flow of FDI, I first constructed an international business cycle model with a specification of flow of foreign direct investment and derived a reduced-form equation for the inward and outward FDI with respect to macroeconomic variables. I then estimated this equation with a panel dataset ranging from 2004 to 2013, which included bilateral inward and outward FDI between China and a number of host countries, as well as macroeconomic variables of China and the host countries that determine FDI flows. Data variables in estimation are stationary to align with the model. The panel estimation used a fixed-effects estimator.

The empirical evidence of this paper provides answers to the following questions:

[1] How do macroeconomic variables affect the flows of FDI? This paper finds that growth of China’s outward FDI is mainly driven by domestic variables, i.e. fall in domestic employment and rise in domestic production costs. The domestic financial variables, i.e. lending rate and capital price, have greater impact on China’s outward FDI than that of labor variables. Consistent with the literature, the inward FDI to China is mainly driven by cost variables in foreign countries.

[2] Do the macroeconomic differences between countries matter to the flow of FDI? The results indicate that China’s fast growing outward FDI from 2004 to 2013 is explained by two reasons: relative real appreciation in Chinese Yuan (CNY) and positive interest rate spread of China over other countries. The relative appreciation in Chinese Yuan has enhanced the purchasing power of Chinese companies for direct investment in foreign countries where the local currency relatively depreciated. The positive lending rate spreads between China and host countries attract more outward FDI from China to foreign destinations.

[3] Does the development level of a country matter to the determinants of FDI? The paper finds that capital price in a developed country is more effective in motivating China’s outward FDI than that in a developing country. In other words, Chinese investors are only attracted to cheaper capital in developed countries. Aguiar and Gopinath (2007) [1] found that developing countries, unlike developed countries, are characterized by excess volatility in capital inflows and frequent regime switches. Therefore, from the aspect of return to volatility, capital (stock) price in a developed countries is more stable, and a lower capital price in developed countries is more attractive to investors.

[4] Did the 2008 crisis structurally change China’s flow of FDI? This paper finds that after the 2008 crisis, China’s outward FDI, inward FDI and net outflows significantly changed by 1.27%, -0.61% and 1.88% on average per annum. This paper also observes an asymmetric
effect of international business cycles on the outward FDI before and after crisis. To be specific, this paper finds that the determinants of FDI flow changed after the crisis. Exchange rates and capital prices became more significant to China’s outward FDI after the crisis. Before the crisis, the flow of FDI was driven by reallocation of production (employment and lending rate). FDI would flow into destinations where production costs were lower. After the crisis, flow of FDI was driven by reallocation of assets (exchange rate and capital price). FDI would flow into destinations where assets could generate extra returns in currencies and in equity prices. This asymmetric effect is consistent with observations in industry-level data. It could be explained by the putty-clay effect on the link between shocks and business cycles by Gilchrist and Williams (2000).

The structure of this paper is organized into several sections. Section 2 introduces several facts about China’s outward FDI and Chinese policy and strategy on overseas investment. Section 3 reviews the literature on three strands: empirics of China’s outward FDI, international business cycles model, and links between FDI and business cycles. Section 4 builds a two-country open economy model which incorporates inward and outward FDI and macroeconomic variables in two countries. Section 5 displays data sources and how this paper deals with data to align with the model. Section 6 reports empirical evidence of the macroeconomic determinants of FDI flows and how the development level and crisis affect the determinants. Section 7 concludes this paper.

3.2 Facts and Policies of China’s Outward FDI and Business Cycles

3.2.1 Two Facts of China’s Outward FDI

We document two facts about China’s foreign direct investment: diverging growth in outward FDI and inward FDI and faster growth of China’s outward FDI into developed countries than into developing countries.

Figure 3.2 illustrates that China’s outward FDI to developed economies grows faster than that to developing economies. For example, the average growth rate of China’s outward FDI to France, United States and Japan is 73%, 64% and 49% respectively, which is much higher than the growth rate of FDI to Latin America, Africa, and Russia at 20%, 14% and 14% (See: Figure 3.3).

Figure 3.1 displays a diverging growth pattern: both China’s outward FDI and inward FDI have been growing, but outward FDI has been catching up with its inward FDI after the financial crisis. This fact implies that one possible reason for China’s outward FDI surge is that Chinese investors were looking for safe assets in developed countries after the financial crisis.
3.2.2 Chinese Business Cycles

The business cycle of China after the financial crisis in Figure 3.4 shows that asset prices in China decreased after the crisis as well. This can be interpreted as a portfolio balance of international assets, meaning that Chinese investors might sell-out the value-declining Chinese assets and buy-in the value-growing foreign assets after the financial crisis. Also, the post-crisis period as shown in Figure 3.4 witnesses a sharp increase in the commodity price (d) and a withered GDP growth rate (a). This provides another possible answer to the surge of China’s outward FDI. This might stem from the mixed effects of China’s growing domestic production cost on the supply side and slowing economic growth on the demand side.

3.2.3 Chinese Policy Strategy on Overseas Investment

Previous empirical studies of the outward FDI of China claim that the growth of China’s outward FDI represents a strategy driven by the central government policy and is mainly associated with natural resource seeking motives in developing economies (Huang and Wilkes, 2011; Cheung and Qian, 2009; Morck, Yeung and Zhao, 2008; Buckley et al., 2007). Making Chinese currency an international reserve currency will ease limits on overseas investments and capital controls. Beijing makes reforms on capital account liberalization to increase the attractiveness of Chinese currency to be included in the IMFs basket of reserve assets, known as special drawing rights (SDRs). Also, Beijing began to lead an Asian Infrastructure Investment Bank (AIIB) and a Silk Road Fund to promote its large-scale infrastructure investment in host countries. Beijing advanced its goal to make it easier for individuals and companies to invest overseas, e.g. qualified domestic institutional investors directly purchasing stocks and bonds in foreign markets, removing limits on such transactions, etc. Some shifts in industries of China’s overseas investment may represent a reform strategy driven by the central government. However, these capital account liberalization efforts aim to ease the limits which were used to hinder the outward investment. They are not used to motivate the outflow investment directly. Therefore, to find out what motivates the outward FDI is the focus of this paper.

3.3 Literature

This paper contributes to the empirical literature on the macroeconomic effects on inward and outward FDI of China. Typically the theoretical and empirical literature on foreign direct investment focuses on the roles and effects of FDI on domestic economic growth and economic conditions; however, little attention has been paid to the impacts of domestic and international business cycles on the flow of FDI. This paper uses an empirical approach to bridge the study of inward and outward FDI with the study of the international business cycle. The paper uses
recent data on China's foreign direct investments including the pre- & post-financial crisis period and focus on the impacts of pre- & post-crisis business cycles on the flow of FDI of China.

This paper is related to three strands of the literature on the empirics of China’s outward FDI and its determinants, the open economy business cycle models and the links between FDI and business cycles.

### 3.3.1 Empirics of China’s Flow of FDI

Based on analysis of data prior to 2011, Huang and Wilkes (2011) [48] concluded that the central government policy has become a main driving force of outward direct investment. Cheung and Qian (2009) [25] chose GDP growth and wages as host countries’ economic factors and used OLS regression to test the coefficients of host countries economic factors on China’s outward direct investment. They found that China’s investments in developed and developing countries are driven by different sets of factors. China’s ODI is driven by both market-seeking and resource-seeking motives. Morck, Yeung and Zhao (2008) [68] analyzed data prior to 2008 and revealed that China’s outward direct investment was mainly located in Asian neighborhoods and resource-rich Africa, mostly conducted by the state-owned enterprise with monopolistic power, and driven by government policy incentives. In earlier research, Buckley et al. (2007) [20] used official Chinese ODI data between 1984 and 2001 and found that China’s outward direct investment is associated with a high level of political risk and is biased toward the market-related economies and countries with rich natural resource endowments.

In general, based on prior-crisis data, the empirical studies on the outward FDI of China conclude that the growth of China’s outward FDI represents a strategy driven by the central government policy and is mainly associated with natural resource seeking motives in developing economies. The shortcoming of the existing literature on China’s outward FDI empirics lies in the choice of the sample period. Since their observations are based on prior-crisis data, they were unable to explain the facts revealed by post-crisis data: i.e., diverging growth in outward and inward FDI of China, faster growth of China’s outward FDI in a developed economy than in a developing economy, diversification in industries of the outward FDI, etc.

### 3.3.2 International Business Cycle Equilibrium Models

The literature on international business cycles dates back to the seminal contribution of Backus, Kehoe and Kydland (1992) [11]. They built a two-country stochastic growth model in which trade fluctuations reflect the dynamics of capital formation. One problem of the international business cycle model is that the model predicts a negative correlation between saving and investment which is inconsistent with the data (Baxter and Crucini, 1993 [14]; Backus, Kehoe
and Kydland, 1993 [10]). Therefore, if FDI is introduced in a traditional international business cycle model, it would predict a negative correlation between inflow FDI and outflow FDI, which contradicts U.S.-Canada FDI data (Petrosky-Nadeau, N., 2011). To solve the problem, Petrosky-Nadeau (2011) [73] built a model of FDI with a search-and-match framework which generated a positive correlation between inward and outward FDI in the short run.

The empirical literature on international business cycles includes Kose, Otrok and Whiteman (2003) [57] and Kose, Otrok and Whiteman (2008) [58]. They employed a Bayesian dynamic factor model to examine the common components in each economy that drive international business cycles. In addition, one strand of the literature draws attention to the spillover effects of monetary and fiscal policy in a domestic economy on the foreign economy by analyzing monetary and fiscal policy in an international economics framework (Clarida, Gali and Gertler, 2002 [28]; Erceg, Guerrieri and Gust, 2005 [35]; Auerbach and Gorodnichenko, 2012 [8]).

3.3.3 Flows of FDI and Business Cycles

This paper observes that increased inflows of FDI into China are accompanied by increased outflows of Chinese FDI abroad. This pattern of contemporaneous inflows and outflows of foreign direct investment for a host economy is not unique. It has been observed in a Canada-U.S. pair economy and within the core members of the European Union over 1985 to 2007 in Petrosky-Nadeau (2011). But the equilibrium models above tend to predict that capital would simultaneously flow in to high productivity and out of low productivity countries. This motivates an idea that the simultaneous growth of outward and inward FDI of China might be a mixed result of development facts in host countries along with international business cycles.

Blonigen (1997) [15] studied the impact of the declining dollar and the link between exchange rates and foreign direct investment. He argues that exchange rate movements may affect FDI because acquisitions involve firm-specific assets that can generate returns in currencies other than that used for purchase. This implies that Chinese acquisitions may be more likely in countries where real currency appreciates relative to RMB and in industries that involve firm-specific assets.

In addition, Gilchrist and Williams (2000) [41] studied the links between putty-clay investment and business cycles. They found that the putty-clay technology may result in deeper and steeper responses of investment to large productivity or factor price shocks in recessions than those in expansions. Their paper might shed light on our observation of asymmetric effects of international business cycles on outward FDI before and after the crisis in this paper. Some FDI investments are irreversible. Some of these foreign direct investments are called putty-clay technology, meaning that investment is not reversible once it is turned into durable goods. They may induce a putty-clay effect on the link between shocks and international business cycles.
When the economy is in an expansion, foreign capital may flow into the heavy assets, e.g. natural resource and manufacture etc, which are irreversible putty-clay technology. But when the economy is in a recession, foreign investment may redirect to liquid assets like financial assets.

### 3.4 Model in a Nutshell

To explain which factors are important to the inward and outward FDI of China, we construct a simple international business cycle model with a specification of domestic and foreign countries’ inward and outward foreign direct investments. The core of the model is the production of the domestic firm and foreign firm in the domestic country and foreign (host) country. Then we draw out the dependent variables to domestic outward FDI and reduced the representation of inward and outward FDI to a testable reduced form. The entire model is logged.

#### 3.4.1 FDI

Following Petrosky-Nadeau (2011) [73], the law of motion for the stock of foreign capital in a domestic economy is:

\[ q_t^* k_{fdi,t} = (1 - \delta) q_t^* k_{fdi,t-1}^* + m_t^* \]  

(3.1)

where \( m^* \) represents the inward FDI to a domestic economy and \( q_t \) represents the price of domestic capital/asset.

The law of motion for the stock of domestic capital in a foreign economy is:

\[ q_t^* k_{fdi,t} = (1 - \delta) q_t^* k_{fdi,t-1}^* + m_t \]  

(3.2)

where \( m \) represents outward FDI to a foreign economy and \( p^* \) represents the price of foreign capital/asset.

#### 3.4.2 Firm

Foreign firms in the domestic economy produce domestic intermediate goods in domestic price:

\[ y_{fdi,t}^* = A_t^* (n_{fdi,t}^*)^{1-\alpha} (k_{fdi,t}^*)^\alpha \]  

(3.3)

where \( y_{fdi,t}^* \) represents foreign firms’ production in the domestic economy, \( A_t^* \) represents foreign firms’ technology, and \( n_{fdi,t}^* \) represents foreign firms’ hire of domestic labor. The foreign firms maximize their profits \( p_t y_{fdi,t}^* - w_t n_{fdi,t}^* - r_t k_{fdi,t}^* \), \( p_t \) is the real price of domestic goods in the domestic economy. Firms in the domestic economy must pay wages and rent on capital in the local currency. \( w_t n_{fdi,t}^* \) is the labor cost of a foreign firm to hire in the domestic economy. \( r_t k_{fdi,t}^* \)
is the borrowing cost of foreign firms to invest in the domestic economy. $r_t$ is the interest rate on borrowing in local currency.

Domestic firms in the foreign economy produce foreign intermediate goods in foreign price:

$$y_{fdi,t} = A_t(n_{fdi,t})^{1-\alpha}(k_{fdi,t})^\alpha$$

where $y_{fdi,t}$ represents a domestic firm’s production in the foreign economy, and $A_t$ represents domestic firms’ technology, $n_{fdi,t}$ represents a domestic firms’ hire of foreign labor, $q^*_t$ represents price of foreign capital. The domestic firms maximize their profits $p^*_ty_{fdi,t} - w^*_tn_{fdi,t} - r^*_tk_{fdi,t}$. $p^*_t$ is the real price of foreign goods in foreign economy. Firms in the foreign economy must pay wages and rent on capital in the foreign currency. $w^*_tn_{fdi,t}$ is the labor cost of a domestic firm to hire in a foreign economy. $r^*_tk_{fdi,t}$ is the borrowing cost of domestic firms to invest in the foreign economy. $r^*_t$ is the interest rate of borrowing in foreign currency.

Domestic firms in the domestic economy produce domestic intermediate goods:

$$y_{d,t} = A_t(n_{d,t})^{1-\alpha}(k_{d,t})^\alpha$$

where $y_{d,t}$ represents a domestic firm’s production in the domestic economy, $n_{d,t}$ and $k_{d,t}$ represent domestic firm’s employment of labor and capital in the domestic economy. The domestic firms maximize their profits $p_ty_{d,t} - wtn_{d,t} - rtk_{d,t}$.

Foreign firms in the foreign economy produce foreign intermediate goods:

$$y^*_{d,t} = A^*_t(n^*_{d,t})^{1-\alpha}(k^*_{d,t})^\alpha$$

where $y^*_{d,t}$, $n^*_{d,t}$ and $k^*_{d,t}$ represent a foreign firm’s production, employment cost and capital rental cost in the foreign economy. The foreign firms maximize their profits $p^*ty^*_{d,t} - w^*tn^*_{d,t} - r^*tk^*_{d,t}$.

### 3.4.3 Production Aggregation

All domestically produced intermediate goods are aggregated into a final homogeneous good. The aggregation is by an Armington (1969) [6] aggregator. The Armington approach is normal for many questions in international macroeconomics. $\phi$ represents the elasticity of between domestic firm-made goods and foreign firm-made goods. This elasticity exists because the final goods producer (or consumers) are assumed with “love of variety” between the heterogeneous producer made goods. The Armington aggregator is a case of horizontal product differentiation. A special case of the Armington aggregator is the extreme preference of one goods to the other, when the elasticity of one goods equals one. The GDP (total expenditure) in a domestic economy
is written as:
\[ y_t = G(y_{d,t}, y_{fdi,t}^*) = [\phi(y_{d,t})^\tau + (1 - \phi)(y_{fdi,t}^*)^\tau]^{\frac{1}{\tau}} \] (3.7)

and the GDP in a foreign economy is:
\[ y_t^* = G(y_{d,t}^*, y_{fdi,t}^*) = [\phi(y_{d,t}^*)^\tau + (1 - \phi)(y_{fdi,t}^*)^\tau]^{\frac{1}{\tau}} \] (3.8)

### 3.4.4 Equilibrium Condition

The competitive equilibrium is a solution for the various macroeconomic aggregates. Appendix C.1 displays log-linearized solutions for first-order conditions and equilibrium equations around the deterministic steady state. The competitive equilibrium ensures that labor markets are clear in both domestic and foreign economies. The labor market clearing condition in the domestic economy is:
\[ n_{d,t} + n_{d,t}^* = n_t \] (3.9)
where \( n_t \) is the total domestic employment level.

The labor market clearing condition in the foreign economy is:
\[ n_{d,t}^* + n_{fdi,t} = n_t^* \] (3.10)
where \( n_t^* \) is the total foreign employment level.

### 3.4.5 Reduced-form

The reduced-form equation to estimate is an equilibrium equation of FDI as a function of domestic and foreign variables. To get the reduced-form equation, we log-linearized the first order conditions of domestic and foreign firms, GDP aggregation and market clearing conditions. Appendix C.1 displays the process to derive the reduced-form equation.

The reduced-form equation is:
\[
\left( \frac{\beta^*}{\alpha^* + \beta^*} - \frac{n_{fdi}}{n_d} \frac{\alpha^*}{\alpha^* + \beta^*} \right) k_{fdi,t} = r_t - r_t^* - \varepsilon_t + \left( \frac{\beta}{\alpha + \beta} - \frac{n_{fdi}^*}{n_d} \frac{\alpha}{\alpha + \beta} \right) k_{fdi,t}^*
\]
\[ + \frac{\alpha}{\alpha + \beta} \left( \frac{n}{n_d} n_t - (1 - \frac{n_{fdi}}{n_d})(w_t - r_t) \right) - \frac{\alpha^*}{\alpha^* + \beta^*} \left( \frac{n^*}{n_d} n_t^* - (1 - \frac{n_{fdi}^*}{n_d})(w_t^* - r_t^*) \right) \] (3.11)

where \( \alpha, \beta, \alpha^*, \beta^* \) are model specific parameters, which are shown in Appendix C.1. \( k_{fdi,t}^* \) and \( k_{fdi,t} \) are endogenous of \( \{q_t, q_t^*, m_t, m_t^*\} \) from Equations (1) and (2). Both variables are also endogenous with all other exogenous variables \( \{n_t, n_t^*, \varepsilon_t, w_t, w_t^*, r_t, r_t^*\} \). Therefore, the final reduced-form of bilateral FDI \( \{m_t, m_t^*\} \), is a function of \( \{n_t, n_t^*, \varepsilon_t, w_t, w_t^*, r_t, r_t^*, q_t, q_t^*\} \).
3.5 Data

3.5.1 Dataset

We assembled a bilateral country-level dataset that includes China’s inward and outward FDI data for China and common business cycle variables of China and FDI host countries. We excluded the continent-level data because countries are heterogeneous and macroeconomic data are not available in continental level. The host countries included in the dataset are Australia, Canada, France, Germany, Indonesia, Japan, Mexico, Russia, Singapore, United Kingdom, and the United States.

We excluded Hong Kong S.A.R. of China, Macau S.A.R. of China, the Cayman Islands and the Virgin Islands, which are the traditional offshore funds investment targets of China. These offshore funds targets are more related to China’s overseas investment strategy than their own business cycles. We excluded New Zealand and the Republic of Korea from the country-level sample since their data include negative outflow FDI which indicates that at least one of the components of FDI is negative and not offset by positive amounts of the remaining components. These instances of reverse investment or disinvestment could cause complex terms in dependent variable logY.

We constructed the inward and outward FDI data for each host country then compiled the FDI data with macroeconomic data of each host country and got a panel data set.

3.5.2 Data Sources

The bilateral (inward and outward) FDI data of China categorized by country from 2004 to 2013 are from the National Bureau of Statistics of China (NBS) and the United Nation Conference on Trade and Development World Investment Reports (UNCTAD) at an annual frequency. The State Administration of Foreign Exchange of China (SAFE) has data on China’s international investment position that includes China’s net position of international assets (e.g. direct investment, portfolio investment and other investment abroad, reserve assets) and the net position of international liabilities (e.g. direct investment, portfolio investment and other investments in China) from 2004 to 2014. The business cycle variables of China and FDI host countries are determined by the reduced-form model. The data of Chinese and international business cycles are from the International Financial Statistics (IFS) from the International Monetary Funds (IMF) and the World Development Indicators (WDI) from the World Bank (WB).

3.5.3 Matching the Data to the Model

The reduced-form equation requires the data of dependent variables \( \{m_t, m^*_t\} \) and explanatory variables \( \{n_t, n^*_t, ex_t, w_t, w^*_t, r_t, r^*_t, q_t, q^*_t\} \).
Table 3.1 displays the variables in the reduced-form model and their corresponding data, data units and data sources. Since the price of capital \( q_t \) is unobservable, we used stock price index as a proxy of capital price. For countries that do not have a wage rates index, we used compensation of employees to construct an index (index of 2010=100) which is consistent with the wage rate index. The BIS real effective exchange rate index is the same weighted averages of bilateral exchange rates adjusted by relative consumer prices. An increase in the index indicates an appreciation.

Table 3.1: Variables and Data Sources (2004-2013)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data</th>
<th>Unit</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FDI:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( m_t )</td>
<td>Outward FDI from China</td>
<td>Current USD</td>
<td>NBS/UNCTAD</td>
</tr>
<tr>
<td>( m_t^\ast )</td>
<td>Inward FDI to China</td>
<td>Current USD</td>
<td>NBS/UNCTAD</td>
</tr>
<tr>
<td><strong>Macro:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( e_t )</td>
<td>Real Effective Exchange Rate</td>
<td>Index</td>
<td>IMF/BIS</td>
</tr>
<tr>
<td>( n_t &amp; n_t^\ast )</td>
<td>Employment</td>
<td>Persons</td>
<td>IMF</td>
</tr>
<tr>
<td>( w_t &amp; w_t^\ast )</td>
<td>Wage Rate</td>
<td>Index</td>
<td>IMF/WB/OECD</td>
</tr>
<tr>
<td>( r_t &amp; r_t^\ast )</td>
<td>Lending Rate</td>
<td>Percent</td>
<td>IMF</td>
</tr>
<tr>
<td>( q_t &amp; q_t^\ast )</td>
<td>Stock Price</td>
<td>Index</td>
<td>IMF</td>
</tr>
</tbody>
</table>

Note: The data ranges from 2004 to 2013 at an annual frequency. The exchange rate index is real.

### 3.6 Results

#### 3.6.1 Software and Data Preparation

The panel analysis uses the Matlab panel toolbox provided by Álvarez, Barbero and Zofío [4]. The panel estimation uses a fixed-effects estimator. The use of the fixed-effects (within) estimator is motivated by some circumstances where individual effects are correlated with the explanatory variables to capture unobservable heterogeneity (Baltagi, 2008 [12]).

To align the data variables with the stationary model, data variables to be estimated must be logged and stationary. Thus, data variables with a unit root must be differenced to be stationary. First, we use Fisher-ADF (Choi, 2011 [26]; Fisher, 1925 [37]) to test the stationarity of panel data. We find that the data variables of domestic employment, domestic wage, and foreign wage are I(1); other variables are I(0). Then, I(1) variables \( \{ n_t, w_t, w_t^\ast \} \) are log-differenced to be I(0) before estimation. Other variables are logged. Therefore, in the interpretation of estimation results, the coefficients of log-differenced variables should be interpreted as a percentage-to-
percentage impact on logged variables. The actual impact should be the coefficients of log-differenced variables divided by a hundred.

In the estimation results, the domestic country is China and the foreign country represents the other eleven host countries where the bilateral FDI flows into and from China.

### 3.6.2 The Determinants of China’s Outward FDI

We consider the dependent variables under three cases: the flow of outward foreign direct investment from the domestic country (China) to the foreign country (eleven host countries); the flow of inward foreign direct investment from the foreign country to the domestic country; and the net outflow (outward - inward) of foreign direct investment from domestic to foreign countries. The FDI net outflows, also called net foreign investment, is an important component for a country’s net capital outflow, which is usually linked to the domestic and global macroeconomic conditions, e.g. conditions in loanable funds market and international foreign exchange market. The three cases investigate the impacts of international and Chinese business cycles on the unilateral flow of FDI and bilateral flow of FDI in one experiment. Therefore, the dependent variables are \{\log(ODI), \log(FDI), \log(ODI) - \log(FDI)\}. The explanatory variables are composed of \{d(\log(n_t)), \log(n_t^*), \log(ex_t), d(\log(w_t)), \log(r_t), d(\log(w_t^*)), \log(r_t^*), \log(q_t), \log(q_t^*)\} where * represents foreign country variable.

### Macroeconomic Determinants of Bilateral FDI Flows

The panel regression results of the outward FDI are displayed in Table 3.2. Columns 1-3 in Table 3.2 report estimations of three dependent variables: outward FDI, inward FDI, and net outflows.

Column 1 reports the estimates of coefficients of outward FDI from China to a destination country regardless of the inward FDI into China. The estimates in column 1 suggest the following findings:

- **[1]** The flow of outward FDI from China is mainly driven by domestic variables, i.e. fall in domestic employment and rise in domestic production costs. This is consistent with our model prediction that higher domestic production cost (labor and capital) would drive up outward FDI to foreign countries.

- **[2]** The rise of foreign employment and the fall of domestic employment explain part of the increase in outward FDI from China to foreign destination countries. For example, for each percent increase in foreign employment, the average increase in outward FDI to foreign country is 5.25%. For each percent decrease in employment of China, the average increase of outward FDI to foreign country is 1.23%.
Table 3.2: Panel Estimation of Bilateral FDI, Fixed Effects

<table>
<thead>
<tr>
<th>Varname</th>
<th>Outward FDI</th>
<th>Inward FDI</th>
<th>Net Outflows</th>
</tr>
</thead>
<tbody>
<tr>
<td>real exchange rate</td>
<td>−0.33</td>
<td>−0.01</td>
<td>−0.31</td>
</tr>
<tr>
<td></td>
<td>(1.63)</td>
<td>(0.74)</td>
<td>(1.81)</td>
</tr>
<tr>
<td>foreign employment</td>
<td>5.25*</td>
<td>0.67</td>
<td>4.58</td>
</tr>
<tr>
<td></td>
<td>(2.91)</td>
<td>(1.33)</td>
<td>(3.22)</td>
</tr>
<tr>
<td>domestic employment</td>
<td>−122.79***</td>
<td>14.97</td>
<td>−137.76***</td>
</tr>
<tr>
<td></td>
<td>(35.19)</td>
<td>(16.09)</td>
<td>(38.95)</td>
</tr>
<tr>
<td>foreign lending rate</td>
<td>−0.39</td>
<td>−0.22*</td>
<td>−0.17</td>
</tr>
<tr>
<td></td>
<td>(0.26)</td>
<td>(0.12)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>domestic lending rate</td>
<td>4.40***</td>
<td>−0.57</td>
<td>4.98***</td>
</tr>
<tr>
<td></td>
<td>(1.24)</td>
<td>(0.57)</td>
<td>(1.38)</td>
</tr>
<tr>
<td>foreign wage</td>
<td>3.01</td>
<td>2.84**</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>(2.91)</td>
<td>(1.33)</td>
<td>(3.22)</td>
</tr>
<tr>
<td>domestic wage</td>
<td>−18.45**</td>
<td>−0.46</td>
<td>−17.99**</td>
</tr>
<tr>
<td></td>
<td>(7.96)</td>
<td>(3.64)</td>
<td>(8.81)</td>
</tr>
<tr>
<td>foreign capital (stock) price</td>
<td>−0.49</td>
<td>−0.19</td>
<td>−0.30</td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td>(0.24)</td>
<td>(0.59)</td>
</tr>
<tr>
<td>domestic capital (stock) price</td>
<td>1.18***</td>
<td>−0.12</td>
<td>1.30***</td>
</tr>
<tr>
<td></td>
<td>(0.34)</td>
<td>(0.15)</td>
<td>(0.38)</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>−14.87</td>
<td>6.03</td>
<td>−20.90**</td>
</tr>
<tr>
<td></td>
<td>(9.47)</td>
<td>(4.33)</td>
<td>(10.48)</td>
</tr>
<tr>
<td>N observations</td>
<td>99</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>R-squared =</td>
<td>0.641</td>
<td>0.156</td>
<td>0.601</td>
</tr>
</tbody>
</table>

Note: Data variables of domestic labor, foreign wage and domestic wage are log-differenced. Other data variables are logged.

[3] The domestic wage has significant but little effect on the outward FDI. For each percent increase in domestic wage, the average decrease in outward FDI is 0.18%.

[4] The domestic financial variables, i.e. lending rate and capital price, have greater impacts on China’s outward FDI. For example, for each percent increase in domestic lending rate and domestic capital (proxy by stock price index), the average increase in outward FDI is 4.40% and 1.18%.

Column 2 reports the estimates of coefficients of inward FDI from a country to China. The inward FDI to China is mainly driven by cost variables in foreign countries, i.e. foreign lending rate and wage. The estimates in column 2 report the following findings:

[1] To be specific, for each percent increase in foreign lending rate, the average decrease in inward FDI to China is 0.22%.
It is an interesting finding that a higher domestic lending rate would increase the outward FDI from domestic to foreign, but a higher foreign lending rate would decrease the inward FDI from foreign to domestic. This is opposite to our model prediction that a higher foreign lending rate would increase the inward FDI to domestic countries. This is not surprising because Chinese authority encourages domestic companies to issue bonds in foreign countries but keeps foreign companies from issuing bonds in China. As a result, foreign companies should finance their FDI to China in foreign countries so that a higher foreign lending rate would decrease the inward FDI to China.

The foreign wage has a little but significant effect on the inward FDI. A one percent increase in the foreign wage would increase the inward FDI to China by 0.03% on average. This finding is consistent with empirical evidence based on China’s inward FDI data before 2004 when labor cost was one of the determinants for inward FDI to China (Ho, 2004 [45]; Buckley et al., 2007 [20]; Ali and Guo, 2005 [2]).

Column 3 reports coefficients estimates of net outflows (outward-inward) of FDI from China. The results in column 3 are consistent with the determinants of outward FDI flows from China. Net outflows of FDI from China are mainly driven by a decrease in domestic employment and an increase in domestic production costs. To be specific, for each percent increase in domestic employment, lending rate, wage and capital price, the average change in net outflows of FDI is -1.37%, 4.98%, -0.18%, and 1.30%. This indicates that higher borrowing cost in China has become a major driving force of China’s net outflows of FDI from 2004 to 2013.

**Impacts of Macro-level Differences on the Flow of FDI?**

Several papers attempt to address the roles of comparative advantage for FDI incentives (Nachum et.al, 2000 [70]; Qiu, 2003 [75]; Markusen, 2005 [64]; Claro, 2009 [29]; Jang and Hyun, 2012 [50]). These papers mainly focus on the productivity differences across sectors and industries, and how these differences affect sectoral FDI between two countries. But how would differences in macroeconomic conditions between two countries affect their bilateral FDI flow? The macroeconomic effect of comparative differences on FDI flow is rarely discussed.

This section will examine the implications of differences in macroeconomic conditions on the FDI flow. The explanatory variables are the differences between macroeconomic variables of foreign countries and domestic countries (China). The dependent variables are outward FDI, inward FDI and net FDI outflows. Using difference as a variable allows us to explore how differences in international business cycles would explain FDI direction and size. The result of panel estimation of differences in international business cycles on flows of FDI is displayed in Table 3.3.
Table 3.3: What differences within countries determine the flow of FDI

<table>
<thead>
<tr>
<th>Varname</th>
<th>Outward FDI</th>
<th>Inward FDI</th>
<th>Net Outflows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign - China: real exchange rate</td>
<td>-4.82***</td>
<td>0.37</td>
<td>-5.20***</td>
</tr>
<tr>
<td></td>
<td>(1.40)</td>
<td>(0.50)</td>
<td>(1.56)</td>
</tr>
<tr>
<td>Foreign - China: employment</td>
<td>3.74</td>
<td>4.40</td>
<td>-0.65</td>
</tr>
<tr>
<td></td>
<td>(9.96)</td>
<td>(3.57)</td>
<td>(11.09)</td>
</tr>
<tr>
<td>Foreign - China: lending rate</td>
<td>-0.65**</td>
<td>-0.15</td>
<td>-0.50</td>
</tr>
<tr>
<td></td>
<td>(0.31)</td>
<td>(0.11)</td>
<td>(0.34)</td>
</tr>
<tr>
<td>Foreign - China: wage</td>
<td>5.10</td>
<td>2.79**</td>
<td>2.30</td>
</tr>
<tr>
<td></td>
<td>(3.62)</td>
<td>(1.29)</td>
<td>(4.03)</td>
</tr>
<tr>
<td>Foreign - China: capital (stock) price</td>
<td>-0.46</td>
<td>-0.02</td>
<td>-0.43</td>
</tr>
<tr>
<td></td>
<td>(0.34)</td>
<td>(0.12)</td>
<td>(0.38)</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>5.75***</td>
<td>6.38***</td>
<td>-0.63</td>
</tr>
<tr>
<td></td>
<td>(0.44)</td>
<td>(0.16)</td>
<td>(0.49)</td>
</tr>
</tbody>
</table>

Note: Data variables of “employment” and “wage” are log-differenced. Other data variables are logged.

Columns 1-3 of Table 3.3 provide two possible reasons that help to explain why China’s outward FDI has been fast growing from 2004 to 2013: relative appreciation in Chinese Yuan (CNY) and positive interest rate spread of China over other countries.

[1] Column (1) indicates that appreciation in domestic currency or depreciation in foreign currency would create greater motivation for China’s outward FDI. For instance, 1% relative appreciation in domestic currency would result in an average of 4.82% increase in outward FDI. Exchange rate here is measured by the real effective exchange rate (REER) of all countries. From 2004 to 2013, REER of CNY has appreciated by 37.8%. During the same period, REER of USD, EUR and JPY have depreciated by 12.6%, 7.2% and 25.4%. The relative appreciation in Chinese Yuan has enhanced the purchasing power of Chinese companies to direct investment in foreign countries where local currency relatively depreciated.

[2] Relative lower lending rates in foreign countries would attract more outward FDI to foreign destinations. For instance, an increase of one percent in the lending rate spread between China and foreign countries would result in an average 0.65% increase in outward FDI to the foreign countries. This result is consistent with the finding in Table 3.2 that raising borrowing cost in China motivates Chinese investors to borrow and invest abroad. Also, data indicated that there was a constant positive interest rate spread between China and
host countries. For example, during the sample period (2004-2013), the average lending rate spreads between China and Japan, US, UK are 4.33%, 1.18%, 3.32%.

[3] Column (2) indicates that relative increase in foreign labor cost has significance in the explanation of inward FDI to China from 2004 to 2013. This finding also aligns with results in column (2) of Table 3.2 and the empirical evidence based on China’s inward FDI data before 2004 (Ho, 2004 [45]; Buckley et al., 2007 [20]; Ali and Guo, 2005 [2]).

[4] Column (3) indicates that China’s net outflows of FDI are almost a result of real relative appreciation in CNY. From Figure 3.1, we can tell that China’s outward FDI grew faster than inward FDI, though both had been increasing from 2004 to 2013. Also, we know that the constant positive lending rate spread between China and foreign countries helps to explain China’s outward growing FDI. But from column (2), the positive lending rate spread had no significance on lowering inward FDI to China because most foreign companies had to finance their FDI out of China. Therefore, the positive lending rate spread may not support the growth of China’s net FDI outflows because it could support the growth of both outward and inward FDI contemporaneously. That is the reason why real relative appreciation in CNY matters more to China’s fast growing net FDI outflows from 2004 to 2013.

3.6.3 The Determinants of FDI Destination: Developed Countries vs. Developing Countries

As seen in Figure 3.2, the outward FDI from China to developed countries has grown faster than to developing countries since 2007, suggesting that the development level of a country matters to determinants of FDI.

As developed and developing countries show different degrees of development, freedoms of market and exposure to international business, pooling them in one sample would cause too much heterogeneity. But treat them as individual countries would lose too many degrees of freedom. Motivated by this issue, we divided the countries into two groups: developed economies (Australia, Canada, France, Germany, Japan, Singapore, UK, US) and developing economies (Indonesia, Mexico, Russia).

Table 3.4 uses the entire sample to test whether a country’s development level matters to the FDI determinants. To test the development-level effect, interaction variables were added to each foreign variable where * denotes interaction with a developed country. The inclusion of interaction variables allows one to test whether the partial effect of variables depends on the development level.

Table 3.4 reports the following findings:
Table 3.4: Comparing developed with developing countries in entire sample with dummy variable

<table>
<thead>
<tr>
<th>Varname</th>
<th>Outward FDI</th>
<th>Inward FDI</th>
<th>Net Outflows</th>
</tr>
</thead>
<tbody>
<tr>
<td>real exchange rate</td>
<td>−1.36</td>
<td>−0.10</td>
<td>−1.25</td>
</tr>
<tr>
<td></td>
<td>(3.20)</td>
<td>(1.43)</td>
<td>(3.49)</td>
</tr>
<tr>
<td>foreign employment</td>
<td>2.72</td>
<td>−7.67</td>
<td>10.39</td>
</tr>
<tr>
<td></td>
<td>(11.16)</td>
<td>(4.99)</td>
<td>(12.19)</td>
</tr>
<tr>
<td>domestic employment</td>
<td>−117.65***</td>
<td>11.55</td>
<td>−129.21***</td>
</tr>
<tr>
<td></td>
<td>(35.96)</td>
<td>(16.08)</td>
<td>(39.29)</td>
</tr>
<tr>
<td>foreign lending rate</td>
<td>−0.03</td>
<td>0.09</td>
<td>−0.12</td>
</tr>
<tr>
<td></td>
<td>(1.42)</td>
<td>(0.63)</td>
<td>(1.55)</td>
</tr>
<tr>
<td>domestic lending rate</td>
<td>5.33***</td>
<td>−0.80</td>
<td>6.14***</td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
<td>(0.63)</td>
<td>(1.54)</td>
</tr>
<tr>
<td>foreign wage</td>
<td>4.67</td>
<td>0.96</td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td>(4.00)</td>
<td>(1.79)</td>
<td>(4.38)</td>
</tr>
<tr>
<td>domestic wage</td>
<td>−17.05**</td>
<td>−0.75</td>
<td>−16.29*</td>
</tr>
<tr>
<td></td>
<td>(8.05)</td>
<td>(3.60)</td>
<td>(8.80)</td>
</tr>
<tr>
<td>foreign capital (stock) price</td>
<td>0.81</td>
<td>0.77</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>(1.52)</td>
<td>(0.68)</td>
<td>(1.66)</td>
</tr>
<tr>
<td>domestic capital (stock) price</td>
<td>0.92**</td>
<td>−0.16</td>
<td>1.09**</td>
</tr>
<tr>
<td></td>
<td>(0.38)</td>
<td>(0.17)</td>
<td>(0.41)</td>
</tr>
<tr>
<td>real exchange rate*</td>
<td>−0.82</td>
<td>−0.59</td>
<td>−0.23</td>
</tr>
<tr>
<td></td>
<td>(3.90)</td>
<td>(1.74)</td>
<td>(4.26)</td>
</tr>
<tr>
<td>foreign employment*</td>
<td>4.96</td>
<td>9.53*</td>
<td>−4.56</td>
</tr>
<tr>
<td></td>
<td>(11.02)</td>
<td>(4.93)</td>
<td>(12.04)</td>
</tr>
<tr>
<td>foreign lending rate*</td>
<td>−0.26</td>
<td>−0.30</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(1.43)</td>
<td>(0.64)</td>
<td>(1.56)</td>
</tr>
<tr>
<td>foreign wage*</td>
<td>−3.25</td>
<td>2.57</td>
<td>−5.83</td>
</tr>
<tr>
<td></td>
<td>(5.54)</td>
<td>(2.48)</td>
<td>(6.06)</td>
</tr>
<tr>
<td>foreign capital (stock) price*</td>
<td>−2.83*</td>
<td>−0.64</td>
<td>−2.19</td>
</tr>
<tr>
<td></td>
<td>(1.64)</td>
<td>(0.73)</td>
<td>(1.80)</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>−7.77</td>
<td>13.59*</td>
<td>−21.37</td>
</tr>
<tr>
<td></td>
<td>(16.45)</td>
<td>(7.36)</td>
<td>(17.98)</td>
</tr>
<tr>
<td>N observations:</td>
<td>99</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.667</td>
<td>0.251</td>
<td>0.639</td>
</tr>
</tbody>
</table>

Note: * represents an interaction term for developed country. Data variables of domestic labor, foreign wage and domestic wage are log-differenced. Other data variables are logged.

[1] In general, business cycles in developed and developing countries did not make huge differences between their impacts on the outward FDI and net outflows of FDI. As found
in Table 3.2, domestic variables mainly drive the outward FDI, and financial variables have greater impact on the outward FDI than labor variables.

[2] However, the capital price interaction variable in column (1) displays that development level of a country matters to the determinants of FDI. For instance, a 1% decrease in the capital price in the developed countries would increase China’s outward FDI to the developed countries by 2.83% on average. That is to say, capital price in the developed countries is more effective for motivating China’s outward FDI than that in the developing countries. In other words, Chinese investors are only attracted to cheaper capital in the developed countries.

One possible explanation for this fact is given by Aguiar and Gopinath (2007) [1]. Developing countries, unlike developed countries, are characterized by excess volatility in capital inflows and frequent regime switches. On the other hand, developed countries are characterized by a relatively stable trend. From the aspect of return to volatility, capital (equity) prices in developed countries are more stable; therefore, the lower capital price in the developed countries is more attractive to investors.

3.6.4 The Determinants of FDI: Prior- vs. Post-crisis

In Figure 3.1, Section 3.1 and Section 3.2.2, we observed that China’s outward and inward FDI rose at a steady rate during the prior-crisis period; then outward FDI accelerated after the crisis while inward FDI slowed down. This poses a question of whether divergent FDI flow prior- and post-crisis is related to the portfolio balance of international asset or Chinese business cycles on aggregate supply and demand. In this section, we analyze the differences in determinants of FDI flow from China to host countries between prior- and post-crisis.

There is a possibility that the economic crisis could change the economic structure of an entire economy. This happened in the late-1990s during the Asian financial crisis and early-1980s during the Latin America debt crisis. This poses a question that whether a change in the determinants of FDI after the crisis is a result of the economic structural change. Therefore, to avoid debate on possible structural change, we estimated the entire sample with a dummy for crisis.

Table 3.5 displays the panel estimation with fixed-effects on the entire sample with a dummy for the post-crisis. It is obvious that after the 2008 global crisis, China’s outward FDI, inward FDI and net outflows changed by 1.27%, -0.61% and 1.88% on average per annum. These findings are consistent with our observations in Figure 3.1 and Section 3.2.2.

Table 3.6 reports the results of panel estimation with interacted foreign variables. The interacted domestic variables are not in this regression because the recent crisis has had greater
Table 3.5: Panel Regression with post-crisis = 1

<table>
<thead>
<tr>
<th>Varname</th>
<th>Outward FDI</th>
<th>Inward FDI</th>
<th>Net Outflows</th>
</tr>
</thead>
<tbody>
<tr>
<td>real exchange rate</td>
<td>−1.19</td>
<td>0.39</td>
<td>−1.58</td>
</tr>
<tr>
<td></td>
<td>(1.62)</td>
<td>(0.75)</td>
<td>(1.73)</td>
</tr>
<tr>
<td>foreign employment</td>
<td>4.19</td>
<td>1.18</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>(2.85)</td>
<td>(1.29)</td>
<td>(3.05)</td>
</tr>
<tr>
<td>domestic employment</td>
<td>−120.79***</td>
<td>14.00</td>
<td>−134.80***</td>
</tr>
<tr>
<td></td>
<td>(34.09)</td>
<td>(1.17)</td>
<td>(36.52)</td>
</tr>
<tr>
<td>foreign lending rate</td>
<td>−0.14</td>
<td>−0.35***</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>(0.27)</td>
<td>(0.12)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>domestic lending rate</td>
<td>3.65***</td>
<td>−0.20</td>
<td>3.866***</td>
</tr>
<tr>
<td></td>
<td>(1.234)</td>
<td>(0.57)</td>
<td>(1.33)</td>
</tr>
<tr>
<td>foreign wage</td>
<td>3.96</td>
<td>2.38*</td>
<td>1.57</td>
</tr>
<tr>
<td></td>
<td>(2.84)</td>
<td>(1.29)</td>
<td>(3.05)</td>
</tr>
<tr>
<td>domestic wage</td>
<td>4.26</td>
<td>−11.43**</td>
<td>15.70</td>
</tr>
<tr>
<td></td>
<td>(11.94)</td>
<td>(5.43)</td>
<td>(12.79)</td>
</tr>
<tr>
<td>foreign capital (stock) price</td>
<td>−0.17</td>
<td>−0.35</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td>(0.24)</td>
<td>(0.57)</td>
</tr>
<tr>
<td>domestic capital (stock) price</td>
<td>0.43</td>
<td>0.23</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>(0.45)</td>
<td>(0.20)</td>
<td>(0.48)</td>
</tr>
<tr>
<td>post-crisis</td>
<td>1.27**</td>
<td>−0.61***</td>
<td>1.88***</td>
</tr>
<tr>
<td></td>
<td>(0.50)</td>
<td>(0.23)</td>
<td>(0.54)</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>−8.17</td>
<td>2.80</td>
<td>−10.97</td>
</tr>
<tr>
<td></td>
<td>(9.55)</td>
<td>(4.35)</td>
<td>(10.24)</td>
</tr>
<tr>
<td>N observations:</td>
<td>99</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.668</td>
<td>0.225</td>
<td>0.653</td>
</tr>
</tbody>
</table>

Note: Data variables of domestic labor, foreign wage and domestic wage are log-differenced. Other data variables are logged.

Impacts on the developed economy than the domestic economy. Following this, the paper asked whether the global economy changes (before and after crisis) would affect the inflow and outflow FDI. Therefore, the domestic economy change (before and after crisis) is not considered in the regression of Table 3.6. * represents an interaction term with a dummy for post-crisis. The following are notable findings of estimation with post-crisis dummy interactions:

1. China’s outward FDI is mainly driven by domestic variables no matter before or after the crisis.

2. Exchange rate and capital price became more significant to China’s outward FDI after the crisis. For instance, after the crisis, a 1% real depreciation in foreign currency would cause

94
Table 3.6: Panel Regression with dummy of post-crisis

<table>
<thead>
<tr>
<th>Varname</th>
<th>Outward FDI</th>
<th>Inward FDI</th>
<th>Net Outflows</th>
</tr>
</thead>
<tbody>
<tr>
<td>real exchange rate</td>
<td>0.01</td>
<td>0.43</td>
<td>−0.41</td>
</tr>
<tr>
<td></td>
<td>(1.77)</td>
<td>(0.82)</td>
<td>(1.92)</td>
</tr>
<tr>
<td>foreign employment</td>
<td>5.47</td>
<td>1.85</td>
<td>3.61</td>
</tr>
<tr>
<td></td>
<td>(3.95)</td>
<td>(1.83)</td>
<td>(4.27)</td>
</tr>
<tr>
<td>domestic employment</td>
<td>−79.35**</td>
<td>21.24</td>
<td>−100.60**</td>
</tr>
<tr>
<td></td>
<td>(38.98)</td>
<td>(18.12)</td>
<td>(42.28)</td>
</tr>
<tr>
<td>foreign lending rate</td>
<td>−0.14</td>
<td>−0.15</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.60)</td>
<td>(0.28)</td>
<td>(0.65)</td>
</tr>
<tr>
<td>domestic lending rate</td>
<td>2.90**</td>
<td>−0.29</td>
<td>3.19**</td>
</tr>
<tr>
<td></td>
<td>(1.34)</td>
<td>(0.62)</td>
<td>(1.46)</td>
</tr>
<tr>
<td>foreign wage</td>
<td>3.58</td>
<td>1.77</td>
<td>1.81</td>
</tr>
<tr>
<td></td>
<td>(3.00)</td>
<td>(1.39)</td>
<td>(3.25)</td>
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<tr>
<td>domestic wage</td>
<td>6.74</td>
<td>−11.92**</td>
<td>18.67</td>
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<tr>
<td></td>
<td>(12.29)</td>
<td>(5.71)</td>
<td>(13.33)</td>
</tr>
<tr>
<td>foreign capital (stock) price</td>
<td>−0.90</td>
<td>−0.40</td>
<td>−0.49</td>
</tr>
<tr>
<td></td>
<td>(0.94)</td>
<td>(0.43)</td>
<td>(1.02)</td>
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<tr>
<td>domestic capital (stock) price</td>
<td>0.56</td>
<td>0.23</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>(0.49)</td>
<td>(0.22)</td>
<td>(0.53)</td>
</tr>
<tr>
<td>real exchange rate*</td>
<td>−2.47*</td>
<td>−0.43</td>
<td>−2.03</td>
</tr>
<tr>
<td></td>
<td>(1.34)</td>
<td>(0.62)</td>
<td>(1.45)</td>
</tr>
<tr>
<td>foreign employment*</td>
<td>0.00</td>
<td>0.02</td>
<td>−0.02</td>
</tr>
<tr>
<td></td>
<td>(0.26)</td>
<td>(0.12)</td>
<td>(0.28)</td>
</tr>
<tr>
<td>foreign lending rate*</td>
<td>−0.01</td>
<td>−0.20</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>(0.48)</td>
<td>(0.22)</td>
<td>(0.52)</td>
</tr>
<tr>
<td>foreign wage*</td>
<td>−1.44</td>
<td>2.01</td>
<td>−3.45</td>
</tr>
<tr>
<td></td>
<td>(4.49)</td>
<td>(2.08)</td>
<td>(4.86)</td>
</tr>
<tr>
<td>foreign capital (stock) price*</td>
<td>2.79**</td>
<td>0.33</td>
<td>2.45*</td>
</tr>
<tr>
<td></td>
<td>(1.24)</td>
<td>(0.57)</td>
<td>(1.34)</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>−16.05</td>
<td>0.18</td>
<td>−16.24</td>
</tr>
<tr>
<td></td>
<td>(13.49)</td>
<td>(6.27)</td>
<td>(14.63)</td>
</tr>
<tr>
<td>N observations:</td>
<td>99</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>R-squared =</td>
<td>0.692</td>
<td>0.241</td>
<td>0.671</td>
</tr>
</tbody>
</table>

Note: * represents an interaction term for post-crisis. Data variables of domestic labor, foreign wage and domestic wage are log-differenced. Other data variables are logged.

A 2.47% increase in China’s outward FDI on average. This is close to Blonigen (1997) who noted that real currency appreciation is more likely associated with FDI involving firm-specific assets which can generate extra returns in currencies. Before the crisis, flow of FDI
was driven by reallocation of production (employment and lending rate). FDI would flow into destinations where production costs were lower. However, the determinants of flow of FDI changed after the crisis. Every 1% increase in the price of foreign capital (stock) after the crisis caused a 2.79% increase in China’s outward FDI on average. After the crisis, flow of FDI was driven by reallocation of assets (exchange rate and capital price). FDI would flow into destinations where assets could generate extra returns in currencies and in equity prices.

This asymmetric effect of international business cycles on the outward FDI before and after the crisis is first observed in this paper. It is possible that the global crisis could bring structural change to China’s outward FDI decisions. Since the end of the recent crisis, the global economy has been in a sloppy recovery and the production sector has been in the center of recession. The change in global economic conditions made the cross-border investment decisions more prudential about liquidity. This is consistent with our observation in Figure 3.5 that China’s outward FDI after the crisis prefers liquid assets (e.g. equities and real estate) rather than illiquid assets (e.g. natural resource and manufacturing).

The putty-clay effect on the link between shocks and business cycles by Gilchrist and Williams (2000) provides a similar explanation to this observation. Some foreign investments are putty-clay technology, meaning that they are irreversible once turned into durable goods. Gilchrist and Williams (2000) found that the putty-clay investment may result in an asymmetric effect of large shocks between recessions and expansions. Therefore, during expansions, FDI may flow into heavy assets, e.g. natural resources, manufacturing and infrastructures, which are irreversible and illiquid. However, during recessions, FDI may reallocate to light assets, such as equities and real estate, which are reversible and liquid.

3.7 Conclusion

This paper investigates the driving force of China’s outward FDI from macroeconomic perspectives. Starting from a reduced form model, this paper tests the empirical link between foreign direct investment and international business cycles.

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1 See coefficients on domestic employment and domestic lending rate in column (1) and domestic wage in column (2).
2 See coefficients on real exchange rate* and foreign capital price* in column (1).
3 The liquid asset here overlaps but does not equal the assets in portfolio investment. The liquid asset here means the liquid factor in investment, compared to the putty-clay factors in investment, such as real estate (liquid) vs infrastructure (illiquid), equities (liquid) vs natural resource (illiquid), etc. To be specific, foreign direct investment (FDI) is distinguished from foreign portfolio investment (FPI) in the notion of direct control of ownership. The FDI is an active investment in the form of controlling ownership of a firm either by Greenfield investment, joint venture or acquisition. FDI could overlap with FPI sometimes. For example, FDI could include equity capital of firms when M&A happens. Therefore, stock price index is one of the variables in the model of FDI. The FPI is a passive investment that groups foreign assets such as stocks, bonds and cash equivalents.
This paper finds the following:

- China’s outward FDI is mainly driven by domestic variables, i.e. fall in domestic employment and rise in domestic production costs. Financial costs variables matters more than labor cost variables to China’s outward FDI flows. The inward FDI to China is mainly driven by labor cost variables in foreign countries.

- China’s fast growing net outflow of FDI from 2004 to 2013 is mainly explained by two reasons: relative real appreciation in Chinese Yuan (CNY) and positive interest rate spread of China over other countries.

- The capital price (proxy by equity price index) in developed countries is more effective in motivating China’s outward FDI than that in developing countries. In other word, Chinese investors are only attracted to the cheaper capital in developed countries.

- The paper also finds that the determinants of FDI flow changed after the crisis. Exchange rate and capital price became more significant to China’s outward FDI after the crisis. This could be seen as a reallocation of FDI from destinations where production costs were lower to where assets could generate extra returns in currencies and in equity prices.

Although the reduced-form equation for the model does not include variables that represent monetary policy and fiscal policy, they can have substantial impacts on the domestic and international business cycles (Clarida, Gali, Gertler, 2002; Erceg and Guerrieri and Gust, 2005). The future research will explore the monetary and fiscal policy effects on the inward and outward FDI of China. We will add variables that identify both fiscal policy (e.g. government consumption expenditure) and monetary policy (e.g. money supply, policy rates) in the econometric analysis to estimate the policy impacts on the FDI flows.

### 3.8 Figures
Figure 3.1: The Outward and Inward FDI of China, 1992-2013
Figure 3.2: The Outward FDI of China to Developed and Developing Countries, 2007-2013

Figure 3.3: Top 10 countries in average growth rate of outward FDI by China, 2007-2013
Figure 3.4: The Chinese Business Cycle
Figure 3.5: China’s outward FDI by industry, 2007-2013
REFERENCES


Appendix A

Chapter 1

A.1 Data Sources

Table A.1: Data Sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data</th>
<th>Frequency</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_c$</td>
<td>Land Sale Volume</td>
<td>Annual</td>
<td>NBS</td>
</tr>
<tr>
<td>$Q_l$</td>
<td>Average Price per sq in Land Transaction</td>
<td>Annual</td>
<td>NBS &amp; MOHURD</td>
</tr>
<tr>
<td>$I$</td>
<td>Fixed-asset Investment</td>
<td>Annual</td>
<td>NBS</td>
</tr>
<tr>
<td>$L$</td>
<td>Real Estate Development</td>
<td>Annual</td>
<td>NBS</td>
</tr>
<tr>
<td>$G^t$</td>
<td>Local Government Investment</td>
<td>Annual</td>
<td>NBS</td>
</tr>
<tr>
<td>$T$</td>
<td>Personal Taxes</td>
<td>Annual</td>
<td>NBS</td>
</tr>
<tr>
<td>$Y$</td>
<td>Real GDP</td>
<td>Annual</td>
<td>NBS</td>
</tr>
<tr>
<td>$G^c$</td>
<td>Local Government Final Consumption</td>
<td>Annual</td>
<td>MOF</td>
</tr>
<tr>
<td>$X$</td>
<td>Required Reserve Ratio</td>
<td>Annual</td>
<td>PBOC</td>
</tr>
<tr>
<td>$A$</td>
<td>Labor Productivity Growth</td>
<td>Annual</td>
<td>NBS</td>
</tr>
<tr>
<td>$\theta'$</td>
<td>Leverage Ratio: Public</td>
<td>Annual</td>
<td>CASS</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Leverage Ratio: Non-financial Private</td>
<td>Annual</td>
<td>CASS</td>
</tr>
</tbody>
</table>

A.2 Log-Linearized System

I log-linearize the model in the preceding appendix around the deterministic steady state.

[1] Agents

\[-c_{h,t} = \lambda_{h,t} \quad (A.2.1)\]
\[\lambda_{h,t} - \tilde{R}_t = \lambda_{h,t+1} \quad (A.2.2)\]
\[-N_{h,t} = \lambda_{h,t} + \hat{w}_t \quad (A.2.3)\]
\[-c_{c,t} = \lambda_{c,t} \quad (A.2.4)\]
\[\lambda_c \hat{c}_{c,t} = \mu_c \Omega'(I_t)(\mu_c + \Omega'(I_t)) + \beta_c \lambda_c \hat{R}_t e(\lambda_{c,t+1} + \hat{R}_{k,t+1} + e_{t+1}) - \beta_c \lambda_c \Psi(e)(\lambda_{c,t+1} + \Psi(e_{t+1})) \quad (A.2.5)\]
\[\mu_c \hat{c}_{c,t} = \beta_c (1 - \delta) \mu_c \hat{c}_{c,t+1} + \beta_c \lambda_c \hat{R}_t e(\lambda_{c,t+1} + \hat{R}_{k,t+1} + e_{t+1}) - \beta_c \lambda_c \Psi(e)(\lambda_{c,t+1} + \Psi(e_{t+1})) \quad (A.2.6)\]
\[\gamma_2 e \hat{e}_t = R_k \hat{R}_{k,t} \quad (A.2.7)\]
\[\lambda_c Q_l(\lambda_{c,t} + \hat{Q}_{l,t}) = \nu \theta Q_l(\nu_{c,t} + \hat{\theta}_t + \hat{Q}_{l,t}) + \beta_c \lambda_c R_l(\lambda_{c,t+1} + \hat{R}_{l,t+1} + e_{t+1}) + Q_l(\lambda_{c,t+1} + Q_{l,t+1}) \quad (A.2.8)\]
\[\lambda_c \hat{c}_{c,t} = \nu \theta R(\nu_{c,t} + \hat{R}_t) + \beta_c \lambda_c R(\lambda_{c,t+1} + \hat{R}_t) \quad (A.2.9)\]
\[\Omega'(I_t) = 1 - \frac{\Omega}{2} (2(1 - \gamma_t) + (1 - \gamma_t)^2) \quad (A.2.10)\]
\[\Omega'(I_{t+1}) = \Omega(1 - \gamma_t) \quad (A.2.11)\]
\[\Omega'(I_t) \Omega'(\hat{I}_t) = \Omega(-3 + 2\gamma_t)(\hat{I}_t - \hat{I}_{t-1}) \quad (A.2.12)\]
\[K \hat{K}_t = (1 - \delta) K \hat{K}_{t-1} + \Omega \hat{\Omega}_t \quad (A.2.13)\]

\[\bar{\Omega} \hat{\Omega}_t = [1 - \frac{\Omega}{2} (1 - \gamma_t)^2] \hat{I}_t - \Omega(1 - \gamma_t) I(\hat{I}_t - \hat{I}_{t-1}) \quad (A.2.13)\]
\[ \dot{y}_t = \dot{A}_t + \alpha (\phi \dot{L}_{c,t} + (1 - \phi) \dot{k}_t) + (1 - \alpha) \dot{n}_t + \gamma' \dot{Y}'_t \]  
(A.2.14)

\[ Y' \dot{Y}'_t = (1 - \delta_y) Y' Y'_{t-1} + y' \dot{y}'_t \]  
(A.2.15)

\[ \dot{y}'_t = \dot{A}'_t + \alpha (\phi' \dot{L}'_{c,t} + (1 - \phi') \dot{k}'_t) + (1 - \alpha) \dot{n}'_t \]  
(A.2.16)

\[ \dot{y}_t - \dot{L}_{c,t} = \dot{R}_{t,t} \]  
(A.2.17)

\[ \dot{y}_t - \dot{k}_t = \dot{R}_{k,t} \]  
(A.2.18)

\[ \dot{y}_t - \dot{n}_t = \dot{\bar{w}}_t \]  
(A.2.19)

\[ \Pi_{\bar{w}} = y_{\bar{w}} - R_k k (\dot{R}_{k,t} + \dot{k}_t) - R_k L_{c}(\dot{R}_{l,t} + \dot{L}_{c,t}) - w n (\dot{\bar{w}}_t + \dot{n}_t) \]  
(A.2.20)

\[ \dot{p}'_G + \dot{y}'_t - \dot{k}'_t = \dot{R}_{k,t} \]  
(A.2.21)

\[ \dot{p}'_G + \dot{y}'_t - \dot{n}'_t = \dot{\bar{w}}_t \]  
(A.2.22)

\[ \Pi'_{\bar{w}} = p' G' (\dot{p}'_G + \dot{y}'_t - \dot{k}'_t) - R_k k' (\dot{R}_{k,t} + \dot{k}'_t) - w n' (\dot{\bar{w}}_t + \dot{n}'_t) \]  
(A.2.23)

\[ \Psi(e) \dot{\Psi}(e_t) = \gamma_1 e \dot{e}_t + \gamma_2 (e^2 \dot{e}_t - e \dot{e}_t) \]  
(A.2.24)

\[ c_h c_{\bar{h},t} + c_c c_{\bar{c},t} + I \dot{I}_t + \Psi(e) K(\dot{\Psi}(e_t) + K_{t-1}) + G^I \dot{G}'_t = y_{\bar{w}} \]  
(A.2.25)

\[ \dot{G}'_t = \dot{y}'_t \]  
(A.2.26)

\[ L_{c} \dot{L}_{c,t} + L' \dot{L}'_t = L \dot{L}_t \]  
(A.2.27)

\[ k \dot{k}_t + k' \dot{k}'_t = e K(\dot{e}_t + K_{t-1}) \]  
(A.2.28)

\[ n \dot{n}_t + n' \dot{n}'_t = N \dot{N}_t \]  
(A.2.29)

\[ Q_t L_{c}(L_{c,t} - L_{c,t-1}) + T \dot{T}_t + \Pi'_{\bar{w}} + \frac{B_g}{R} (B_{g,t} - \dot{R}_t) = B_g B_{g,t-1} + p^G G^e (\dot{p}'_G + \dot{G}'_t) + G^I \dot{G}'_t \]  
(A.2.30)

\[ \eta \delta_L \dot{G}'_t = (\dot{Q}'_t + \dot{L}'_t) - (1 - \delta_L)(\dot{Q}'_t + L'_{t-1}) \]  
(A.2.31)

\[ \tau (\dot{T}_t - \dot{Y}_t) = a G (\dot{G}_t - \dot{Y}_t) + \sigma_\tau \epsilon_{\tau,t} \]  
(A.2.32)
financial intermediary

\[ B_h B_{h,t} + X \hat{X}_t = B_c \hat{B}_{c,t} + B_g \hat{B}_{g,t} \quad (A.2.33) \]
\[ \hat{B}_{c,t} = \hat{\theta}_t + \hat{Q}_{l,t} + L_{c,t} \quad (A.2.34) \]
\[ \hat{B}_{g,t} = \hat{\theta}_t' + \hat{Q}_{l,t} + \hat{L}_t' \quad (A.2.35) \]

shocks

\[ \hat{A}_t = \rho_A \hat{A}_{t-1} + \sigma_A \epsilon_{A,t} \quad (A.2.36) \]
\[ \hat{A}'_t = \rho'_A \hat{A}'_{t-1} + \sigma_A' \epsilon_{A',t} \quad (A.2.37) \]
\[ \hat{G}_c = \rho_{g,c} \hat{G}_{c,t-1} + \sigma_g \epsilon_{g,t} \quad (A.2.38) \]
\[ \hat{\theta}_t = \rho_\theta \hat{\theta}_{t-1} + \sigma_\theta \epsilon_{\theta,t} \quad (A.2.39) \]
\[ \hat{\theta}'_t = \rho'_\theta \hat{\theta}'_{t-1} + \sigma_\theta' \epsilon_{\theta,t} \quad (A.2.40) \]
\[ \hat{X}_t = \rho_x \hat{X}_{t-1} + \sigma_x \epsilon_{x,t} \quad (A.2.41) \]
A.3 Steady States of System

In this section, I solve the system of model at steady state.

\[
\begin{align*}
\lambda_h &= 1/c_h \\
R &= 1/\beta_h \\
N_h &= \frac{\Psi}{\lambda_h w} \\
\lambda_c &= 1/c_c \\
\lambda_c &= \mu_c (1 - \frac{\Omega}{2}(2(1 - \gamma_l) + (1 - \gamma_l)^2)) + \beta_c \mu_c \Omega (1 - \gamma_l)^2 \\
\beta_c (1 - \delta) + \frac{\lambda_c}{\mu_c} (R_k e - \Psi(e)) &= 1 \\
\gamma_1 + \gamma_2 (e - 1) &= R_k \\
- \lambda_c Q_l + \nu_c \theta Q_l + \beta_c \lambda_c (R_l + Q_l) &= 0 \\
\frac{\lambda_c}{R} &= \nu_c + \beta_c \lambda_c \\
R_l &= \alpha \phi \frac{y_l}{l} \\
R_k &= \alpha (1 - \phi) \frac{y_k}{k} \\
w &= (1 - \alpha) \frac{y}{n} \\
R_k &= \alpha (1 - \phi') \frac{p^G y'}{l'} \\
w &= (1 - \alpha) \frac{p^G y'}{n'} \\
L' &= L - L_c \\
eK &= k + k' \\
N &= n + n' \\
B_c &= \theta Q_l L_c \\
B_g &= \theta' Q_l L' \\
B_h - B_c - B_g &= 0 \\
\Delta L &= F(G^I) \\
X &= 0.2 \\
\end{align*}
\]
Appendix B

Chapter 2

B.1 Wage bargain problem

\[ W_t = w_t h_t - \frac{g(h_t)}{\lambda_t} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} [(1 - \rho) W_{t+1} + \rho W_t^U] \]  
(B.1.1)

\[ W_t^U = w_t^u + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} [p_t^u W_{t+1} + (1 - p_t^u) W_t^U] \]  
(B.1.2)

Surplus of employment for workers,

\[ W_t - W_t^U = w_t h_t - \frac{g(h_t)}{\lambda_t} - w_t^u + E_t \beta \frac{\lambda_{t+1}}{\lambda_t} [(1 - \rho)(1 - p_t^u)(w_{t+1} - w_t^u)] \]  
(B.1.3)

Surplus of employment for firms,

\[ J_t^E \]  
(B.1.4)

Bargain solution,

\[ (1 - b)(W_t - W_t^u) = b J_t^E \]  
(B.1.5)

The solution of bargaining problem within both bargain schemes is

\[ w_t h_t = \frac{b}{1 - b} J_t^E + \frac{g(h_t)}{\lambda_t} + w_t^u - E_t \beta \frac{\lambda_{t+1}}{\lambda_t} [(1 - \rho)(1 - p_t^u)(w_{t+1} - w_t^u)] \]  
(B.1.6)

Insert the unemployment benefit wage and rearrange the solution,

\[ (1 - \mu)w_t h_t = \frac{b}{1 - b} J_t^E + \frac{g(h_t)}{\lambda_t} - E_t \beta \frac{\lambda_{t+1}}{\lambda_t} [(1 - \rho)(1 - p_t^u)(w_{t+1} - w_t^u)] \]  
(B.1.7)
B.2 The Social Planner’s Problem

In this section, I solve the model with a social planner and compare the results with decentralized equilibrium. In the planner’s problem, wage and hour are determined by the social planner instead of splitting surplus within a bargain. Specifically, the planner maximizes

$$\max E_t \sum_{t=0}^{\infty} \beta^t U\{C_t, N_t, h_t\}$$

subject to household’s and firm’s budget constraint, law of motion for capital, law of motion for labor, and matching function: (3), (6), (8), (9), (10). The social planner chooses \{\(C_t, h_t, I_t, K_{t+1}, V_t, N_{t+1}, B_{t+1}\)\}. The solution satisfies a series of efficiency conditions.

$$-\frac{U'_t(h_t)}{\lambda_t^c} = \frac{\partial y_t}{\partial h_t}$$

which implies that the value of the marginal product of hours is equal to the marginal rate of substitution.

$$\tilde{w}_t = \frac{(1 - \alpha) y_t}{h_t N_t}$$

which implies that wage is equal to the value of the marginal product of hours input. Wage clears the labor market in a social planner’s problem, but not in a decentralized problem with incomplete labor market. Thus, the solution of efficient bargaining wage (34) is different with that in planner’s problem (C.3). With Hosios efficiency condition applied, the solution of efficient bargaining hour (35) is the same with the solution of hour in the planner’s problem (C.2).

Hosios (1990) has worked out the conditions that, the worker’s bargain share \(b\) is equal to the elasticity of matches with respect to unemployment \(1 - \gamma\), under which the solution to the welfare-maximizing problem can be decentralized as a market equilibrium.

It is useful to compare the equilibrium conditions of the planner economy to those of the decentralized equilibrium. It allows us to identify the distortions at work in our model and define inefficiency wedges relative to the efficient allocations. This wedge, represented by the difference between wage in the planner’s problem and in decentralized problem, is the result of two distortions.

$$\Delta w_t = \tilde{w}_t - w_t = \frac{(1 - \alpha) y_t}{h_t N_t} - \frac{b I_t E_t + g(h_t) + w_t^u - E_t \beta \lambda_{t+1}^c}{h_t} \left[ (1 - \rho)(1 - p_{t+1}^u) (w_{t+1} - w_{t+1}^u) \right]$$

First, the financial friction plays a distortion role in the inefficiency wedge as the external finance \(B_{t+1}\) is constrained by a fraction of collateral value. Second, the labor search friction is the other distortion in the inefficiency wedge as wage no longer plays an allocative role for
hours due to the search and matching frictions.

B.3 Data Sources

Data is in quarterly frequency and covers from 1990:Q1 to 2014:Q1. Employment is normalized from the ratio of civilian employment and civilian labor force. Unemployed is normalized from the ratio of unemployed and civilian labor force. The real wage is from the average hourly earnings of all employees (Bureau of Labor Statistics). Working hours is from the average weekly hours of all employees (Bureau of Labor Statistics). Vacancy is normalized from the ratio of job openings: total non-farm to civilian labor force. Match is normalized from the ratio of hires: total non-farm to civilian labor force. Job Separation rate is from the ratio of total separations: total nonfarm to civilian employment. Replacement ratio is from the ratio of unemployment insurance per unemployed to wage compensation per employee. The unemployment insurance is constructed by dividing the total personal current transfer receipts: government social benefits to persons: unemployment insurance (Bureau of Economic Analysis) to the total number of unemployed (Bureau of Labor Statistics). The wage uses the average hourly earnings of all employees (Bureau of Labor Statistics). The consumption and government spending are from Bureau of Economic Analysis.

B.4 Log-Linearized System

I log-linearize the model in the preceding appendix around the deterministic steady state.

[1] Marginal utility in terms of consumption
\[ \bar{\lambda}_t = \frac{-c_t - \zeta c_{t-1}}{\bar{c}(1 - \zeta)^2} + \beta \frac{\zeta}{\bar{c}(1 - \zeta)^2}(c_{t+1} - \zeta c_t) \] (B.4.1)

[2] Law of motion for capital
\[ k_{t+1} = \frac{\bar{I}}{\bar{k}} I_t + (1 - \delta)k_t \] (B.4.2)

[3] Production
\[ y_t = A_t + \alpha k_t + (1 - \alpha)(N_t + h_t) \] (B.4.3)

[4] Negative productivity shock
\[ A_t = \rho_a A_{t-1} - \epsilon_a \] (B.4.4)

[5] Value of match
\[ J_t = -p_t^e \] (B.4.5)
\[
\frac{\bar{J}}{y} \tilde{N}(J_t+N_t) = \left(1-\alpha\right)y_t - \frac{\bar{w}h}{N}(w_t+h_t+N_t) + \frac{\bar{B}}{y}(B_{t+1} - \bar{R}(R_t + B_t)) + \beta(1-\rho)\frac{\bar{J}}{y} \tilde{N}(\lambda_{t+1} - \lambda_t + J_{t+1} + N_t)
\]

(B.4.6)

[7] Firm’s bond Euler equation
\[
\tilde{\mu}_t = \lambda \lambda_t - \beta \lambda \bar{R}(\lambda_{t+1} + R_{t+1})
\]

(B.4.7)

[8] Firm’s bond Euler equation (if financial decision is subsequent to match)
\[
\mu_t = 0
\]

[9] Capital Euler equation (Tobin’s Q for capital)
\[
\bar{q}q_t = -\frac{\bar{\mu}q}{\lambda} (\mu_t + \theta_t + q_{t+1} - \lambda_t) + \beta \alpha \frac{\bar{y}}{\bar{k}} (\lambda_{t+1} - \lambda_t + y_{t+1} - k_{t+1}) + \beta(1-\delta)\bar{q}(\lambda_{t+1} - \lambda_t + q_{t+1})
\]

(B.4.8)

[10] Capital Euler equation (if financial decision is subsequent to match)
\[
\bar{q}q_t = \beta \alpha \frac{\bar{y}}{\bar{k}} (\lambda_{t+1} - \lambda_t + y_{t+1} - k_{t+1}) + \beta(1-\delta)\bar{q}(\lambda_{t+1} - \lambda_t + q_{t+1})
\]

\[
h_t = y_t - w_t - N_t
\]

(B.4.9)

[12] Borrowing constraint (if \(B_t\) and \(\theta_t\) is prior to match, and if \(B_t\) is post match but \(\theta_t\) is at the beginning of period)
\[
B_{t+1} = q_t + \theta_t + k_{t+1}
\]

(B.4.10)

[13] Borrowing constraint (if financial decision \(B_t\) and \(\theta_t\) is subsequent to match)
\[
B_{t+1} = q_t + \theta_{t+1} + k_{t+1}
\]

[14] Negative financial shock
\[
\theta_t = \rho_\theta \theta_{t-1} - \epsilon_\theta
\]

(B.4.11)
[15] Wage bargain (whether financial decision is prior to or subsequent to match)

\[ (1 - \mu)\bar{w}h(\hat{w}_t + \hat{h}_t) = \frac{b}{1 - b}\bar{J}\hat{J} + \frac{g(\bar{h})}{\lambda}(g(\hat{h} - \hat{\lambda}_t) - \beta(1 - \rho)(1 - \tilde{p}^u)(1 - \mu)\bar{w}h(\lambda_{t+1} - \hat{\lambda}_t - \frac{\tilde{p}^u\tilde{p}_t}{1 - \tilde{p}^u} + (1 - \mu)(\bar{w}_{t+1} + \bar{h}^{\hat{t}+1})]\] (B.4.12)

[16] Unemployment insurance

\[ w^u_t = w_t \] (B.4.13)

[17] Job searchers

\[ \tilde{u}u_t = -\tilde{N}N_t \] (B.4.14)

[18] Matching function

\[ m_{t+1} = (1 - \gamma)u_t + \gamma v_t \] (B.4.15)

[19] Law of motion for employment

\[ \tilde{N}N_t = (1 - \rho)\tilde{N}N_{t-1} + \bar{m}m_t \] (B.4.16)

[20] Match rate

\[ p^u_t = m_t - u_t \] (B.4.17)

[21] Vacancy filling

\[ p^v_t = m_t - v_t \] (B.4.18)

[22] Household budget constraint

\[ \tilde{c}_t + \bar{B}B_{t+1} + \tau_t = \bar{R}\tilde{B}(R_t + B_t) + \bar{w}\tilde{N}h(w_t + h_t + N_t) + \bar{w}^u(1 - \tilde{N})(w^u_t - \frac{\tilde{N}}{1 - \tilde{N}}N_t) \] (B.4.19)

[23] Tax rule

\[ \tau_t = \rho_\tau \tau_{t-1} + \epsilon_\tau \] (B.4.20)


\[ G_t = \rho_g G_{t-1} + \epsilon_g \] (B.4.21)

[25] Resource constraint

\[ \bar{H}_t = \ddot{y}y_t - \ddot{c}c_t - \ddot{G}G_t - \ddot{w}^u(1 - \bar{N})(w^u_t - \frac{\tilde{N}}{1 - \tilde{N}}N_t) - \kappa \bar{v}v_t \] (B.4.22)
B.5 Steady States of System

This section displays the steady states that were used to solve the model.

[1] Match
\[ \bar{m} = \rho \bar{N} \]  (B.5.1)

[2] Unemployed
\[ \bar{u} = 1 - \bar{N} \]  (B.5.2)

[3] Vacancy
\[ \bar{v} = \left( \frac{\bar{m}}{\chi \bar{u}^{1-\gamma}} \right)^{1/\gamma} \]  (B.5.3)

\[ \bar{p}^u = \frac{\bar{m}}{\bar{u}} \]  (B.5.4)

[5] Vacancy filling rate
\[ \bar{p}^v = \frac{\bar{m}}{\bar{v}} \]  (B.5.5)

\[ \frac{\bar{\mu}}{\lambda} = 1 - \beta \bar{R} \]  (B.5.6)

[7] Capital-output
\[ \frac{\bar{k}}{\bar{y}} \]  (B.5.7)

[8] Debt-output
\[ \frac{\bar{B}}{\bar{y}} = \frac{\bar{\theta} \alpha}{1 - \frac{\bar{\theta}}{\beta} - (1 - \delta)} \]  (B.5.8)

[9] Wage income-output
\[ \frac{w \bar{h} \bar{N}}{\bar{y}} = \frac{b(1 + \frac{B}{\bar{y}}(1 - \bar{R}))}{1 - \beta(1 - \rho - p^u)} + b \]  (B.5.9)

[10] Labor input-output ratio
\[ \frac{\bar{h} \bar{N}}{\bar{y}} = \left( \frac{\bar{A}(\frac{\bar{k}}{\bar{y}})^{\alpha}}{\bar{y}} \right)^{1/(\alpha - 1)} \]  (B.5.10)

\[ \bar{w} = \frac{1 - \alpha}{\frac{\bar{h} \bar{N}}{\bar{y}}} \]  (B.5.11)
[12] Unemployment insurance-output
\[ \frac{\dot{w}^u}{\dot{y}} = \Omega \frac{\dot{w} \dot{h} N}{\dot{y}} \] (B.5.12)

[13] Investment-capital
\[ \frac{\ddot{I}}{\ddot{k}} = \delta \] (B.5.13)

[14] Investment-output
\[ \frac{\ddot{I}}{\ddot{y}} = \frac{\ddot{I}}{\ddot{y}} = \frac{\ddot{I} \ddot{k}}{\ddot{k} \ddot{y}} \] (B.5.14)

\[ \frac{\ddot{G}}{\dot{y}} = 0.242 \] (B.5.15)

[16] Tax ratio
\[ \frac{\ddot{\tau}}{\dot{y}} = 0.078 \] (B.5.16)

[17] Employment value
\[ \frac{\ddot{J}}{\ddot{y}} = \frac{\left(1 - \frac{\dot{w} \dot{h} N}{\dot{y}} + (1 - \bar{R}) \frac{\ddot{B}}{\ddot{y}} / \bar{N}\right)}{(1 - \beta(1 - \rho))} \] (B.5.17)

[18] Vacancy cost
\[ \ddot{\kappa} \ddot{y} = \ddot{p} \ddot{J} \ddot{y} \] (B.5.18)

[19] Capital price
\[ \ddot{q} = \frac{(\alpha \beta / \ddot{k})}{(1 + \ddot{\mu} \ddot{\lambda} / \ddot{y} - \beta(1 - \delta))} \] (B.5.19)

[20] Consumption-output
\[ \frac{\ddot{c}}{\ddot{y}} = 1 - \frac{\ddot{I}}{\ddot{y}} - \frac{\ddot{G}}{\ddot{y}} - \frac{\dot{w}^u}{\ddot{y}} (1 - \bar{N}) - \ddot{\kappa} \ddot{y} \ddot{v} \] (B.5.20)

[21] Consumption-multiplier
\[ \ddot{c} \ddot{\lambda} = \frac{1 - \beta \zeta}{1 - \zeta} \] (B.5.21)

B.6 Robustness of Timing Assumption

B.6.1 Overview

This Appendix reports the results of additional robustness exercises testing the timing assumption of financial decision and labor market decision.
B.6.2 Timing sequence of financial decisions and labor market search

The point is to check whether it matters for model dynamics if the financial shock $\theta_t$ is realized prior to or subsequent to non-employed workers and firms engage in labor market search.

Figure 2.4 is the timing assumption in baseline model in which the realization of financial shock $\theta_t$ and financial decisions $B_{t+1}$ are made before labor market search and match and wage bargain with new matched workers. An alternative version of this timing sequence is that financial decisions $\theta_t$ and $B_{t+1}$ are subsequent to search and wage bargain.

I have resolved the model with two versions of timing sequences and compared the solutions of labor market variables, $m_t$, $w_{t+1}$, $h_t$, and macroeconomic variables, $k_{t+1}$, $B_{t+1}$. The major difference of the solutions of two versions is in the firm’s problem. If the firm realizes its financial decision first, it needs to count its payment of old loan $RB_t$ and borrowing of new loan $B_{t+1}$ into its dividends. In the FOCN of the firm’s problem, the multiplier of financing constraint $\mu_t$ is not necessarily zero, and $k_{t+1}$ is dependent on $\theta_t$. Otherwise, if financial decision is realized subsequently, $\mu_t$ is zero and $k_{t+1}$ is independent with financial variables.

In the first scenario, where realization of financial shock $\theta_t$ occurs prior to labor decisions, model dynamics are the same as the solutions of the baseline model. New match, $m_t$, is independent with either $B_{t+1}$ or $\theta_t$. Wage bargain, $w_{t+1}$, is dependent on the realized level of the new loan $B_{t+1}$. Working hours, $h_t$, does not depend on either $B_{t+1}$ or $\theta_t$. Whether new capital stock $k_{t+1}$ depends on $\theta_t$ is conditional on the timing of realization of $B_{t+1}$. $k_{t+1}$ is dependent on financial shock $\theta_t$ if the financing decision of loan $B_{t+1}$ is made before labor decisions. Otherwise, it is irrelevant with $\theta_t$ if $B_{t+1}$ is determined after search and wage bargain.

In the second scenario, where financial decisions are subsequent to labor decisions, model dynamics of $w_{t+1}$ and $k_{t+1}$ are different with those in the first scenario. Since search and wage bargain occur prior to the realization of financial shock $\theta_t$, the new bargained wage $w_{t+1}$ is dependent on the expectation of $\theta_t$. $k_{t+1}$ is independent with $\theta_t$ because the multiplier $\mu_t$ is zero.

B.6.3 Timing of realization of financial shock

The point is to check if it matters for model dynamics whether $\theta_t$ is realized at the beginning of date $t$ or when the firm makes its financing decision.

In the baseline model, also in Figure 2.4, financial shock $\theta_t$ is realized when the firm makes its financing decision $B_{t+1}$. Alternatively, $\theta_t$ is realized at the beginning of date $t$. The major difference of the model dynamics with two versions of timing assumption is in the solution of wage bargain. What matters for the two versions of timing sequences is the timing of financial decision of loan, say, when $B_{t+1}$ is realized.

If $B_{t+1}$ is realized prior to wage bargain, it does not matter whether $\theta_t$ is realized at the
beginning of date $t$ or when the firm makes its financing decision. In both cases, $B_{t+1}$ is constrained by the realization of $\theta_t$ and $k_{t+1}$ is dependent on $B_{t+1}$ as well.

If $B_{t+1}$ is realized subsequent to wage bargain, whether $\theta_t$ is realized at the beginning of date $t$ or when the firm makes its financing decision matters to $w_{t+1}$. If $\theta_t$ is realized at the beginning of date $t$, wage bargain $w_{t+1}$ is dependent on the realized $\theta_t$. Otherwise, wage bargain $w_{t+1}$ is dependent on the expectation of $\theta_t$.

B.6.4 Timing of the firm’s intensive- and extensive-margin employment choices

The point is to check whether it matters for model dynamics if the firm’s choice of hour $h_t$ is realized before or after the firm’s choice of vacancy $v_t$. The probability of a vacancy filled $p^v_t$ is a function of choice of hour $h_t$. In the baseline model, this probability is chosen if hour choice is realized. Otherwise, the firm needs to decide $p^v_t$ based on its expectation of $h_t$. If $p^v_t$ is chosen after the financial decision, there is no new information between the choice of $p^v_t$ and $h_t$. Thus, the $p^v_t$ based on expectation of $h_t$ is the same as that based on realized $h_t$. If $p^v_t$ is chosen before the financial decision, as discussed in Appendix B.6.1, the effect of changing timing sequence of financial decisions and labor market search on model dynamics is not significant. Thus, the firm’s expectation of $h_t$ is not significantly affected by sequence of employment choices.

B.6.5 Timing of wage bargaining and intensive margin employment

The point is to check whether it matters for model dynamics if the firm’s choice of hour $h_t$ is made with expected wage rate or with realized wage rate. In the former case, wage bargaining is a function of realized hour while hour is a function of expected wage bargain. Thus, firm determines hour unilaterally by solving functions of hour choice and wage bargain. The latter case is exactly the same as in the right-to-manage bargain solution in Trigari (2006), where firm adjusts hour given wage bargain. Again, firm determines hour unilaterally by solving functions of hour choice and wage bargain. Thus, the timing of sequence between wage bargaining and intensive margin employment does not matter.
Appendix C

Chapter 3

C.1 Reduced-form

I first solve the first-order conditions of model. Then I log-linearize the first-order conditions and equilibrium equations around the deterministic steady state. The final reduced-form to estimate in this paper is an equilibrium equation of FDI as a function of domestic and foreign variables.

Variables with $t$ on footer are log-linearized variables. Variables without $t$ on footer are steady states. Otherwise are parameters. Presentations of variables are in the model.

[1] First-order condition of domestic capital

$$r_t = y_t - k_{d,t} + p_t$$  \hspace{1cm} (C.1.1)

[2] First-order condition of inward FDI capital

$$r_t = y_{f_{di},t} - k_{f_{di},t}^* + p_t$$  \hspace{1cm} (C.1.2)

[3] First-order condition of foreign capital

$$r_t^* = y_{d,t}^* - k_{d,t}^* + p_t^*$$  \hspace{1cm} (C.1.3)

[4] First-order condition of outward FDI capital

$$r_t^* = y_{f_{di},t} - k_{f_{di},t} + p_t^*$$  \hspace{1cm} (C.1.4)
[5] Log-linearize the Armington aggregator of domestic GDP

\[ y_t = \Phi \frac{y_d^\tau}{y} (r_t + k^d_{d,t} - p_t) + (1 - \Phi) \frac{y_{fdi}^\tau}{y} (r_t + k^*_{fdi,t} - p_t) \]  
(C.1.5)

[6] Log-linearize the Armington aggregator of foreign GDP

\[ y_t^* = \Phi \frac{y_d^*}{y^*} (r^*_t + k^*_{d,t} - p^*_t) + (1 - \Phi) \frac{y_{fdi}^\tau}{y^*} (r^*_t + k^*_{fdi,t} - p^*_t) \]  
(C.1.6)

[7] Take out \( p_t \) from \( y_t \)

\[ p_t = \frac{\alpha}{\alpha + \beta} (r_t + k^d_{d,t}) + \frac{\beta}{\alpha + \beta} (r_t + k^*_{fdi,t}) - \frac{1}{\alpha + \beta} y_t \]  
(C.1.7)

[8] Take out \( p_t^* \) from \( y_t^* \)

\[ p_t^* = \frac{\alpha^*}{\alpha^* + \beta^*} (r^*_t + k^*_{d,t}) + \frac{\beta^*}{\alpha^* + \beta^*} (r^*_t + k^*_{fdi,t}) - \frac{1}{\alpha^* + \beta^*} y_t^* \]  
(C.1.8)

[9] The parameter \( \alpha \) is

\[ \alpha = \Phi \frac{y_d^\tau}{y} \]  
(C.1.9)

[10] The parameter \( \beta \) is

\[ \beta = (1 - \Phi) \frac{y_{fdi}^\tau}{y^*} \]  
(C.1.10)

[11] The parameter \( \alpha^* \) is

\[ \alpha^* = \Phi \frac{y_d^*}{y^*} \]  
(C.1.11)

[12] The parameter \( \beta^* \) is

\[ \beta^* = (1 - \Phi) \frac{y_{fdi}^\tau}{y^*} \]  
(C.1.12)

[13] Assume purchasing power parity to get real exchange rate

\[ e_{xt} = p_t - p_t^* \]  
(C.1.13)

[14] Replace \( p_t \) and \( p_t^* \), and reduce equilibrium conditions to fewer variables

\[ \frac{\beta^*}{\alpha^* + \beta^*} k_{fdi,t} = r_t - r_t^* + \frac{\alpha}{\alpha + \beta} k_{d,t} + \frac{\beta}{\alpha + \beta} k^*_{fdi,t} - \frac{\alpha^*}{\alpha^* + \beta^*} k^*_{d,t} - \frac{1}{\alpha + \beta} y_t + \frac{1}{\alpha^* + \beta^*} y_t^* - e_{xt} \]  
(C.1.14)
[15] But there is endogeneity of variables: $k^*_{d,t}$ and $k_{fdi,t}$, $k_{d,t}$ and $k^*_{fdi,t}$. Use the labor market clearing condition to eliminate the endogeneity.

[16] Clearing of domestic labor market

$$nn_t = n_d n_{d,t} + n_{fdi}^* n_{fdi,t}^* \quad \text{(C.1.15)}$$

[17] Clearing of foreign labor market

$$n^* n^*_t = n^*_d n^*_{d,t} + n_{fdi} n_{fdi,t} \quad \text{(C.1.16)}$$

[18] Use $k_{fdi,t}$ to represent $k^*_{d,t}$

$$k^*_{d,t} = \frac{n^*}{n_d} n^*_t - (w^*_t - r^*_t) - \frac{n_{fdi}}{n_d} (k_{fdi,t} - w_t^* + r_t^*) \quad \text{(C.1.17)}$$

[19] Use $k^*_{fdi,t}$ to represent $k_{d,t}$

$$k_{d,t} = \frac{n}{n_d} n_t - (w_t - r_t) - \frac{n_{fdi}}{n_d} (k_{fdi,t}^* - w_t + r_t) \quad \text{(C.1.18)}$$

[20] Eliminate the endogenous variables $k^*_{d,t}$, $k_{d,t}$ and get the reduced-form of equilibrium

$$\left(\frac{\beta^*}{\alpha^* + \beta^*} - \frac{n_{fdi}}{n_d} \frac{\alpha^*}{\alpha^* + \beta^*}\right) k_{fdi,t} = r_t - r^*_t - \text{ex}_t + \left(\frac{\beta}{\alpha + \beta} - \frac{n_{fdi}}{n_d} \frac{\alpha}{\alpha + \beta}\right) k_{fdi,t}^*$$

$$+ \frac{\alpha}{\alpha + \beta} \left(\frac{n}{n_d} n_t - \left(1 - \frac{n_{fdi}}{n_d}\right)(w_t - r_t)\right) - \frac{\alpha^*}{\alpha^* + \beta^*} \left(\frac{n^*}{n_d} n^*_t - \left(1 - \frac{n_{fdi}}{n_d}^*\right)(w^*_t - r^*_t)\right) \quad \text{(C.1.19)}$$

[21] Now the equation was left with stock of inward and outward FDI, $k^*_{fdi,t}$ and $k_{fdi,t}$. They are dual variables and endogenous of $\{q_t, q^*_t, m_t, m^*_t\}$ from Equations (1) and (2). Both variables are endogenous of the same set of variables $\{n_t, n^*_t, \text{ex}_t, w_t, r_t, w^*_t, r^*_t\}$. Therefore, the final reduced-form of bilateral FDI $\{m_t, m^*_t\}$ is a function of $\{n_t, w_t, r_t, q_t, n^*_t, w^*_t, r^*_t, \text{ex}_t\}$. 

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