Transition and Inequality*

Haiyan Ding†, Zhe Fu‡, Hui He§

August 22, 2018

Abstract

Transition increases economic inequality. This paper establishes a theory to explain why. Workers in state-owned enterprises (SOEs) face on average significantly lower idiosyncratic income shocks than their counterparts in private-owned enterprises (POEs). Economic transition, resulting from a continuously reducing subsidy to SOEs, pushes workers to move from SOEs to POEs. The transition in labor market thus changes the composition of underlying income shock structure in the aggregate economy. This leads to rising income inequality and co-moving consumption inequality. We calibrate the model to the Chinese economy in transition and show that the model is able to capture the majority of rising economic inequality in urban China.

Keywords: Economic transition; Income, Consumption, and Wealth Inequalities; Income Shocks; SOE vs. POE; Incomplete-Market Model; Risk Sharing

JEL codes: E20, E21, D31, P20, P31

---

*We thank Tianshu Chu, David Lagakos, Kjetil Storesletten, Tao Zha for the insightful discussion. We also benefit from helpful comments by seminar participants at Shanghai University of Finance and Economics, Huazhong Normal University, Huazhong University of Science and Technology, and Workshop on Growth and Development held by Dongbei University of Finance and Economics. Hui He is grateful for research support by the National Natural Science Foundation of China (Project Number 71633003). The views expressed in this paper are those of the authors and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

†School of Public Finance and Taxation, Zhejiang University of Finance and Economics. E-mail: haiyan0819@aliyun.com.

‡School of Banking and Finance, University of International Business and Economics, Beijing, China. E-mail: fzecon@hotmail.com.

§International Monetary Fund, and Shanghai Advanced Institute of Finance, Shanghai Jiao Tong University. E-mail: HHe@imf.org.

1 Introduction

The transition from centrally planned economy to market-oriented economy increases economic inequality. Milanovic and Ersado (2012) document that all Eastern European (EE) countries and former Soviet Union (FSU) countries experienced an increase in inequality after the transition, with considerable variations. Some countries such as Russia experienced a rapid increase in income inequality. Income Gini increased from 0.259 for the period 1989-1990 before the transition took place to 0.409 in 1994, immediately after the transition dismantling the old socialist system in 1991. Other countries witnessed a more modest increase in inequality. For example, Poland started about the same level of income Gini as Russia before the transition (0.255 in 1989-1990). But the Gini only increased to 0.32 in 1995.

EE and FSU countries are well known for taking so-called "big bang" strategy in transition, i.e., radically dismantling old system and *simultaneously* implementing all reforms leading to a new market system. In contrast, China had been adopting a "gradualism" transition strategy that *sequentially* implementing reforms on an experimental basis. However, different transition strategy/speed seems not alter the fact that inequalities increase after the transition. Using a unique micro-level urban household survey data, Ding and He (2018) document that household earnings Gini in China increased from 0.218 in 1986 to 0.372 in 2001, accompanying the urban economic reforms which were initiated in 1984 and peaked in the late 1990s (from 1989 to 1995, the earnings Gini increased from 0.245 to 0.301). In addition, they also find that consumption inequality has increased significantly as well during the same period. And surprisingly, consumption inequality and income inequality exhibit a close co-movement between each other. Moreover, Ding and He (2018) show that wealth inequality has also increased during the transition period.

Why economic transition leads to rising inequality? This paper provides an answer, both qualitatively and quantitatively. Our story hinges on a key fact on economic transition, i.e., a transition often is accompanied by a sharp declining in SOE employment share, resulting from the less favoritism towards SOEs (see Song, Storesletten, and Zilibotti 2011). What we find, by investigating the micro-level household survey data, is that POE workers on average face significantly higher idiosyncratic income shocks than

their SOE counterparts, although on average their productivity is higher. The shift in employment share, thus, leads to a "composition" effect on the income shock structure on the aggregate level, meaning that the income shocks in the population would increase over time, as we observe in the data. This leads to an increase in income inequality. More importantly, the changing income shock structure would have a profound impact on risk-sharing across households since it is much more difficult to insure against idiosyncratic permanent income shocks than against transitory income shocks (Blundell, Pistaferri, and Preston, 2008). As permanent income shocks increase over time, consumption-smooth across individuals becomes more difficult, which leads to rising consumption inequality and a co-movement between income inequality and consumption inequality.

To answer the question and quantify the mechanism, we build a two-sector (SOE vs. POE) Bewley-Huggett-Aiyagari-type incomplete market model with endogenous choice of occupations. On the preference side, an individual is subject to subsistence consumption. Consistent with the empirical evidence, we assume that SOEs have a lower total factor productivity (TFP) than POEs. However, SOE workers also face lower permanent and transitory income shocks than their POE counterpart. Initially, the government imposes a very high tax on POEs and uses the tax revenue to subsidize SOEs heavily. The wedge thus guarantees an initial equilibrium with the prevalence of SOEs in the economy ("centrally planned economy"). The economic transition is modeled as a gradual reduction in the wedge. With less subsidy from the government, SOEs become less attractive so that workers start to move from SOEs to POEs. The whole transition stops when the economy stabilizes in the final steady state.

We calibrate the model to the Chinese economy, largely because of the data availability which allows us to get access to a rich micro-level household survey in urban China, which is also used in Ding and He (2018). Specifically, we calibrate the model to Chinese economy before 1992 when the market-oriented reform and massive privatization have not begun yet. We then solve the model through the transition path, matching the declining SOE employment share over time by calibrating the time-varying wedge.

With the exogenous change in the wedge, which mimics the transition in employment structure, the model is able to generate a significant rise in both income inequality and consumption inequality, which accounts for about 62% of the increase in income

inequality and 33% of the increase in consumption inequality in urban China for the transition period from 1992 to 2006. This shows that the composition effect, interacting with the market incompleteness, might indeed be a key channel to explain quantitatively the rising income and consumption inequalities after the economic transition. We also find that the subsistence consumption in the preference plays a key role in generating rising wealth inequality quantitatively. Without the feature, the model actually generates a declining wealth inequality. The reason is that facing higher income shocks, poor would disproportionately save more to hedge against the shocks. This precautionary saving motive would allow poor to accumulate wealth even more quickly than rich, and hence leads to a shrinking wealth inequality.

In summary, the contribution of the paper is to provide a plausible theory to explain the simultaneously rising economic (income, consumption, and wealth) inequalities accompanying the transition. The key mechanism here is that the transition shifts the employment share towards POEs, and it leads to a changing income shock structure on the aggregate level. With the permanent income shocks rising and becoming dominant, income inequality rises and risk-sharing across individuals becomes more difficult. The market incompleteness embodied in severe financial constraints further prevents an effective risk sharing to contain rising consumption inequality. Consumption inequality thus also rises and highly co-move with income inequality. Finally, on one hand, rich tend to have a higher saving propensity. Therefore, rising income inequality would make rich save even more. On the other hand, poor are subject to subsistence consumption, therefore they cannot save much, although they might want to do so to hedge against rising income shocks. As a result, wealth inequality rises along the transition as well. All these channels together contribute to explaining the rising inequalities after the transition.

This paper contributes to two strands of literature. For the macro-inequality literature, our paper brings transition on the radar. Heathcote, Storesletten, and Violante (2010, hereafter HSV) study the macro implications of increasing volatility in both persistent and transitory shocks in the US wage structure. The distinct exogenous forces–skill- and gender-biased demand shifts–exogenously change the underlying income shock structure. The changing wage structure is the model input. Through a lens of a standard overlapping generations incomplete market model, HSV ask can the changing wage

structure explain the salient trends in the cross-sectional distributions of individual hours worked, household earnings, and household consumption in the US. Notice that the biggest difference between our paper and HSV is that changing income/wage structure is not an exogenous assumption but rather an endogenous equilibrium result in the current paper. In other words, it is the model output rather input. We argue that economic transition leads to changing income shock structure in a certain group of countries called "transition economies." The two papers thus have a very different focus.

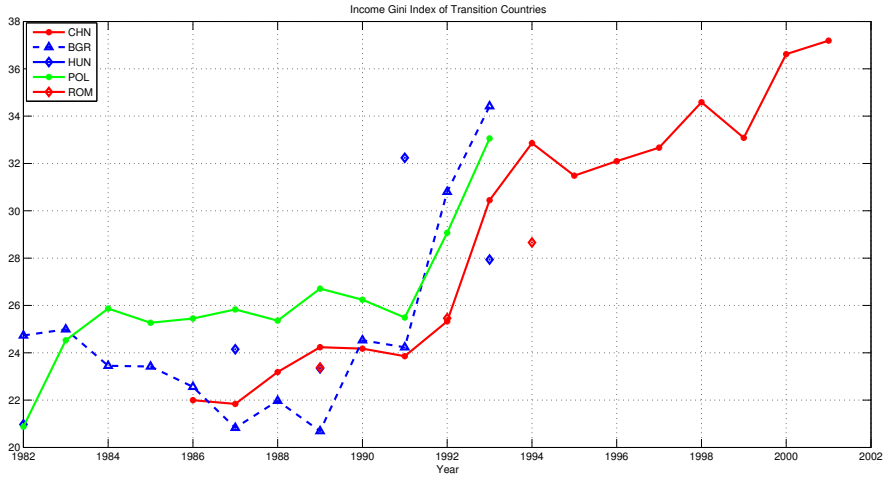
This paper provides a theoretical foundation to the empirical findings of the relationship between transition and inequality, surveyed by Milanovic and Ersado (2012). Milannovic (1999) sets up a simple static partial equilibrium model to explain rising income inequality during the transition. We extend his simple model to many dimensions: dynamic, heterogeneous agents, and non-homothetic preference. Turns out each extension/feature is important to explain a dimension of rising inequalities during the transition. Ding and He (2018) make an empirical link between the economic transition and rising income and consumption inequalities. We build a model to generate the link and provide a theory to explain all stylized facts they emphasized.

The rest of the paper is organized as follows. Section 2 outlines a series of empirical findings that motivate our theoretical model, using China's urban household survey data. Section 3 lays out the model. Section 4 describes the calibration and the computation algorithm of the model. Section 5 shows the quantitative results. Finally, Section 6 concludes.

2 Empirical Motivation

In this section, we present empirical findings that motivate our theoretical model. Transitional economies often experienced drastically widening economic inequalities, which is shown in Figure 1 for selected transition countries. Economic transition also led to dramatically declining SOE employment share and rising POE share. Figure 2 highlights the dynamics of earnings inequality and the privatization process in China. Prior to 1993, both the earnings Gini index and the employment share of POEs were stable in China. Once the market reform took place, however, the earnings inequality

Figure 1: Income Gini Index of Transition Countries



Data Sources: Calculations based on Measuring Income Inequality Database of World Bank (for Bulgaria, Hungary, Poland, and Romania) and Urban Household Survey of China

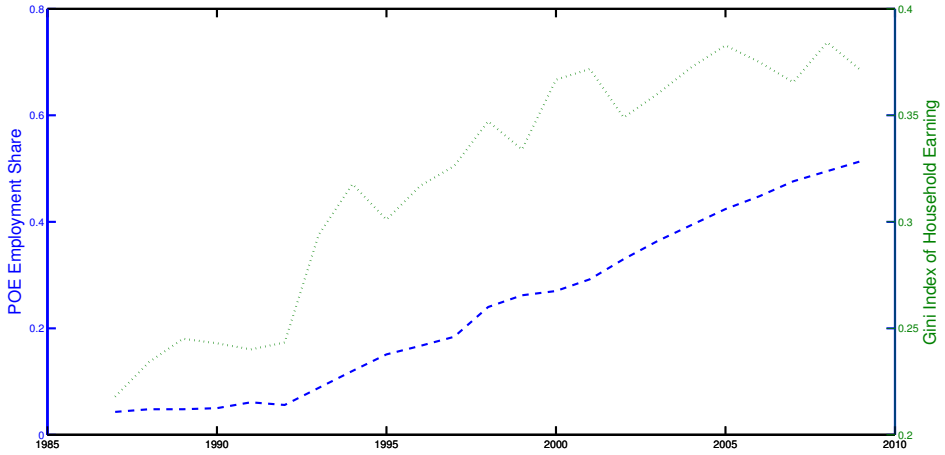
rose together with the employment share of POEs.

With the access to a rich micro-level urban household survey data in China, we look into details of the data to explore how the market reform connects to the rising inequality.[1] The market reform can affect SOE and POE workers in a very different way. Figure 3 plots the income inequality by the ownership of the firms that workers are employed, using four different measures. We can see a significant difference in the inequality dynamics between SOE workers and POE workers. The income inequality of the POE workers persistently lies above the SOE counterpart. Using a simple t-test, we find that the income inequalities are significantly different for SOE workers and POE workers at 1% significance level. The findings from Figures 2 and 3 imply that there might be a close relationship between a rising employment share of POEs and a widening economic inequality.

What is the driving force behind the significant difference in income inequality between SOEs and POEs? We further decompose the variance of log disposable income into between-group and within-group inequalities (see the details in Ding and He (2018)).

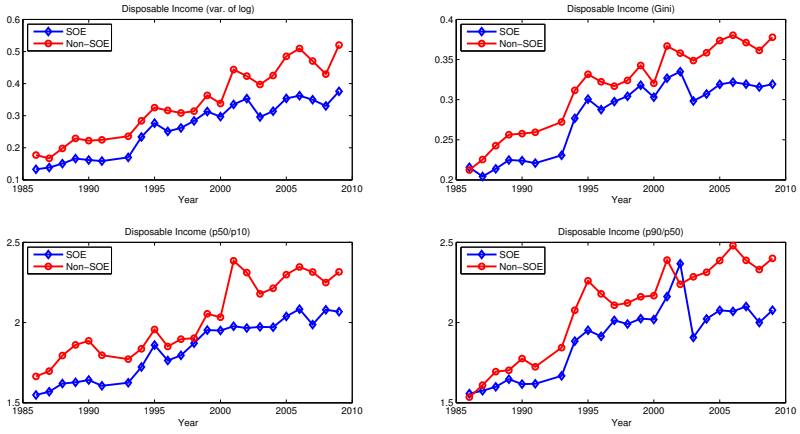
[1]For the detailed description of the urban household survey data, see Ding and He (2018).

Figure 2: China: Earnings Gini Index vs Employment Share of POEs



Data Sources: Calculations based on China Statistical Yearbook, China Labor Statistical Yearbook, and Urban Household Survey of China

Figure 3: Income Inequality: SOEs vs. POEs



Data Source: Calculations based on Urban Household Survey of China

Figure 4: Between-group and ithin-group Inequalities: SOEs vs. POEs

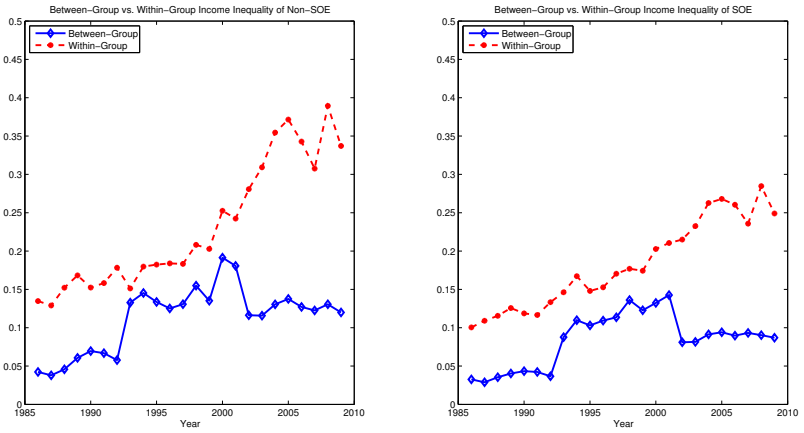


Figure 4 shows the results. We see that an increase in within-group inequality captures the majority of the increase in disposable income inequality for both SOE workers and POE workers. We thus turn our attention to understand what drives rising within-group inequality for both SOE workers and POE workers. With the help from the Urban Household Survey data, we are able to look into the difference in the stochastic labor income process between POE workers and SOE workers. To start, we define e_t as the stochastic and individual-specific labor productivity, then log of e_t evolves according to the following labor income process,

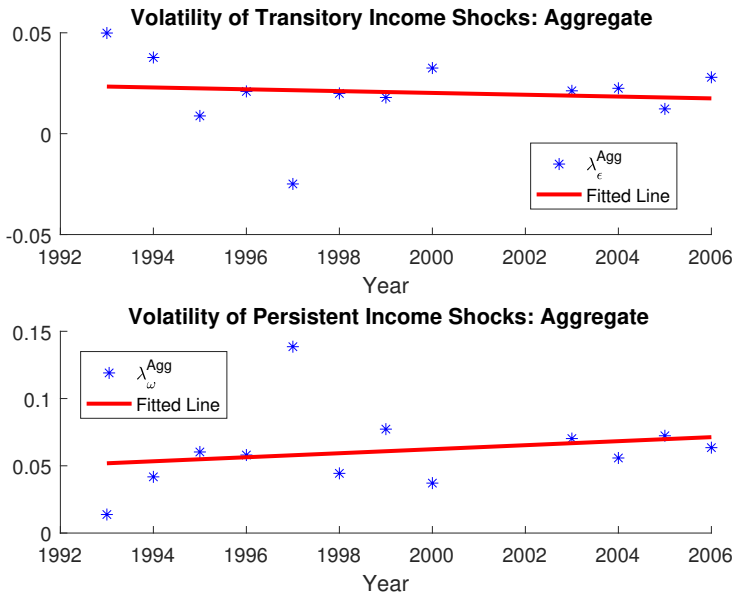
$$\ln e_t = z_t + \epsilon_t, \quad \epsilon_t \sim N(0, \lambda_{\epsilon t}) \tag{1}$$

$$z_t = \rho z_{t-1} + \omega_t, \quad \omega_t \sim N(0, \lambda_{\omega t}) \tag{2}$$

where $\ln e_t$ is obtained as the income residual from the Mincerian regression, ϵ_t represents transitory income shocks with variance $\lambda_{\epsilon t}$, ω_t are permanent income shocks with variance $\lambda_{\omega t}$, and ρ measures the persistence of permanent income shocks. We estimate the aggregate income shocks following the level method from Heathcote, Perri, and Violante (2010, hereafter HPV).[2]

[2]Different from HPV, we do not impose the restriction which requires ρ to be 1 (random walk). There are two methods to identify parameters in the labor income process in HPV: level method and

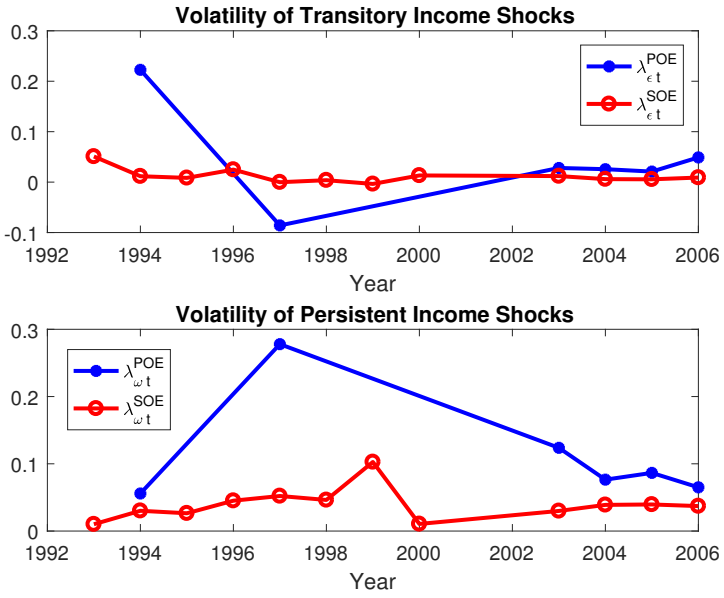
Figure 5: Variances of Income Shocks: Aggregate, Level Method



As we can see from Figure 5, the variances of permanent income shocks exhibit a rising trend during the transition, while the variances of the transitory income shocks are relatively stable with no rising trend. To further explore forces behind the increase in permanent income shocks, we divide our sample into groups of SOE workers and POE workers, respectively. We find that on average the permanent income shocks are much higher for workers that are employed by POEs than by SOEs. Figure 6 depicts that the variances of transitory shocks of POE and SOE workers are relatively close to each other with no clear trend. Similarly, the variances of permanent income shocks of POE and SOE have no clear trend. But the variances of permanent income shocks of POE workers are significantly higher than those of SOE workers. Since the economic transition in China features a large scale of reallocation of workers from SOEs to POEs, the rising aggregate permanent income shocks can be the results of the change in the composition

difference method. In order to identify ρ, we need at least a panel data with three years. The panels we use to estimate the labor income process are the rolling panels with only three years for each panel, constructed from the urban household survey (Ding and He, 2018). Therefore, we have to use level method since difference method requires a panel with four years or more to estimate ρ. Similar to HPV, we only keep estimates for years in which the observations are greater than 100 to avoid limited sample problem.

Figure 6: Variances of Income Shocks by Ownership: Level Method



of employment.

By restricting $\rho = 1$, we can also use the difference method from HPV to estimate the labor income process.[3] Consistent with the level method, Figure 7 further confirms the fact that the variances of aggregate permanent income shock significantly increased after the early 1990s. Figure 8 shows that both the variances of transitory income shocks and the variances of permanent income shocks of POE workers are higher than those of SOE workers. Nevertheless, the variances of permanent income shocks of POE are much higher than those of SOE. This also confirms that the rising variances of aggregate permanent income shocks could be due to the composition effect. [4]

The economic transition in urban China led to a large number of workers moving from SOEs to POEs since the early 1990s. The rise of employment share of POEs due to the

[3]With the restriction of $\rho = 1$, difference method only requires a panel of three years to identify the other parameters from the labor income process, which is available.

[4]It is worth noticing that the transitory income shocks of POE workers show a strong declining trend during the transition in Figure 8. The composition effect suggests that aggregate transitory income shocks could rise based on the fact that POE workers face higher *level* of transitory income shocks than SOE workers. However, the decline *trend* of POE transitory income shocks itself can have a negative impact on the aggregate transitory income shocks over time, as shown in the upper panel of Figure 7.

Figure 7: Variances of Income Shocks: Aggregate, Difference Method

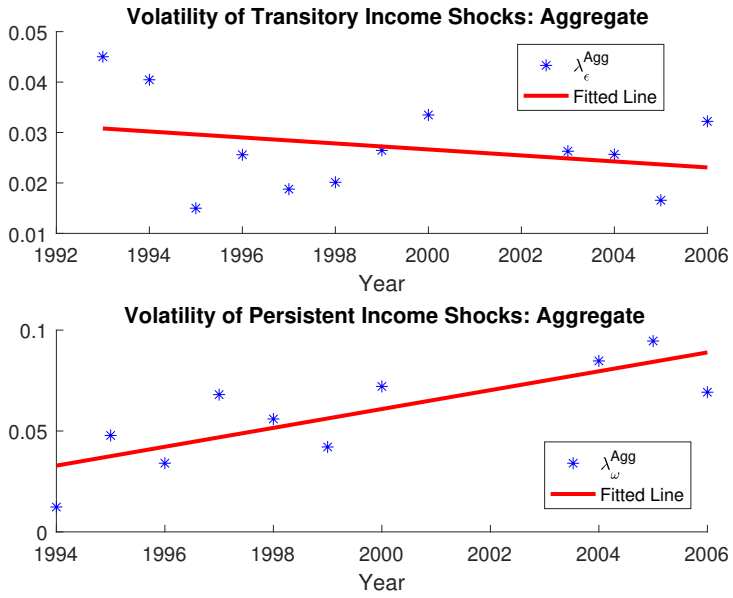
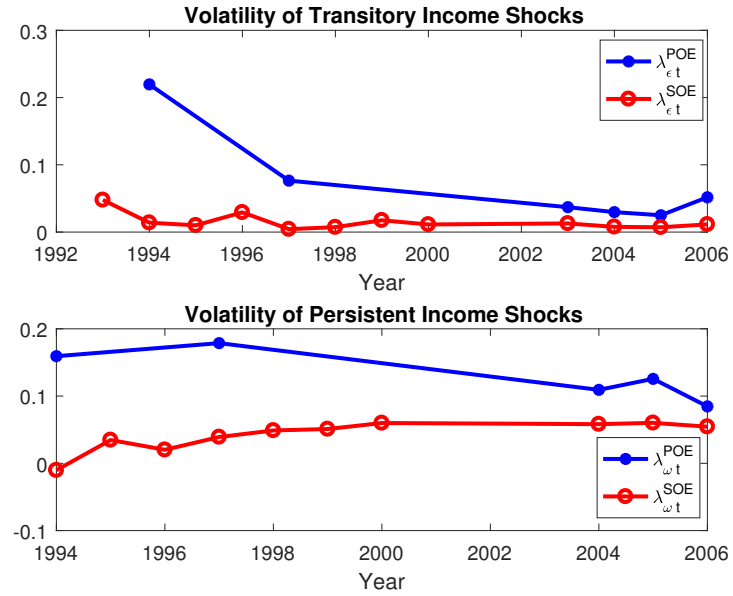


Figure 8: Variances of Income Shocks by Ownership: Difference Method



market reform, associated with the higher sectoral inequality and higher idiosyncratic income shocks in POEs than SOEs, suggests that market reform and economic transition can bring higher inequality in the whole economy due to the composition effect.

3 The Model

Our model is based on the heterogeneous agent model with incomplete asset markets as in Bewley (1986), Huggett (1993), and Aiyagari (1994). The model features two production sectors, SOE and POE. POE workers although are more productive than SOE workers, they face a higher labor income volatility than their SOE counterparts, motivated by the empirical findings mentioned above. The government imposes taxes on POEs to subsidize SOEs, which creates efficiency loss. The market reform is modeled as subsequent exogenous reductions in the SOE subsidies, which leads to workers optimally choose to move from SOEs to POEs.

3.1 Households

The economy is populated by a continuum of infinitely-lived households with a unit measure. Households are categorized into N productivity types from low productivity to high productivity: e_1, e_2, ..., e_N.

At the beginning of each period, each household draws from the distribution of productivity shocks and knows immediately their productivity type. The labor productivity endowment is determined based on their productivity type and firm type. For example, a household with productivity type N who works for POE in the period t has e_{Nt}^{POE} amount of productivity endowment. Similarly, a household with the same productivity type who works for SOE has e_{Nt}^{SOE}. Therefore, in each period, there are $2N$ possible productivity endowment states in total: $\{e_{1t}^{POE}, e_{2t}^{POE}, ..., e_{Nt}^{POE}\}$ and $\{e_{1t}^{SOE}, e_{2t}^{SOE}, ..., e_{Nt}^{SOE}\}$. The above assumption renders the idea that people with the same level of ability (productivity type) can perform differently (carry different productivity endowment) when working for different types of enterprises. Given these information, the households then choose to work for either POE or SOE.

For all workers, the productivity type e_j ($j = 1, 2, ..., N$) evolves according to a N-states Markov chain, with transition matrix Π,

$$\Pi(e'|e) = Prob(e_{jt+1} = e'|e_{jt} = e) > 0 \tag{3}$$

There are two state variables for each household: asset holdings a_t and productivity type e_{jt}. At the beginning of time t, households with a_t reveal their productivity type e_{jt}. Taking the market wages for POE (w_t^{POE}) and SOE (w_t^{SOE}) as given, the households supply $\bar{n}$ units of labor hours and optimally choose to work for a firm (POE or SOE) that pays her the highest labor income ($\max\{w_t^{SOE} e_{jt}^{SOE} \bar{n}, w_t^{POE} e_{jt}^{POE} \bar{n}\}$). The model of discrete and static choice of occupations follows Buera and Shin (2013), where in their paper households choose to work as an entrepreneur or an employee. Also, the households rent assets a_t to firms and collect rental income $r_t a_t$. Constrained by the total income from labor and assets, the households optimally choose consumption c_t and savings a_{t+1} to solve the lifetime utility maximization problem.

Each household is maximizing its lifetime utility from consumption, c_t,

$$\max E_0 \sum_{t=0}^{\infty} \beta^t log(c_t - \bar{c}) \tag{4}$$

subject to

$$c_t + a_{t+1} = \max\{w_t^{SOE} e_{jt}^{SOE} \bar{n}, w_t^{POE} e_{jt}^{POE} \bar{n}\} + r_t a_t + (1 - \delta) a_t \tag{5}$$

where E_0 is the expectation operator conditional on information in period 0, β is the subjective time preference, and $\bar{c}$ represents the subsistence level of consumption. r_t is the rental rate of assets and w_t is the wage per effective labor. δ is the depreciation rate of assets. The no-borrowing constraint is imposed so that $a_{t+1} \geq 0$.

3.2 Firms

There are two representative firms, POE and SOE. POE produces output Y_t^{POE} using a Cobb-Douglas production function with capital K_t^{POE} and effective labor L_t^{POE} as inputs.

$$Y_t^{POE} = A^{POE}(K_t^{POE})^{\alpha}(L_t^{POE})^{1-\alpha} \tag{6}$$

where $\alpha \in (0,1)$ represents the share of capital in total output, and A^{POE} represents the Hicks-neutral productivity of POE.

In each period, POE borrows capital and uses effective labor in the production to maximize its profits π_t^{POE} and it is subject to a government tax τ_t,

$$\max \pi_t^{POE} = (1-\tau_t)Y_t^{POE} - w_t^{POE}L_t^{POE} - r_t K_t^{POE} \tag{7}$$

Solving the firm's problem specified in equation (7) implies,

$$r_t = (1-\tau_t)\alpha A^{POE}(K_t^{POE})^{\alpha-1}(L_t^{POE})^{1-\alpha} \tag{8}$$

$$w_t^{POE} = (1-\tau_t)(1-\alpha)A^{POE}(K_t^{POE})^{\alpha}(L_t^{POE})^{-\alpha} \tag{9}$$

SOE has the following production function

$$Y_t^{SOE} = A^{SOE}(K_t^{SOE})^{\alpha}(L_t^{SOE})^{1-\alpha} \tag{10}$$

where A^{SOE} represents the Hicks-neutral productivity of SOE.

In each period, SOE borrows capital and uses effective labor in the production to maximize its profits π_t^{SOE} and it is subsidized by a government subsidy s_t,

$$\max \pi_t^{SOE} = (1+s_t)Y_t^{SOE} - w_t^{SOE}L_t^{SOE} - r_t K_t^{SOE} \tag{11}$$

Similarly, we have the following first-order conditions

$$r_t = (1+s_t)\alpha A^{SOE}(K_t^{SOE})^{\alpha-1}(L_t^{SOE})^{1-\alpha} \tag{12}$$

$$w_t^{SOE} = (1+s_t)(1-\alpha)A^{SOE}(K_t^{SOE})^{\alpha}(L_t^{SOE})^{-\alpha} \tag{13}$$

3.3 Government

Government levies taxes from POE to subsidize SOE and runs a balanced budget each period,

$$\tau_t Y_t^{POE} = s_t Y_t^{SOE} \tag{14}$$

3.4 Aggregate Economy and Equilibrium

Let $\mu : A \times E$ represents the measure of households over asset and labor productivity space, where A contains all possible discrete values of assets a.

Because households make occupational choice period by period based on their salary, the optimal decision of working for POE or SOE results in an indicator function $I(e_{jt}; w)$ which only depends on labor productivity and wages,

$$I(e_{jt}; w) = \begin{cases} 1 & (POE) \\ 0 & (SOE) \end{cases} \tag{15}$$

Equation (5) implies that $I(e_{jt}; w) = 1$, when $w_t^{SOE} e_{jt}^{SOE} < w_t^{POE} e_{jt}^{POE}$.

The aggregate effective labor supply for POE (L_{St}^{POE}) is

$$L_{St}^{POE} = \int_{A,E} (e_{jt}^{POE} \bar{n}) I(e_{jt}; w) \mu_t(da, de; r, w) \tag{16}$$

The aggregate effective labor supply for SOE (L_{St}^{SOE}) is

$$L_{St}^{SOE} = \int_{A,E} [(e_{jt}^{SOE} \bar{n})(I(e_{jt}; w) + 1) - 2(e_{jt}^{SOE} \bar{n}) I(e_{jt}; w)] \mu_t(da, de; r, w) \tag{17}$$

The labor market clearing condition implies that the effective labor supply (L_{St}^i) equals the labor demand (L_t^i), for $i = POE$, or SOE,

$$L_{St}^i = L_t^i \tag{18}$$

Also, we define the decision rule of the optimal asset holding ($\hat{a}_{t+1}$) for each household as,

$$\hat{a}_{t+1} = A(a_t, e_{jt}; r, w) \tag{19}$$

The decision rule of the optimal consumption ($\hat{c}_t$) in period t for each household is then given by,

$$\hat{c}_t = C(a_t, e_{jt}; r, w) \tag{20}$$

Therefore, the aggregate consumption in period t can be written as $C_t = \int_{A,E} \hat{c}_t \mu_t(da, de; r, w)$.

Next, we can write the aggregate supply of capital in period t as $A_t = \int_{A,E} \hat{a}_t \mu_t(da, de; r, w)$.

The condition for capital market clearing is,

$$A_t = K_t = K_t^{POE} + K_t^{SOE} \tag{21}$$

Finally, the goods market clearing condition implies that

$$C_t + K_{t+1} - (1 - \delta)K_t = Y_t \tag{22}$$

where aggregate output is the sum of production from two sectors

$$Y_t = Y_t^{POE} + Y_t^{SOE}. \tag{23}$$

4 Calibration and Computation

In this section, we calibrate the model at annual frequency using Chinese data for the period $1992 - 2006$. Then, we introduce the algorithm used for solving the model. Table 1 presents the values of the calibrated parameters.

Table 1: **Parameter Values (Annual Basis)**

Capital Income Share	α	0.5
Capital Depreciation Rate	δ	0.09
Labor Hours	$\bar{n}$	1/3
Productivity of SOE	A^{SOE}	1
Productivity of POE	A^{POE}	1.8
Subjective Time Preference	β	0.97
Subsistence Level of Consumption	$\bar{c}$	0.28
Government Tax on POE in 1992	τ_{1992}	0.49
Government Tax on POE in 2006	τ_{2006}	0.13

We set capital income share α at 0.5 and depreciation rate δ at 0.09 to be consistent with empirical estimates by Bai et al. (2006) and Zhang (2008), respectively. We set $\bar{n} = \frac{1}{3}$ such that workers spend one-third of their time working. The productivity of SOE A^{SOE} is normalized to 1. And the productivity of POE A^{POE} is set at 1.8 to be consistent with the average sectoral TFP gap estimated in Brandt, Hsieh, and Zhu (2008) for China during the period of 1998-2004. We calibrate β at 0.97 so that the real interest rate in the initial steady state is 2.5% between 1992 and 2006, corresponding to the official one-year deposit interest rate announced by People's Bank of China and CPI inflation calculated from Statistical Yearbook of China. We calibrate the subsistence level of consumption $\bar{c}$ at 0.28 so that the average investment-GDP ratio is 39% between 1992 and 2006. The government tax on POE in 1992 τ_{1992} is set at 0.49 to match POE employment share of 5% in 1992. The government tax on POE in 2006 τ_{2006} is set at 0.13 to match POE employment share of 45% in 2006. The government tax rates between 1993 and 2005 are then interpolated so that they decrease gradually and evenly each year to mimic the fact that the POE employment share gradually rose from 5% in 1992 to 45% in 2006.

For $i = POE$ or SOE, the level of productivity endowment is drawn from the following process,

$$\ln e_t = z_t + \epsilon_t, \quad \epsilon_t \sim N(0, \lambda^i_{\epsilon t}) \tag{24}$$

$$z_t = \rho z_{t-1} + \omega_t, \quad \omega_t \sim N(0, \lambda^i_{\omega t}). \tag{25}$$

Between 1992 and 2006, the average estimates of $\lambda^i_{\epsilon t}$ are 0.04 for POE and 0.01 for SOE, while the average estimates of $\lambda^i_{\omega t}$ are 0.11 for POE and 0.04 for SOE, based on the level method. The estimates of ρ are 0.90 for POE and 0.88 for SOE. Given these estimates, we apply Tauchen (1986)'s method to discretize the above process into a finite-state Markov chain ($N = 39$) to obtain the vectors of productivity endowments ($\{e^{POE}_{1t}, e^{POE}_{2t}, ..., e^{POE}_{Nt}\}$, $\{e^{SOE}_{1t}, e^{SOE}_{2t}, ..., e^{SOE}_{Nt}\}$) and the transitional probability matrix Π.[5]

Then, we solve the model numerically based on the algorithm from Domeij and Heathcote (2004). Specifically, τ_t stays constant at τ_{1992} before period 0 (initial steady state). The government then announces the market reform (the series of new τ after period 0) in period 1, and the model economy transits to the final steady state in a far future where τ_t stays constant at τ_{2006}.

The computation involves eight steps:

1. Given $\tau = 0.49$, solve for the initial steady state ($t = 0$, year 1992) as follows: (a) Guess an initial value for the capital (output and prices are therefore determined). (b) Solve for household decision rules using value function iteration (discrete). (c) Simulate the economy to generate a stationary asset/productivity distribution. (d) Check if the aggregate holding (supply) of household savings equals to the initial guess of the aggregate capital demand. (e) Adjust the initial guess until step (d) holds.

2. Choose new values of τ in the future, which is announced before households make decisions in the first period unexpectedly. Assume that the economy will converge to a new steady state at date T.

3. Solve for the final steady state by repeating step 1 mentioned above, compute K_T given the final steady state value of τ (τ_{2006}).

4. Guess a sequence K_1, ..., K_{T-1} for capitals in the transition path. We know K_T since it is solved in step 3.

[5]To reduce computation burden, we transform the system of equations (24) and (25) into one AR(1) process, and then apply Tauchen (1986)'s method to it (see the Appendix for details). Also, since the estimates of ρ are close between POE (0.90) and SOE (0.88), to further reduce computation cost, we set ρ as 0.89 for both POE and SOE. Then, the transitional probability matrices Π obtained from Tauchen (1986)'s method are the same for POE and SOE, which is consistent with our model assumption that e_j (productivity type) evolves according to Π for all workers.

5. Solve the household saving decisions along the transition path using backward induction: (a) Taking value function at T (solved in step 3), K_{T-1} (guessed in step 4), and the market clearing prices as given, solve for household value functions and saving decisions at T-1. (b) Repeat this process until we solving back to the first period.

6. Simulate the path of capital along the transition from the first period using the distribution of households over assets and productivity in the first period and decision rules along the transition path that we obtain from the step 5.

7. Check if the simulated path of capital coincides with the guessed path in step 4. If yes, we find the equilibrium transition path. Otherwise, return to step 4 and update our guess until we find the convergence.

8. Check whether T is large enough by trying a larger T and see if the equilibrium path is robust.

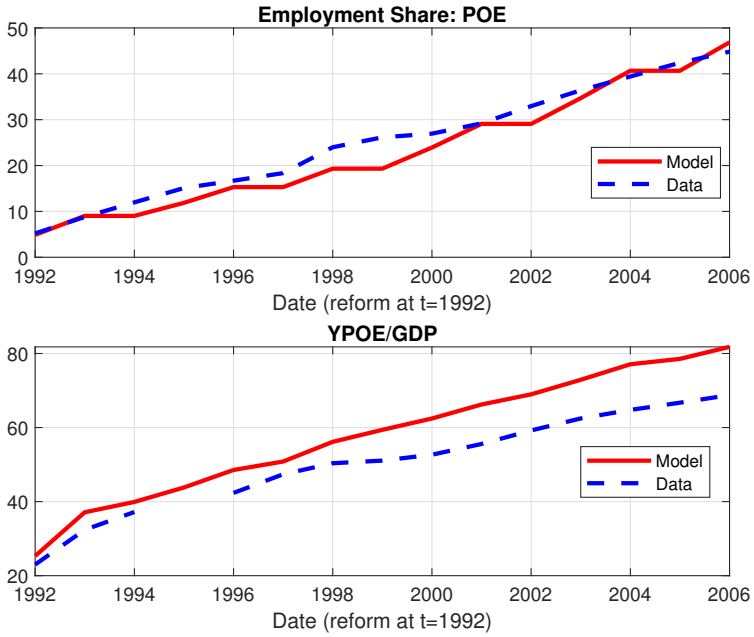
5 Results

This section presents the quantitative results of the transition path of the model economy. The transition is caused by a market reform which reduces the government tax on POEs from τ_{1992} to τ_{2006} gradually and evenly each year to mimic the fact that the POE employment share gradually rose from 5% in 1992 to 45% in 2006.

5.1 Transition and Inequality

The market reform started from 1992 reduces taxes imposed on POE and subsidies given to SOE. This change encourages POE to expand its production by hiring more workers. The upper panel in Figure 9 illustrates that workers shift voluntarily from SOE to POE given the market reform. In the model employment share of POE gradually rises from 5% in 1992 to 45% in 2006, which tracks the data closely as we calibrated τ_t to target the POE employment share in 1992 and 2006. The lower panel of Figure 8 displays the expansion of POE production due to the reallocation from SOE to POE. Without targeting the output share of POE in the calibration, the model generates that output share of POE rises from 25% in 1992 to 81% in 2006, while the data shows that the POE

Figure 9: POE Employment and Output Share: Model vs Data



Data Source: Calculations based on China Labor Statistical Yearbook

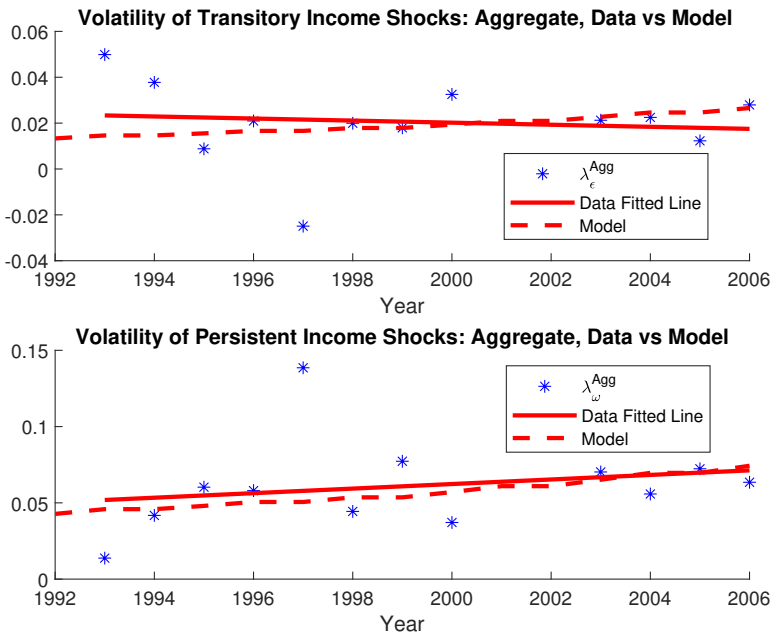
output share increased from 23% in 1992 to 69% in 2006.[6]

Based on the findings that workers from POEs face a significantly higher labor income volatility than workers from SOEs, the reallocation of employment from SOEs to POEs due to the market reform can profoundly increase the aggregate income shocks that households face. Figure 10 shows the impact of composition effect on aggregate income shocks in the model and compared it with the data. In the lower panel of Figure 10, we see that the model nicely captures the rising permanent income shocks in the data. In the upper panel of Figure 10, although the model roughly matches the average level of transitory income shocks in the data, but it fails to capture the declining trend of the data. This could be due to the assumption of constant transitory income shock variances $\lambda^i_{\epsilon t}$ for POEs. As documented in Figure 6, volatility of transitory income shocks for POE

[6]The reason why our model overpredicts the rising output share of POEs might be that the model does not take into account the fact that SOEs caught up with POEs in TFP level after the SOE reform (documented in Hsieh and Song (2015) and Fang, He, and Li (2016)). With narrowing TFP differences over time between POE and SOE, the model should be able to do a better job in capturing the output share of POEs.

workers actually declines over time in the data. If we relax the assumption to adopt time-varying $\lambda^i_{\epsilon t}$ for POEs (and SOEs), the model should be able to do a better job in capturing the rising trend of $\lambda^i_{\epsilon t}$.

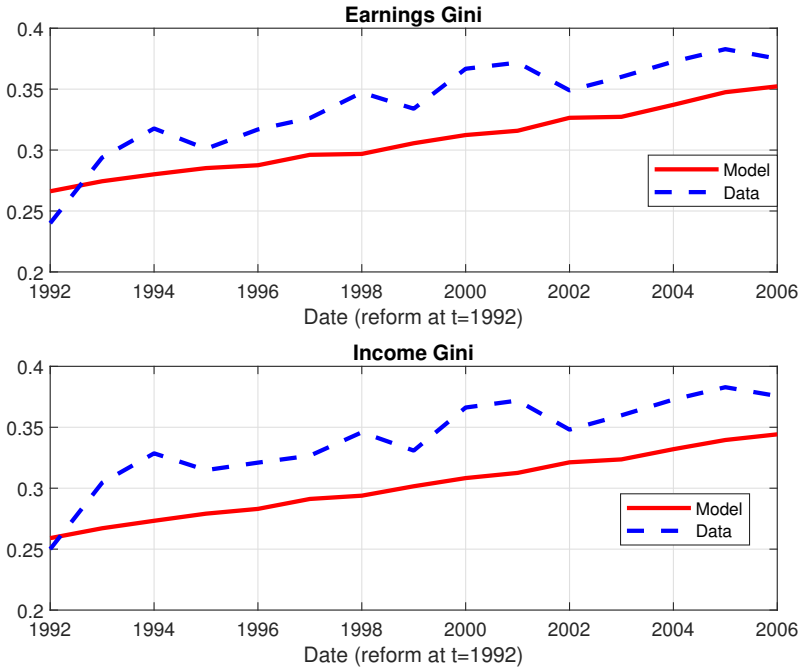
Figure 10: Variances of Aggregate Income Shocks: Model vs. Data



Data Source: Calculations based on Urban Household Survey of China

With finely matching the level and the evolution of volatility of income shocks workers face, the heterogeneous agent model used here allows us to track the income distribution during the entire transition. Figure 11 compares the dynamics of earnings and income Gini in the model to the data for the period 1992-2006. When workers move from a sector with relatively low permanent income shocks (SOE) to a sector with higher permanent income shocks (POE), the average level of earnings volatility rises due to this change in the employment composition. Without targeting any inequality measure in our calibration, our model generates earnings Gini and income Gini that are fairly close to the data in both 1992 and 2006. Therefore, as shown in Table 2, from 1992 to 2006, income Gini increased from 0.25 in 1992 to 0.38 in 2006. The model generates income

Figure 11: Earnings and Income Inequality: Model vs Data



Data Source: Urban Household Survey of China

Gini to be 0.26 in 1992 and 0.34 in 2006. In other words, the model is able to explain about 62% of the increase in income Gini. Similarly, the market reform contributes to 57% of the increase in earnings Gini for the period 1992-2006.

Table 2 also shows that the magnitude of the rise in consumption Gini is much smaller compared to the rise in income Gini due to the existence of subsistence consumption. In addition, the rise in consumption Gini in the model is much smaller than the increase of non-durable consumption Gini in the data, showing the consumption-smooth is still

Table 2: **Quantitative Fit**

Gini	Data (1992)	Model (1992)	Data (2006)	Model (2006)	Explained (92-06)
Earnings	0.24	0.27	0.38	0.35	57%
Income	0.25	0.26	0.38	0.34	62 %
Consumption	0.23	0.18	0.32	0.21	33 %

Data Source: Urban Household Survey of China

too strong in the model. Overall, the market reform contributes to about 33% of the increase in non-durable consumption Gini for the period 1992-2006.[7]

However, both income Gini and consumption Gini co-move quite closely during the economic transition, which we also observe in the data. The correlation coefficient between income Gini and consumption Gini is 0.93 in the model simulation between 1992 and 2006, which is very close to the correlation coefficient we calculate from data (0.98). The lack of risk-sharing due to rising uninsurable permanent income shocks (as shown in Figure 10) and the model feature of incomplete asset markets contribute to this co-movement between consumption Gini and income Gini.

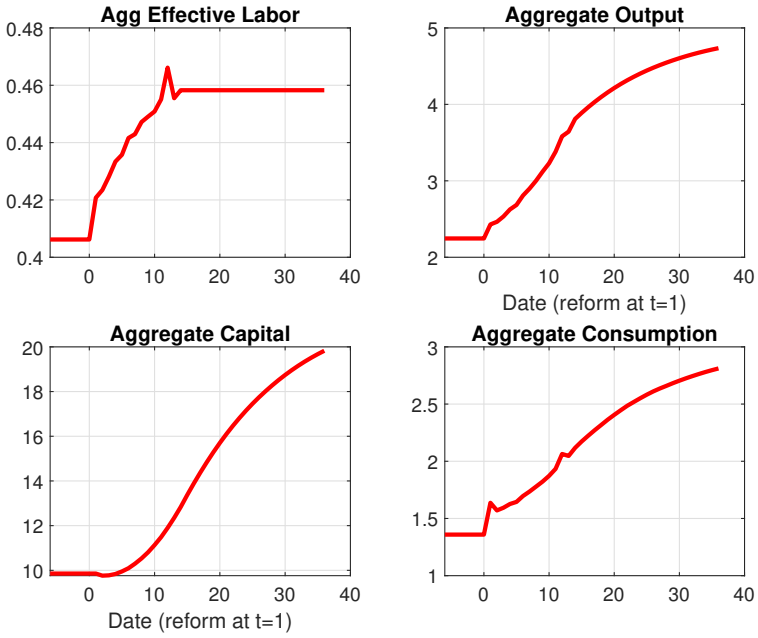
5.2 Transition and Aggregate Economy

Solving the model economy along the transition path, our model is also able to produce the evolution of other aggregate macro variables. Because POE has higher average labor productivity than SOE, the aggregate effective labor rises since 1992 ($t = 0$), shown in panel A of Figure 12. Meanwhile, since POE has relatively higher TFP than SOE, as the production shifts from SOE to the more productive POE, the aggregate output, capital, and consumption also increase, as shown in remaining panels of the figure. Consistent with results in the seminal papers of Song, Storesletten, and Zilibotti (2011) on the transition of China, our model simulation generates transition paths of aggregate variables that are in line with the experiences of China since the 1990s.[8]

[7]To analyze the change in wealth distribution during the transition, we use Chinese Household Income Project which contains wealth information for surveyed households in 1995 and 2002. The Gini of financial net worth rose from 0.71 to 0.81 between 1995 and 2002 in the data, while in the model the wealth Gini rises from 0.45 to 0.48 during the same period.

[8]Chang, Chen, Waggoner, and Zha (2016) also document key facts of post-1990s economic transition, such as persistently rising investment rate, the declining labor income share, and a growing foreign surplus. However, to account for these facts, they focus more on the role of preferential credit policy for promoting heavy industries.

Figure 12: Aggregate Economy: Transition Path



5.3 Additional Analysis

In this section, we conduct two experiments to justify the key features of the model: 1) Allow households to borrow (now the lower bound of the asset grid is set at a negative number, -10); 2). Remove the subsistence consumption, $\bar{c}$.

First, allowing households to borrow does not change the major message of our results. However, the experiment changes the correlation between income Gini and consumption Gini. The correlation coefficient in the data is 0.98. In our baseline model, this coefficient is 0.93. After allowing the household to borrow, it becomes 0.82. Also, the wealth Gini rises more compared to the no-borrowing case. Poor households have strong precautionary savings motive because they are more vulnerable to the bad productivity shocks. However, the precautionary savings motive is not as strong as the no-borrowing constraint case since now poor can borrow to hedge against negative income shocks. As a result, the poor now increases consumption, which reduces the correlation between consumption Gini and income Gini. Therefore, the assumption of no-borrowing

constraint is important in generating the close co-movement between consumption Gini and income Gini as in the data.

Second, after removing $\bar{c}$, to hedge against negative income shocks, precautionary savings motive makes poor households to save disproportionally more relative to the rich households, which leads to declining wealth Gini over time. With $\bar{c}$, wealth Gini rises for years because poor households have to consume at least $\bar{c}$ and therefore cannot save that much. The motivation of consuming at least $\bar{c}$ thus dominates the precautionary savings motive. Therefore, the existence of subsistence consumption is crucial for the model to deliver a persistent rise in the wealth Gini after the market reform as we see in the data.

6 Conclusion

This paper develops a theory to explain why economic transition leads to rising income, consumption, and wealth inequalities. We find empirically that the permanent income shocks are much higher for POE workers than their SOE counterparts. A market reform that pushes workers moving from SOEs to POEs thus can drive up both permanent income shocks and income inequality due to the composition effect. And the rising uninsurable permanent income shocks also lead to more difficult risk-sharing, which in turn contributes to rising consumption inequality. Higher income inequality, on one hand, makes the rich save even more because they are richer and they have a higher saving tendency. On the other hand, the poor could not save that much to hedge against a bigger dispersion of income shocks due to the existence of subsistence consumption. As a result, wealth inequality also increases after the transition.

We build a two-sector heterogeneous agents model with incomplete markets, endogenous occupational choice, and subsistence consumption. And we calibrate the model to Chinese economy. The model simulation suggests that the market reform can explain 57% of the increase in earnings Gini, 62% of the increase in the income Gini, and 33% of the rise in the consumption Gini in urban China between 1992 and 2006. Economic transition is a major driving force behind rising economic inequalities.

References

Aiyagari, S. R., & S. Rao. (1994), Uninsured idiosyncratic risk and aggregate saving. Quarterly Journal of Economics 109(3), 659-684.

Bai, C., Hsieh, C., and Qian, Y. (2006), The Return to Capital in China, Brookings Papers on Economic Activity, 2, 2006, 61-101.

Bewley, T. F. (1986), Statationary monetary equilibrium with a continuum of independently fluctuating consumers. In Hildenbrand and Mas-Colell ed. Contributions to Mathematical Economics in Honor of Gerard Debreu.

Blundell, R., Pistaferri, L., & Preston, I. (2008). Consumption inequality and partial insurance. American Economic Review, 98(5), 1887-1921.

Brandt, L., Hsieh, C., and Zhu, X. (2008). "Growth and Structural Transformation in China." In China's Great Economic Transformation, ed. Loren Brandt, and Thomas G. Rawski, 683-708. New York: Cambridge University Press.

Buera, F. J., & Shin, Y. (2013). Financial Frictions and the Persistence of History: A Quantitative Exploration. Journal of Political Economy, 121(2), 221-272.

Chang, C., Chen, K., Waggoner, D. F., & Zha, T. (2016). Trends and cycles in Chinas macroeconomy. NBER Macroeconomics Annual, 30(1), 1-84.

Ding, H., & He, H. (2018). A Tale of Transition: An Empirical Analysis of Economic Inequality in Urban China, 1986-2009. Review of Economic Dynamics, 29, 106-137.

Domeij, D., & Heathcote, J. (2004). On The Distributional Effects Of Reducing Capital Taxes. International Economic Review, 45(2), 523-554.

Fang, J., He, H., & Li, N. (2016). Chinas Rising IQ (Innovation Quotient) and Growth: Firm-level Evidence. IMF Working Paper 16/249.

Heathcote, J., Perri, F., & Violante, G. L. (2010). Unequal we stand: An empirical analysis of economic inequality in the United States, 1967-2006. Review of Economic dynamics, 13(1), 15-51.

Heathcote, J., Storesletten, K., & Violante, G. L. (2010). The macroeconomic

implications of rising wage inequality in the United States. Journal of Political Economy, 118(4), 681-722.

Huggett, M. (1993). The risk-free rate in heterogeneous-agent incomplete-insurance economies, Journal of Economic Dynamics and Control 17, pp. 953-970.

Milanovic, B. (1999). Explaining the increase in inequality during transition. Economics of Transition 7(2), 299–341.

Milanovic, B., & Ersado, L. (2012). Reform and inequality during the transition: an analysis using panel household survey data, 1990-2005. In Economies in Transition (pp. 84-108). Palgrave Macmillan, London.

Song, Z., Storesletten, K., & Zilibotti, F. (2011). Growing like China. The American Economic Review, 101(1), 196-233.

Tauchen, G. (1986). Finite state markov-chain approximations to univariate and vector autoregressions. Economics Letters, 20(2), 177-181.

Zhang, Jun. (2008). Estimation of China's provincial capital stock (1952-2004) with applications. *Journal of Chinese Economic and Business Studies* 6(2): 177-196.

Appendix

The log of e_t evolves according to the following labor income process,

$$\ln e_t = z_t + \epsilon_t, \quad \epsilon_t \sim N(0, \lambda_{\epsilon t}) \tag{26}$$

$$z_t = \rho z_{t-1} + \omega_t, \quad \omega_t \sim N(0, \lambda_{\omega t}) \tag{27}$$

where $\ln e_t$ is obtained as the income residual from the Mincerian regression, ϵ_t represents transitory income shocks with variance $\lambda_{\epsilon t}$, ω_t are permanent income shocks with variance $\lambda_{\omega t}$, and ρ measures the persistence of permanent income shocks.

To transform the above system into one AR(1) process, we first rewrite equation (26),

$$z_t = \ln e_t - \epsilon_t \tag{28}$$

Then, we plug equation (28) into (27),

$$\ln e_t = \rho \ln e_{t-1} + \omega_t + \epsilon_t - \rho\epsilon_{t-1} \tag{29}$$

Define the error term $\xi_t = \omega_t + \epsilon_t - \rho\epsilon_{t-1}$, the income process of $\ln e_t$ is now a single AR(1) with ξ_t as the weighted income shock with the variance $\lambda_{\omega t} + \lambda_{\epsilon t} - \rho^2\lambda_{\epsilon t-1}$. The transitory income shock has the weight of $\frac{\lambda_{\epsilon t} - \rho^2\lambda_{\epsilon t-1}}{\lambda_{\omega t} + \lambda_{\epsilon t} - \rho^2\lambda_{\epsilon t-1}}$ (the calibration suggests that on average, this weight is 6%), while the permanent income shock has the weight of $\frac{\lambda_{\omega t}}{\lambda_{\omega t} + \lambda_{\epsilon t} - \rho^2\lambda_{\epsilon t-1}}$ (94%, according to the calibration).