ESSAYS ON THE MACROECONOMICS OF CHINA

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by

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_______________________
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Abstract

by

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China’s economic importance in the world’s economy is difficult to overstate. By population it is the world’s largest and by gross domestic product (GDP) it trails only the United States. This dissertation addresses some of the most pressing questions pertaining to China’s rise onto the world’s economic stage. Composed of three chapters, the first is part of a broader question on how economic researchers should approach analyzing China’s economy from a methodological standpoint. Specifically, it asks if the tools used to study business cycles in developed countries can also be used to study China. Or is it the case that China is too “different” from developed economies? Co-authored with Nelson C. Mark, this chapter shows that standard business cycle models work as well for studying China as they do for Canada. However, the dimensions by which the tools succeed and fail are different between the two.

The second chapter, adapted from a co-authored paper with Steven Lugauer and Nelson Mark, studies the effect that changing demographic patterns have had on the household saving rate in China. China’s population composition from a very young to an older population has been dramatic from a sharp reduction in fertility rates following the initiation of government sponsored population programs such as the One Child Policy. At the same time, saving as a share of household income has steadily increased from 5 percent in the 1970s to over 27 percent by 2008. This chapter presents a quantitative
model with life-cycle components and a changing age composition that account for nearly all of the increase in household saving.

Finally, the third chapter investigates the extent that economic reforms that removed barriers to entry by private businesses in 1992 can quantitatively account for China’s growth in total factor productivity (TFP). This chapter presents a model of both the private and state sectors which shows that entry by private businesses is limited to only the most productive due to imperfect access to financial markets. Thus, the 1992 reforms initiated aggregate TFP growth through the entry and expansion of exclusively the most productive private businesses.
For Dr. Kerry M. Iselin

and for Huyen
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CHAPTER 1

BUSINESS CYCLES, CONSUMPTION, AND RISK SHARING

1.1 Introduction

Can standard business-cycle methodology be applied to China? This chapter addresses this question by examining the macroeconomic time series and identifying dimensions in which China differs from economies (such as Canada and the U.S.) that are typically the subject of business-cycle research. Naively applying the standard business-cycle tools to China is no more ridiculous than applying it to Canada, although the dimensions along which the model struggles is different. For China, the model cannot account for the low level of consumption (or high saving) as a proportion of income observed in the data. An examination of provincial level consumption data suggests that the absence of channels for intranational consumption risk sharing may be an important reason why the business-cycle model has trouble accounting for Chinese consumption and saving behavior.

This chapter examines the extent to which China’s macroeconomy is suitable for business cycle modeling. It address whether China is sufficiently similar or different, say in comparison to Canada and the U.S. This focuses on two issues. First, it investigates the extent to which the cyclical properties of the post-reform Chinese economy (1978 to 2007) can be understood with a very basic real business cycle model. The model used is

\[ \text{This chapter, coauthored with Nelson Mark is a modified version of Curtis and Mark (2010).} \]
nearly identical to Mendoza (1991), who studied the Canadian economy from 1946-1985. The only part of the model that is specific to China is the parameters of the exogenous processes (government spending and productivity) that are estimated from the Chinese data. Otherwise, the same parameter values as Mendoza are employed to facilitate the comparison between Chinese and Canadian macroeconomic behavior.

The main finding from this analysis is that China is not so very different. The business cycle model works about as well for China as it does for Canada in terms of matching the volatility and persistence of the macroeconomic data. For China, the model’s primary shortcoming is in explaining consumption and saving behavior whereas for Canada it is in explaining the persistence of investment and the trade balance. The model predicts consumption to be too smooth and to be too large a fraction of GDP as compared to the data.

The second issue addressed is motivated by the ‘failure’ of the business cycle model to explain household consumption behavior. Here, we examine the extent to which either markets or institutions in China carry out intranational risk sharing as a potential cause of the anomalous consumption/saving behavior. Since the representative agent setup in the business cycle model rests on an assumption of perfect within country risk sharing, severe violations of the risk-sharing assumption may explain the inability of the model to account for this aspect of the data. If opportunities for consumption risk-sharing are absent, people will have a strong precautionary saving motive that normally does not arise in the model.

Using provincial level data on real per capita consumption and income, a formal test is conducted on the risk-sharing assumption following Crucini’s (1999) study of risk-sharing across U.S. states and among G-7 countries. Employing the same methodology as Crucini allows direct comparison of results for China with his results for the U.S. and
across the industrialized economies.

The primary finding from this analysis is the degree of within China risk sharing is strikingly low. During the post market reform period (1979-2004), the data tell us that there was about as much risk sharing across Chinese provinces (i.e., very little) as there was internationally among G-7 countries from 1970 to 1987. Since many capital controls were still in place during the 1970s and 1980s, it is perhaps not surprising that international risk sharing was imperfect. We find the degree of risk sharing across Chinese Provinces is much lower than that across U.S. states.\(^2\) The differences in risk-sharing opportunities (and by implication of consumption and saving ratios) constitute one of the major differences between China and the industrialized countries.

The remainder of the chapter proceeds as follows. The next section covers the application of the business cycle model to China. Section 1.3 presents an informal examination of the provincial level data. The formal test of the risk-sharing hypothesis and comparison of our results to Crucini’s for the U.S. and G-7 countries is undertaken in Section 1.4 and Section 1.5 concludes.

1.2 Does the business cycle framework work for China?

This section investigates the extent the cyclical properties of the post-reform Chinese economy be understood with a very basic real business cycle model.

The model employed is a variant of Mendoza (1991) and Uribe and Schmidt-Grohe (1994). It is a one-good small open economy model with a representative

\(^{2}\)While the primary focus is on risk-sharing during the post-reform years, we also conduct our analysis on pre-reform data from 1954-1977. This analysis finds that consumption risk was shared even less under central planning than has been observed in the post-reform period. The central planning committee evidently did not direct allocations in the same way as the social planner of our macro models.
consumer/producer who seeks to maximize expected lifetime utility,

\[ E_t \sum \beta^j \left( c_{t+j} - \frac{h_{t+j}^\omega}{\omega} \right)^{1-\gamma} - 1 \]

where \( \beta \in (0,1) \) is the subjective discount factor, \( c_t \) is consumption, \( h_t \) is hours worked, and \( \gamma \in (0, \infty) \) is the coefficient of relative risk aversion. This is same the period utility function used by Mendoza. The difference is that he assumes an endogenous subjective discount factor. Agents can issue or hold an internationally traded one-period non state contingent bond that pays off one unit of the consumption good next period. The current resources available to the agent are the value of the bond holdings \( b_t \) and income \( y_t \). These are consumed \( c_t \), saved, and paid as lump sum taxes \( \tau_t \). Taxes fund wasteful government purchases \( g_t \), and the government runs a balanced budget so that \( g_t = \tau_t \). Saving is achieved by investment \( i_t \) in real capital or bond purchases \( b_{t+1} \). The period budget constraint facing the agent is

\[ c_t + \tau_t + i_t + \frac{b_{t+1}}{1 + R_{t+1}} = y_t + b_t \]

where \( R_{t+1} \) is the rate of return on the bond between time \( t \) and \( t+1 \).

Output is produced by the Cobb-Douglas technology

\[ y_t = a_t k_t^\alpha h_t^{1-\alpha} \]

where \( a_t \) is an exogenous technology shock and the capital stock \( k_t \) accumulates according to

\[ k_{t+1} = (1 - \delta) k_t + i_t - \frac{\phi}{2} \left( \frac{k_{t+1} - k_t}{k_t} \right)^2. \]

The last term in the accumulation equation is an adjustment cost that imposes a
penalty for rapid changes in the capital stock. In open economy models, including the adjustment cost is standard and necessary in order to prevent international investment flows from being overly responsive.

The exogenous state variables are government purchases, technology, and the world interest rate, $r_t$, which are assumed to evolve according to the first-order autoregressive processes,

\[
\ln(g_t) = (1 - \rho_g) \ln(g) + \rho_g \ln(g_{t+1}) + \varepsilon^g_t,
\]
\[
\ln(a_t) = \rho_a \ln(a_{t-1}) + \varepsilon^a_t,
\]
\[
r_t = (1 - \rho_r)\tau + \rho_r r_{t-1} + \varepsilon^r_t,
\]

where $\varepsilon^g \sim iid N(0, \sigma^2_g)$, $\varepsilon^a \sim iid N(0, \sigma^2_a)$, and $\varepsilon^r \sim iid N(0, \sigma^2_r)$. The subjective rate of time preference is set to the long-run (steady-state) interest rate such that it equals $(1 + r)^{-1}$.

As in Schmitt-Grohe and Uribe (2003), we achieve a stationary steady state level of bonds $\bar{b}$ by introducing a country premium $R_t - r_t$ that is increasing in deviations from a fixed debt level\(^3\)

\[
R_{t+1} = r_{t+1} + \psi \left[ \exp(\bar{b} - b_{t+1}) - 1 \right].
\]

The model is closed by imposing the national income accounting identity

\[
y_t = c_t + i_t + g_t + \bar{b} t,
\]

where $\bar{b} t$ is the trade balance. Given the solution of the model, construction of auxiliary

\[^3\]Mendoza achieves a stationary steady state by assuming that the subjective discount factor is endogenous.
variables such as the current account,

\[ ca_t = tb_t + \frac{R_t}{1 + R_t} b_t, \]

and national saving,

\[ s_t = i_t + ca_t \]

follow directly.

1.2.1 Calibration and simulation

The data that employed in the quantitative analysis are annual observations from the China Statistical Yearbook (various issues, see statistical appendix) spanning 1978-2007. In calibrating the model, the parameters that govern the exogenous state variables \((g_t, r_t, a_t)\) are estimated from the data by least-squares of the AR(1) models. The capital adjustment parameter \(\phi\) is chosen to match the volatility of investment. In setting the remaining parameter values, we draw from the literature and make no special adjustments specific to China. Table 1.1 reports the parameter values used. We take \(\omega\) from Mendoza (1991) and \(\psi\) from Schmitt-Grohe and Uribe (2003). The discount factor is \(\beta = (1+r)^{-1}\) where \(r\) is the mean world real interest rate. The values for \(\gamma, \alpha,\) and \(\delta\) are all standard in the business cycle literature (recall that this is an annual model).

We examine four versions of the model which differ by the shocks that are allowed to hit the economy. They are,

1. The All Shocks model, which has all three shocks \((g_t, r_t, a_t)\) running.

2. The No Government model, which allows productivity and interest rate shocks only.
### TABLE 1.1

**PARAMETER VALUES**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.978</td>
<td>$\rho_a$</td>
<td>0.600</td>
</tr>
<tr>
<td>$\omega$</td>
<td>1.45</td>
<td>$\rho_g$</td>
<td>0.809</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>2</td>
<td>$\rho_r$</td>
<td>0.434</td>
</tr>
<tr>
<td>Preferences</td>
<td>$\alpha$</td>
<td>0.33</td>
<td>Exogenous processes</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.1</td>
<td>$\sigma_a$</td>
<td>0.017</td>
</tr>
<tr>
<td>$\psi$</td>
<td>0.00074</td>
<td>$\sigma_g$</td>
<td>0.010</td>
</tr>
<tr>
<td>$\phi$</td>
<td>2</td>
<td>$\sigma_r$</td>
<td>0.010</td>
</tr>
<tr>
<td>Bonds (SS)</td>
<td>$\bar{b}$</td>
<td>-0.05</td>
<td>$\bar{g}$</td>
</tr>
</tbody>
</table>

3. The *Domestic Shocks* model, which shuts down world interest rate shocks but leaves productivity and government shocks running.

4. The *Productivity Shocks* model, which shuts down interest rate and government spending shocks.

Table 1.2 shows implied volatility of the key variables from the model and in the data since 1978. Let us begin with the “All Shocks” model. In the data, consumption is somewhat more volatile than output, a feature that the model has trouble explaining. The high consumption volatility is not a feature specific to China, as this is a feature of many emerging market economies and also of some industrialized countries such as Great

---

4 This is a stationary model so the data have all been passed through the Hodrick-Prescott filter.
TABLE 1.2

VOLATILITIES
OPEN ECONOMY
1978-2007

<table>
<thead>
<tr>
<th>Series</th>
<th>Data</th>
<th>All Shocks</th>
<th>No Government</th>
<th>Domestic Shocks</th>
<th>Prod. Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma(y)$</td>
<td>0.048</td>
<td>0.050</td>
<td>0.049</td>
<td>0.050</td>
<td>0.049</td>
</tr>
<tr>
<td>$\frac{\sigma(c)}{\sigma(y)}$</td>
<td>1.167</td>
<td>0.877</td>
<td>0.660</td>
<td>0.883</td>
<td>0.721</td>
</tr>
<tr>
<td>$\frac{\sigma(c)}{\sigma(y)}$</td>
<td>1.792</td>
<td>1.687</td>
<td>1.703</td>
<td>1.677</td>
<td>1.682</td>
</tr>
<tr>
<td>$\frac{\sigma(c)}{\sigma(y)}$</td>
<td>0.458</td>
<td>0.664</td>
<td>0.662</td>
<td>0.664</td>
<td>0.663</td>
</tr>
<tr>
<td>$\frac{\sigma(c)}{\sigma(y)}$</td>
<td>1.500</td>
<td>1.237</td>
<td>2.003</td>
<td>1.273</td>
<td>1.882</td>
</tr>
<tr>
<td>$\frac{\sigma(c)}{\sigma(y)}$</td>
<td>0.958</td>
<td>0.904</td>
<td>0.910</td>
<td>0.910</td>
<td>0.910</td>
</tr>
<tr>
<td>$\sigma(y)$</td>
<td>0.027</td>
<td>0.016</td>
<td>0.014</td>
<td>0.017</td>
<td>0.015</td>
</tr>
<tr>
<td>$\sigma(y)$</td>
<td>0.033</td>
<td>0.013</td>
<td>0.015</td>
<td>0.012</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Britain. While also understating the volatility of net exports and the current account, the model overstates the relative volatility of investment, employment, and savings.

World interest rate shocks have a small contribution to the volatility of the endogenous variables. Eliminating government spending shocks, however, results in consumption being even quieter (and saving being much too volatile). The ability of either the “All Shocks” or the “Domestic Shocks” model to generate the correct amount of volatility is mixed.

Table 1.3 reports (model) implied and data values of the first-order autocorrelation of
the macro time series. Keeping government spending shocks in the model are important, otherwise the implied trade balance (and current account) to GDP ratio becomes too persistent. The persistence of the other variables are little affected by the inclusion of government spending. The primary shortcomings of all four versions of the model are that implied persistence of employment is overstated and that of investment is understated.

Table 1.4 examines the co movements of the macro variables. Consumption, investment, and saving all comove with output in the appropriate direction. The last two rows highlight the importance of the government shocks, for the external balances become much too procyclical when they are omitted. Although slightly positive, the low cyclical-
**TABLE 1.4**
CORRELATIONS
OPEN ECONOMY
1978-2007

<table>
<thead>
<tr>
<th>Series</th>
<th>Data</th>
<th>All Shocks</th>
<th>No Gov.</th>
<th>Domestic Shocks</th>
<th>Prod. Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho(y, c)$</td>
<td>0.834</td>
<td>0.933</td>
<td>0.985</td>
<td>0.916</td>
<td>0.942</td>
</tr>
<tr>
<td>$\rho(y, i)$</td>
<td>0.800</td>
<td>0.812</td>
<td>0.817</td>
<td>0.826</td>
<td>0.824</td>
</tr>
<tr>
<td>$\rho(y, s)$</td>
<td>0.829</td>
<td>0.994</td>
<td>0.993</td>
<td>0.992</td>
<td>0.993</td>
</tr>
<tr>
<td>$\rho(c, i)$</td>
<td>0.437</td>
<td>0.705</td>
<td>0.759</td>
<td>0.703</td>
<td>0.719</td>
</tr>
<tr>
<td>$\rho(c, s)$</td>
<td>0.384</td>
<td>0.910</td>
<td>0.987</td>
<td>0.879</td>
<td>0.907</td>
</tr>
<tr>
<td>$\rho(s, i)$</td>
<td>0.890</td>
<td>0.827</td>
<td>0.832</td>
<td>0.849</td>
<td>0.857</td>
</tr>
<tr>
<td>$\rho(y, g)$</td>
<td>0.391</td>
<td>0.399</td>
<td></td>
<td>0.398</td>
<td></td>
</tr>
<tr>
<td>$\rho(\frac{nx}{y}, y)$</td>
<td>-0.098</td>
<td>0.058</td>
<td>0.529</td>
<td>0.025</td>
<td>0.439</td>
</tr>
<tr>
<td>$\rho(\frac{ca}{y}, y)$</td>
<td>-0.167</td>
<td>0.020</td>
<td>0.534</td>
<td>0.021</td>
<td>0.510</td>
</tr>
</tbody>
</table>

The other difficulty in the model is that the predicted co movements between saving and consumption are much higher than in the data.

To compare how China’s business cycle differs from developed economies, Table 1.5 shows the main results from Mendoza’s (1991) simulations from the model calibrated to Canadian data from 1946 to 1985. He calibrates his model to exactly match the volatility of GDP. In doing so, the model is able to match the volatility of consumption,
### TABLE 1.5

RESULTS FOR CANADA

1946-1985

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Volatility</th>
<th>Model Volatility</th>
<th>Data Autocorr.</th>
<th>Model Autocorr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>2.81</td>
<td>2.81</td>
<td>0.615</td>
<td>0.615</td>
</tr>
<tr>
<td>Cons.</td>
<td>2.46</td>
<td>2.225</td>
<td>0.701</td>
<td>0.689</td>
</tr>
<tr>
<td>Saving</td>
<td>7.31</td>
<td>5.58</td>
<td>0.543</td>
<td>0.629</td>
</tr>
<tr>
<td>Inv.</td>
<td>9.82</td>
<td>9.89</td>
<td>0.314</td>
<td>-0.017</td>
</tr>
<tr>
<td>Hours</td>
<td>2.02</td>
<td>1.94</td>
<td>0.541</td>
<td>0.615</td>
</tr>
<tr>
<td>Productivity</td>
<td>1.71</td>
<td>0.87</td>
<td>0.372</td>
<td>0.615</td>
</tr>
<tr>
<td>TB/Y</td>
<td>1.87</td>
<td>1.97</td>
<td>0.663</td>
<td>0.032</td>
</tr>
</tbody>
</table>

investment, hours, and the trade balance to GDP ratio. Saving and productivity implied by the model are not volatile enough but the most obvious shortcoming of the model is the lack of persistence that it generates in investment and in the trade balance.

How different is China? Overall, the model actually works about as well for China as it does for Canada, although the dimensions along which it fares poorly is different in each case. A pretty consistent theme that emerges from the analysis of China is that the standard specification and calibration has trouble explaining household consumption, which in the data is too volatile and too low relative to GDP. The other side of this problem is that both the investment and saving ratios implied by the model are too low.
To give one more illustration of this difficulty, note that the mean values of consumption, investment, and saving in the data (as a fraction of GDP) are 0.465, 0.375, and 0.393, respectively. China’s current account surplus did not accelerate until around 2004, so the national saving ratio is only around 2 percentage points higher than the investment ratio. These values contrast with the steady state ratios implied by the model, which are 0.600 for consumption, 0.268 for investment, and 0.268 for saving.

One potential explanation for these deviations between the moments in the data and those implied by the model is a severe violation of the perfect within country risk sharing assumption.

1.3 Examination of China’s provincial data

The business cycle model assumes that markets are complete and/or a social planner directs allocations to achieve a Pareto Optimum. In either case, consumption growth across households are predicted to be highly (possibly perfectly) correlated. This section focuses on that prediction.

We employ provincial level data, which we obtain from the *China Statistical Yearbook* (various issues) and the *China Statistical Data Compilation 1949-2003*. “Provinces” are referred to as regions classified as Provinces, Autonomous Regions, and Municipalities. These exclude Hong Kong and Macau. These are annual observations spanning from 1954-2004 and have not been subjected to the NBS revisions\(^5\)\(^6\). Nominal values are deflated with the aggregate price deflator. Provincial nominal figures are also deflated

---

\(^5\) Provincial data is reported by each Provincial Statistical Bureau, not the NBS. So, the dates of revisions to provincial accounts data are staggered.

\(^6\) The provincial data only spans up to 2004 where the aggregate data used in business cycle calibration extends to 2007. We used the revised aggregate data but the business cycle moments are similar to the unrevised series.
using provincial price deflators. The main results are unchanged by doing this. The primary interest is in consumption behavior during the post-reform (1978-2004) period. However, since they are available, we also examine the data from the pre-reform (1954-1977) period which allows assessing consumption allocations determined under central planning.

We begin with an examination of provincial real per capita consumption growth. Average growth rates over the subsamples are displayed in Figure 1.1 where a large jump in growth can be observed for every region in the post-reform period. At the aggregate level, consumption growth nearly triples from 2.5% to 7.2% per year. In provinces such as Shanghai, the growth rate went from 0.6% during the pre-reform era to 8.3% in the post-reform period. However, Shanghai is an example of a province that suffered a great deal from the Great Leap Forward (1958-1961) that resulted in widespread famine. Omitting these years, the growth rate is slightly under 3%. In fact, 8 provinces experienced an annual consumption growth rate of less than -20% in at least one year during this period. This contrasts with the much more modest change in Qinghai province. Qinghai, which seemed to be doing relatively well in the pre-reform period, had an average growth rate of 4.0%. In the post-reform era, it’s growth increased only to 4.7%.

In addition to raising consumption growth, the economic reforms after 1978 also seemed to have reduced the overall riskiness of life. Figure 1.2 shows provincial volatility (standard deviation) of consumption growth in the two periods. Volatility declines in every province except for the southern province of Yunnan and Zhejiang bordering Shanghai to the south on the eastern coast. Gansu, an economy based heavily on mining in the interior western region, shows a huge decline in consumption growth volatility. A curious (perhaps troubling) feature of the data is that consumption growth volatility reported in the aggregate China figures lies below most of the provincial volatility levels.
Turning to output, Figure 1.3 shows the well known and corresponding acceleration of average annual growth rate of real per capita provincial GDP in the post-reform era. An interesting feature of this figure is the unevenness of output growth across the provinces. During the pre-reform period, the interior provinces such as Xinjiang (1.2%) and Inner Mongolia (0.5%) experienced very low growth. Even when omitting years of the Great Leap Forward, growth rates are a low 1.8% for Xinjiang and 1.7% for Inner Mongolia whereas areas such as Hubei grew at nearly 5%. Similarly, post-reform output growth is unbalanced and ranges from 6% in Gansu to 11.7% in Zhejiang.

The volatility of provincial output growth is displayed in Figure 1.4 shows the huge reduction in volatility following the market reforms. Pre-reform output volatility during our sample was largely self-inflicted by central planning disasters such as the Great Leap forward (1958-1961) and the Cultural Revolution (1966-1976) which resulted in serious
Figure 1.2. Volatility of per capita consumption growth

Figure 1.3. Growth rate of output
economic upheaval. While pre-reform China seems unimaginably unstable, post-reform China has been quite the opposite. The aggregate volatility of per capita output growth of 2.5% from 1979-2004 is roughly the same level experienced in the U.S. during the years (1969-1983) before the ‘Great Moderation.’

To get an idea of the degree of integration or coordination across provinces, Figure 1.5 shows the correlation between provincial output growth and aggregate output growth. Correlations during the Mao Zedong years are relatively high with an average value of 0.84. This is higher than output growth correlations among US states shown in Figure 1.6. For the U.S., the correlation average is 0.7 from 1969-1983 and 0.56 from 1984-2008. In post-central planning China, the average correlation falls to 0.4 which suggests a low level of integration across provinces on the production side and an increase in the relative importance of idiosyncratic (provincial level) risk.

We next proceed to get a sense of the ability to insure against idiosyncratic income risk. The typical approach to risk sharing is an environment of complete financial markets
Figure 1.5. Correlation between provincial and aggregate output growth

Figure 1.6. Output growth correlation in the United States
where a full menu of state-contingent assets are traded. China’s pre-reform environment was perhaps the farthest thing possible from complete markets. But, by the second theorem of welfare economics, if the leadership acts to maximize social welfare, any Pareto Optimal allocation achieved can also be achieved by a competitive equilibrium. China potentially had at its disposal an institutional setup that could actually achieve perfect consumption insurance. A benevolent social planner would have ordered that consumption be directed across provinces such that consumption growth between any two provinces is perfectly correlated. Such is the basic tenet of communism: “From each according to his ability, to each according to his need,” as the Marxist slogan goes.

The key figure of this section and the one that speaks directly to the risk-sharing issue is Figure 1.7. It displays the correlation between provincial and aggregate per capita consumption growth, which should be close to 1 under perfect insurance. In 15 of the 24 provinces for which we have data over the two subsamples, the correlation declines. So for slightly more than half of the provinces, the pre-reform regime was better able to provide consumption insurance. The average correlation declines from 0.42 to 0.32 in the post-reform period, a statistically significant difference at the 10% level, and the correlation for three of the provinces in the latter period are negative.

The degree of risk sharing across countries is a topic also studied by international economists. In the international economics literature, a widely documented fact, known as the ‘consumption correlation puzzle,’ is that the correlation of consumption growth

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7 The existence of non traded goods and differences in consumption weights across provinces would cause the correlation to drop below, but not far from 1 even with complete risk sharing.

8 The puzzle was noted by Backus et al. (1992) who find that a two-country business cycle model fails to explain most of co-movements of major macroeconomic variables across countries. Subsequent studies that attempt to explain the puzzle include Baxter and Crucini (1995), Kehoe and Perri (2002), Kollmann (1996), and Iacoviello and Minetti (2006) who study the role of the asset market incompleteness in the international business cycles whereas Stockman and Tesar (1995), Wen (2007), Xiao (2004) introduce taste or demand shocks in their models.
between two countries is typically smaller than the correlation between output growth between the same two countries. For example, Choi and Mark (2010) report an average consumption correlation across G-7 countries and the aggregate of 0.4 and an output correlation of 0.5. This is a puzzle, because even if financial markets are incomplete (say there is only a single non-state contingent bond traded across countries), we expect the correlation between the two countries’ consumption to be much higher than the correlation between their output. It is against this backdrop that we present Figures 1.8 and 1.9 which plots the correlation between provincial and aggregate consumption and output. During the pre-reform years, there is a substantial consumption correlation puzzle as provincial consumption correlations (average value 0.42) lie far below the output correlations (average value 0.84). During the post-reform period, the puzzle is attenuated to the extent that provinces look like the industrialized countries in this dimension with
Figure 1.8. Correlation between provincial and aggregate growth: 1954-1977

an average consumption correlation of 0.32 against an average output correlation of 0.40.
1.4 A test of the perfect risk sharing hypothesis

This section employs a methodology used by Crucini (1999) to formally test of the risk-sharing hypothesis across Chinese provinces. Since Crucini applied the same test to U.S. states and G-7 countries, the results from this chapter can be used to assess the degree of within country risk-sharing in China to that in the U.S. and to international risk sharing across industrialized countries.

Let $c_{jt}$ be log real per capita consumption of province $j$ in year $t$, and $C_t$ be log aggregate real per capita consumption. If there is perfect risk sharing, provincial consumption growth should be perfectly correlated with aggregate consumption growth. A testable implication of the hypothesis of perfect risk sharing is that a regression of the change in provincial consumption, $\Delta c_{jt}$, on the change of aggregate consumption, $\Delta C_t$, will yield a unit-valued slope coefficient and that coefficients on any additional regressors will be zero. Let $\Delta y_{jt}^p$ be the innovation (unexpected change) to province $j$'s permanent income.
Crucini (1999) suggest running the regression

\[ \Delta c_{jt} = \alpha_j + \lambda_j \Delta C_t + (1 - \lambda) \Delta y^p_{jt} + \varepsilon_{jt} \tag{1.4.1} \]

and testing the null hypothesis (perfect risk sharing) that \( \lambda_j = 1 \) against the alternative hypothesis (imperfect risk sharing) that \( 0 \leq \lambda_j < 1 \). The innovation to permanent income is unobserved and must be estimated. As in his paper, this chapter considers three alternative estimates of this variable. Income model I assumes that provincial and aggregate income growth, \( \Delta y_{jt} \) and \( \Delta Y_t \), are generated by a first-order vector autoregression. Income model II assumes that provincial income growth follows a first-order autoregression. Income model III assumes that log provincial income is a driftless random walk. The residual from estimating the income model serves as the estimated innovation to permanent income, \( \Delta y^p_{jt} \).

For each income model specification, we estimate 24 regressions of eq. (1.4.1). Although there are 31 provinces, we have continuous observations from 1954 to 2004 for only 24 of these provinces. To summarize the results, we report average figures in Table 1.6.

The estimates of are not exceedingly precise as the standard errors are about the same size as the estimates. In the pre-reform era, under income model I [provincial and aggregate income growth generated by a VAR(1)], perfect risk sharing is not be rejected at the 5 percent level for 6 provinces. In 8 provinces, the hypothesis of zero risk sharing could not be rejected, and in 8 others, the data are uninformative as neither the hypothesis that \( \lambda = 1 \) or \( \lambda = 0 \) can be rejected. The evidence for effective consumption risk sharing is not much different when innovations to permanent income are modeled by income models II (AR(1)) and III (random walk).
TABLE 1.6

TEST OF PERFECT RISK SHARING
ON 24 CHINESE PROVINCES

<table>
<thead>
<tr>
<th>Income Model</th>
<th>( \bar{\lambda} )</th>
<th>Ave. S.E. (( \bar{\lambda} ))</th>
<th># Provinces which 95% C.I. contains value of ( \lambda ) such that ( \lambda = 1 ) or ( 0 &lt; \lambda &lt; 1 )</th>
<th>( \lambda = 0 )</th>
<th>( \lambda = 1 ) or 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1954-1977</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>0.45</td>
<td>0.43</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>0.39</td>
<td>0.40</td>
<td>6</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>0.33</td>
<td>0.38</td>
<td>5</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>1978-2004</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>0.50</td>
<td>0.32</td>
<td>9</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>0.49</td>
<td>0.32</td>
<td>8</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>0.43</td>
<td>0.31</td>
<td>6</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

In post-reform China, there is some evidence of a slightly increased degree of risk sharing. The magnitude of our estimated \( \lambda \) coefficients is bigger, and perfect risk sharing is not rejected for 9 provinces under income model I.

To compare China to within U.S. and international G-7 risk sharing, Table 1.7 reproduces Crucini’s results. Since state level consumption data is unavailable for the U.S., he uses retail sales as the proxy. It can be seen on the basis of retail sales, there appears to be a great deal of risk-sharing within the U.S. Perfect insurance cannot be rejected for
### TABLE 1.7

TEST OF PERFECT RISK SHARING
ON US AND G-7 COUNTRIES

<table>
<thead>
<tr>
<th>Income Model</th>
<th>( \bar{\lambda} )</th>
<th>Ave. S.E. (( \bar{\lambda} ))</th>
<th># Provinces which 95% C.I. contains value of ( \lambda ) such that</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>( \lambda = 1 )</td>
</tr>
<tr>
<td>US States, 1972-1990</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>0.94</td>
<td>0.31</td>
<td>31</td>
</tr>
<tr>
<td>II</td>
<td>0.84</td>
<td>0.34</td>
<td>29</td>
</tr>
<tr>
<td>III</td>
<td>0.88</td>
<td>0.32</td>
<td>33</td>
</tr>
<tr>
<td>G-7 countries, 1972-1990</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>0.60</td>
<td>0.26</td>
<td>2</td>
</tr>
<tr>
<td>II</td>
<td>0.44</td>
<td>0.44</td>
<td>1</td>
</tr>
<tr>
<td>III</td>
<td>0.37</td>
<td>0.37</td>
<td>1</td>
</tr>
</tbody>
</table>

33 states (66\% of the sample) using income model III. The international story, at least among the G-7 during the 70s and 80s is one of substantially less risk sharing. Perfect risk sharing cannot be rejected for at most 28\% of the sample.

Thus for post-reform China, the degree of risk sharing is substantially below that in the U.S. and about at the same level across industrialized countries in the 70s and 80s. It makes sense that international risk sharing may have been low at that time since there
were still many capital controls in place (1970-1987). Overall, the conclusion has to be that there is very little consumption risk sharing across Chinese provinces.\footnote{Xu (2008) employs the Crucini test but employs household survey data spanning 1980-2004 and reaches conclusions similar to ours.}

To summarize the findings on risk sharing; first, as measured by income volatility, the pre-reform era was a riskier environment than post reform. Although riskier, the state run model appears not to have done substantially worse at implementing a program of consumption risk sharing than post-reform China. Nevertheless, the ability to hedge against idiosyncratic provincial level income risk appears modest. The absence of effective risk-sharing channels tells us that the precautionary saving motive must be very strong for Chinese households. Presumably, this is an important factor driving high household saving rates and the current account. We caution the reader not to infer normative implications of this analysis. Even though risk-sharing is still quite modest, the growths enabled by the post-1978 reforms have undoubtedly improved welfare.

1.5 Conclusion

To answer the questions posed in the introduction, this chapter shows that China’s macroeconomics are different from developed countries that are usually studied in business cycle research, but not so different that it is an unsuitable target for this research. One of the most prominent differences in the Chinese data that sets it apart lies in the consumption/saving decisions by households. The business cycle model cannot explain why Chinese households consume such a small fraction of income, why consumption moves around so much relative to income, and why the co movement between consumption and saving is so low. We get a clue as to why the model falls short in this dimension from the analysis on intranational consumption risk sharing. As in Xu (2008), we detect
a low degree of cross-province risk sharing. In this dimension, each province is about as segmented from one another as between the G-7 countries during the 70s and 80s. Given the difficulty of hedging income risk and natural household concerns about income security, the environment would seem to create a significant motive for precautionary saving, which is not present say within the U.S.
CHAPTER 2

DEMOGRAPHIC PATTERNS AND HOUSEHOLD SAVING

2.1 Introduction

In 2008, the household saving rate in China surpassed 27 percent\(^1\) The 27 percent figure, certainly high by international standards, is also high in comparison to China’s saving in earlier periods. From 1959 to 1977 for example, the household saving rate averaged only 3.9 percent, lower in comparison to an average of 8.9 percent observed in the US over the same period. The transition from low to high saving in China began around 1978, corresponding to the initiation of market-based economic reforms. In addition to a changing economic landscape, large demographic changes from a predominantly young to an older population were simultaneously taking place. Fertility rates of almost 6 children per woman as late as 1967 declined to under 2 by the mid-1990s and the fraction of children (ages 0-17) as a fraction of parents (ages 18-60) halved from 0.73 to 0.36. Also, the number of the aged (ages 61-85) per worker (ages 18-60) increased from 0.14 to 0.17 and is projected to accelerate to 0.39 by 2030.

This chapter examines the role played by the changing demographics on the time-path of household saving in China from 1963 to 2008. We undertake a quantitative investigation using an overlapping generations (OLG) model where agents live for 85

\(^1\)This chapter is coauthored with Nelson Mark and Steven Lugauer from a 2012 working paper of the same title.
years. Consumers begin making decisions when they are 18. From age 18 to 60, they work and raise children. Dependent children’s utility enters into parent’s utility where parents choose the consumption level of the young until they leave the household. Working agents give a portion of their labor income to their retired parents and save for their own retirement. The aged live on their accumulated assets and support from their children while remaining assets are bequeathed to the living upon death.

Our set-up allows demographic variations to affect the saving rate through more than one channel. First, the household saving rate is inversely related to the fertility rate. Having fewer “mouths to feed” raises the availability of resources that can be saved for the future. Second, due to the importance of children as a source of retirement income, the decline in the number of children by the working generation promotes saving as they must rely more on savings for retirement in comparison to previous generations. Finally, saving also increases as a result of a composition effect; a large portion of saving tends to occur between the ages of 40 to 65, and China has witnessed a growth in this cohort over the past 30 years.

Our analysis also allows variation in wages and interest rates to affect the saving rate. We parameterize the model and take future demographic changes, labor income, and interest rates as exogenously given from the data. We then run the model from 1963 to 2009 and find that the model can account for nearly all the observed increase in the household saving rate.

The high household saving rate in China has generated the attention of many researchers. Some authors have investigated clever and nonstandard channels. Wei and Zhang (2009) hypothesize that the male sex imbalance, resulting from a Chinese cultural preference for sons and the one-child policy of population control, is the driving force in

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2Data exists beginning in 1953 but we begin our simulations in 1963 to avoid extreme outcomes associated with the Great Leap Forward and the Great Famine (1961).
raising the saving rate. They argue that families with one son compete for a spouse in the marriage market through wealth accumulation and that the intensity of this wealth competition has increased in recent years as the sex ratio has become more imbalanced. While the “excess male” hypothesis predicts lower saving by parents of daughters, Banerjee et al. (2010) report evidence that saving by these households is higher than by parents of sons. Their explanation is that due to the cultural convention that sons (not daughters) will provide for parents in old age, parents of daughters need to save more so as to provide for themselves in their retirement.\textsuperscript{3}

Our paper does not distinguish agents by gender and is more closely related to the empirical studies of Modigliani and Cao (2004) and Horioka and Wan (2007) who investigate life-cycle determinants of saving. These authors show that China’s age structure and saving rate have been related over a 50 year period, but they rely on a form of the dependency ratio in reduced form regressions and do not control for the entire population distribution. In our paper the entire age distribution, both current and future, have an impact on the saving decision.

Other work that employs the OLG framework to study saving include Ferrero (2010), who finds an important role for demographics in explaining the long run trend in US saving relative to other G6 countries; Krueger and Ludwig (2007) and Fehr et al. (2007) show the importance of demographic change in multi-country OLG models; Chen et al. (2006) argue that the decline in population growth has had only a small effect on the Japanese saving rate; and Song and Yang (2010) study the effects of a flattening of the age-earnings profile on Chinese household saving. Two dimensions along which our paper differs from these, however, is that we enter consumption by children directly into house-\textsuperscript{3}

\textsuperscript{3}See also Chamon and Prasad (2010) who argue that saving has responded to provide for a rising private burden of expenditures on housing, education and health care, and Chamon et al. (2010) who argue that income uncertainty and pension reform have led to increased household saving.
hold utility as in the Barro and Becker (1989) model and we allow an explicit bequest motive. Our paper also makes contact with the broader literature on how demographic changes affect the macro-economy. Shimer (2001) details how the age distribution impacts unemployment rates; Feyrer (2007) relates demographic change to productivity growth; and Jaimovich and Siu (2009) and Lugauer (2010) connect the age distribution to the magnitude of business cycles.

The economic importance of China in the world economy is difficult to overstate. Simply by virtue of China’s 1.3 billion people its economy is very large and has overtaken Japan as the world’s second largest in terms of aggregate GDP. The saving rate in China exceeds that of nearly every other country, and Chinese savings have been used to purchase large amounts of assets denominated in US dollars. The US current account deficit with China was nearly $270 billion in 2008, about 2% of US GDP. The high household saving rate in China helps make these gigantic capital flows possible.

2.2 The data

The historical and projected demographic estimates come from the United Nations World Population Prospects. The Chinese household saving rate data comes from Modigliani and Cao (2004) and various issues of the China Statistical Yearbook. We report and use the available information as provided by these sources and without modification. The Figure 2.1 plots the household saving rate (household saving divided by household income) in China from 1963 to 2009 that we seek to understand. The saving rate hovered around 5 percent until 1978 when it began accelerating. The post 1978 high-saving rate

\footnote{See Curtis and Mark (2010) for more about Chinese data and studying China using standard economic models. Ma and Yi (2010) also discuss the data and give some empirical evidence suggesting that demographic change has helped increase the Chinese household saving rate.}
regime, though, is punctuated by sizable fluctuations. In a short 6 year span between 1978 and 1984, the saving rate increased by 15 percentage points, fell to 10 percent in 1985 to 1988, then resumed more or less a steady upward trend.

To place the saving rate in the international context, Table 2.1 shows household saving as a percent of GDP for five countries in 2004. Recent Chinese household saving has been high even in comparison to its Asian neighbors Japan and Korea.

Figure 2.2 illustrates the magnitude of the changes in China’s age distribution. In this figure, the ratio of the population aged 0 to 17 to the number aged 18 to 60 (labeled young to working) provides us with a measure of family size. Family size is relatively flat until 1975 then falls steadily through 2009. The other series is the old-age dependency ratio
(aged 60 to 85 relative to working aged). The old-age dependency ratio begins to rise around 1990 and is projected to trend upwards sharply after 2009. The current working age population has relatively few retirees to support, but when the current workers retire, there will be relatively few workers to support them. The dramatic change comes from the decline in fertility and also an increase in the average life span.

To place China’s fertility rate in the international context, Table 2.2 shows fertility rates for China, the US, and Japan. Chinese women had a fertility rate of over 6 between 1950 to 1954, but now this figure is even lower than for the U.S. The variations in China’s fertility rate are due in large part to the government’s policy on family planning. As is well known, China’s one-child policy was implemented in 1979 and officially remains in effect although enforcement varies among jurisdictions and rural and urban areas. Perhaps lesser known is that various (although less effective) fertility reduction programs had been implemented since at least 1964. As can be seen, fertility rates had already begun to decline in response to the 1971 “Later-Longer-Fewer” campaign where the suggestion was for two children in urban areas and three in rural areas (Kaufman et al

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**TABLE 2.1**

HOUSEHOLD SAVING AS A PERCENT OF GDP IN 2004

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>USA</th>
<th>France</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saving Rate</td>
<td>18.5</td>
<td>5.1</td>
<td>10.9</td>
<td>6.2</td>
</tr>
</tbody>
</table>
Figure 2.2. Demographic variation

Figure 2.3 illustrates how closely the household saving rate and the working age proportion of the population move together. This makes sense since only people who are earning income can save, and the majority of income for the majority of people will be labor income. But in addition to this composition effect, the working aged population corresponds in age, roughly to households with dependent children. Over the sample, the proportion of working cohorts is rising at the same time family size is falling, providing a second channel for the saving rate to rise.

Figure 2.4 plots the saving rate with the log real wage, which we calculate as the

\[ \text{Log Real Wage} = \log \left( \frac{\text{Real Wage}}{\text{Consumer Price Index}} \right) \]

In our quantitative analysis, the age distribution is assumed to be exogenously determined. The strong response of fertility to policy provides some justification for this assumption.
TABLE 2.2

TOTAL FERTILITY RATES

<table>
<thead>
<tr>
<th>Year</th>
<th>China</th>
<th>USA</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-54</td>
<td>6.1</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>1955-59</td>
<td>5.5</td>
<td>3.7</td>
<td>2.2</td>
</tr>
<tr>
<td>1960-64</td>
<td>5.6</td>
<td>3.3</td>
<td>2.0</td>
</tr>
<tr>
<td>1965-69</td>
<td>5.9</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>1970-74</td>
<td>4.8</td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
<td>1975-79</td>
<td>2.9</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>1980-84</td>
<td>2.6</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>1985-89</td>
<td>2.0</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>1990-94</td>
<td>1.8</td>
<td>2.0</td>
<td>1.5</td>
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<tr>
<td>1995-99</td>
<td>1.8</td>
<td>2.0</td>
<td>1.4</td>
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<td>2000-04</td>
<td>1.8</td>
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<td>1.3</td>
</tr>
<tr>
<td>2005-09</td>
<td>1.8</td>
<td>2.1</td>
<td>1.3</td>
</tr>
</tbody>
</table>

annualized marginal product of labor. The wage shows substantial volatility in the 1960s, reflecting the hard times associated with the Great Famine. The wage has an apparent trend break in 1978 where wages grow faster in the post reform period. The relatively low wage growth before 1978 should tend to induce a higher saving rate, and the relatively high wage growth after 1978 should induce a lower saving rate. Ex ante, the dynamics of labor income seem to work against the way a successful model would work to account for the data.
To summarize, the correlation between the large increase in the saving rate and the dramatic demographic transition represents the main stylized fact we wish to explore. Standard life cycle considerations predict that household saving should increase in response to exogenously mandated reductions in family size because (a) fewer mouths to feed frees up resources that can be saved and (b) looking ahead at fewer children to help provide for old age means people need to save more for retirement. Additionally, we should observe that the household saving rate is increasing in the proportion of the working age population simply through changes in the composition (or share) of life-cycle savers. Finally, high labor income growth should work to depress the saving rate whereas low income growth should encourage greater saving. The pattern of income growth and demographics (low income growth, large families, relatively few working age before 1978
2.3 An overlapping generations model of saving

We work with a partial equilibrium model consisting of decision making households of cohort age ranging from 18 to 85. A representative firm employs all working age agents and pays them the market wage, which is given by the marginal product of labor. A national financial intermediary clears excess supply or demand for capital on the international market. The age distribution, wage, and interest rate are given exogenously, and all agents know the current and future values.

Figure 2.4. Saving rate and log real wage

and the reversal after 1978) seen in the data influence the saving decision in different directions. To sort out these effects and to examine which ones dominate, we turn to the OLG model.
2.3.1 Consumers

Consumers live 85 periods or years. At any point in time, 85 generations are present but only those aged 18 to 85 make decisions. The population is classified into 4 not necessarily disjoint groups: Children (age 0 to 17); workers (age 18 to 60) who are also the parents of the dependent children; adult children (age 35 to 60), a subset of the working age population who are the children of the retired; and retirees (age 61 to 85). Let $N_t^c, N_t^w, N_t^{ac}$, and $N_t^r$ be the number of people in these respective groups at time $t$, and let $N_t$ be the total population. For the first 17 years, people live as children and are dependent upon their parents. They do not save and consume what their parents choose for them. Parental and children’s consumption enter separately into parental utility, as in Barro and Becker (1989). People work and earn labor income from ages 18 to 60. During retirement, people live off their accumulated assets and transfers received from their working adult children.6 People die with certainty at age 85. In the last year of life, utility depends on consumption in that year and a bequest that is distributed in the year after death to their adult children.

2.3.1.1 Budget constraints

Let $c^i_t$ be the consumption of the decision making cohorts $i \in [18,85]$. Individuals in cohorts $i \in [18,60]$ have $n_t = N_t^c/N_t^w$ dependent children living with them, each of whom consume in the amount $c_{c,i}^t$. During the parenting years, agents choose their own consumption $c^i_t$, their dependent children’s consumption $c_{c,i}^t$, and assets $a_{t+1}^{i+1}$ to take into the next period. They also transfer a fraction $\tau_t$ of their labor income $w_t$ to support their elderly parents. The inheritance is $B^i_t = n_t^i a_{t+1}^{85}$ for cohorts $i \in [35,65]$ and zero

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6We model support for the aged as a pay-as-you-go transfer scheme to avoid having parent’s consumption in adult children’s utility. In that case, both aged parents and adult children would be choosing aged parent’s consumption, which makes analysis more difficult.
otherwise, where \( n_t^b = (N_t^{85}/N_t^{ac}) \) and \( N_t^{85} \) is the number of people aged 85 in period \( t \).

The budget constraints during these years are

\[
n_t c_t^i + c_t^i + a_{t+1}^i = (1 - \tau_t)w_t + (1 + r_t)a_t^i + B_t^i, \quad i \in [18, 60]
\]  

(2.3.1)

where \( B_t^i = 0 \) for \( i \in [18, 34] \) and \( B_t^i > 0 \) for \( i \in [35, 60] \). The budget constraint facing retired cohorts is

\[
c_t^i + a_{t+1}^i = P_t + (1 + r_t)a_t^i + B_t^i, \quad i \in [61, 85],
\]  

(2.3.2)

where \( P_t = \frac{N_t^w}{N_t^p} \tau_t w_t \) is the per retiree pay-as-you-go transfer received from adult children. Asset holdings are required to be non negative (consumers are not allowed to borrow).

2.3.1.2 Preferences

During those years in which parents make decisions for children, we follow Barro and Becker (1989) and use the period utility function

\[
u_t^i \left( c_t^i, c_t^i \right) = \mu(n_t)^\eta \left( \left( c_t^i \right)^{1-\sigma} \right) + \left( c_t^i \right)^{1-\sigma}, \quad i \in [18, 60]
\]  

(2.3.3)

where \( \mu < 1 \) and \( \eta < 1 \) determine the degree to which parents care for their children

and \( \frac{1}{\sigma} > 0 \) is the elasticity of intertemporal substitution. These are interpreted as single-parent households each with \( n = N^c/N^p \) dependent children.\(^7\)

In the last year of life, utility is defined over consumption for that year \( c_t^{85} \) and assets \( a_{t+1}^{85} \) bequeathed to the surviving \( n_t^b \) children of the oldest cohort. The period utility

\(^7\)While children live in the household until age 60, this does not literally mean that children live with their parents until age 42. Instead we are spreading current year births across parents of varying ages, so that some women aged 18 are having children and also some aged 38 are having children.
function for agents in the last year of life is

\[
u_t^{85} \left( c_t^{85}, a_{t+1}^{85} \right) = \mu \left( n_t \right) \eta \left( \frac{\left( a_{t+1}^{85} \right)^{1-\sigma}}{1 - \sigma} \right) + \left( \frac{\left( c_t^{85} \right)^{1-\sigma}}{1 - \sigma} \right).
\] (2.3.4)

Utility for the remaining cohorts is the standard isoelastic function

\[
u_i^t (c_i^t) = \left( c_i^t \right)^{1-\sigma}, \quad i \in [61, 84].
\]

Thus, in the first year of decision making, lifetime utility for the representative 18 year-old cohort in year \( t \) is

\[
U_t^{18} = \sum_{j=0}^{42} \beta^j \left( \mu \left( n_t \right) \eta \left( \frac{\left( c_t^{j+18} \right)^{1-\sigma}}{1 - \sigma} \right) + \left( \frac{\left( c_t^{j+18} \right)^{1-\sigma}}{1 - \sigma} \right) \right)
+ \sum_{j=43}^{66} \beta^j \left( \frac{\left( c_t^{j+18} \right)^{1-\sigma}}{1 - \sigma} \right)
+ \beta^{67} \left( \frac{\left( a_t^{85} \right)^{1-\sigma}}{1 - \sigma} + \left( \frac{\left( c_t^{85} \right)^{1-\sigma}}{1 - \sigma} \right) \right).
\] (2.3.5)

where \( \beta \in (0, 1) \) is the subjective discount factor. The problem facing the household, written in recursive form is

\[
V_t^i (a_t^i) = \max \left\{ u_t^i (c_t^i, c_t^i) + V_{t+1}^i (a_{t+1}^i) \right\}
\]
subject to (2.3.1)–(2.3.2) and where \( V_t^{85} (a_t^{85}) \) is (2.3.4).

The age distribution affects household saving in two other key ways. First, relative

\footnote{The value function also depends on the exogenous portion of the state vector. We suppress the notational dependence on the exogenous portion of the state vector and implicitly recognize that dependence with the \( t \) subscript on the functions.}
cohort sizes affect intergenerational transfers. The saving rate increases when $n_t$ decreases because there will be fewer workers paying to support retirees in the future. Second, retirees leave bequests and the larger is the older generation, the more assets received by the current workers. Before examining the quantitative importance of demographic change for aggregate saving, we present details on the firm and the financial intermediary.

2.3.2 Firm

A representative firm with Cobb-Douglas technology in capital $K$ and labor $N_{tw}$ produces output $Y$ according to

$$Y_t = A_t K_t^\alpha (N_{tw})^{1-\alpha}.$$ 

Parameter $A$ measures total factor productivity (TFP), and $\alpha$ is the capital share. Labor is supplied inelastically by working age consumers, so the aggregate labor input is $N_{tw} = N_{tp}$. Capital accumulates according to

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

where $I$ is investment and capital depreciates at rate $\delta$. The firm seeks to maximize profits. As such, the wage it pays is the marginal product of labor

$$w_t = (1 - \alpha) \frac{Y_t}{N_{tw}},$$

and it pays a rental on capital that is the marginal product of capital less the depreciation rate

$$r_t = \alpha \left( \frac{Y_t}{K_t} \right) - \delta.$$
The rental rate is identified by the marginal product of capital from the Chinese data and the firm adjusts its capital stock to satisfy this expression to equality.

2.3.3 Intermediation and net foreign assets

The capital stock is financed by an intermediary bank through foreign and domestic borrowing. Let $F_t$ be the number of internationally traded bonds held by the bank and $N_i^t$ be the number of people in cohort $i$ at date $t$. The net foreign asset position equals the difference between deposits (assets supplied by consumers) and loans (capital demanded by the firm)

$$F_t = \sum_{i=18}^{85} (N_i^t a_i^t) - K_t.$$

Changes to the intermediary’s foreign asset position do not correspond to the actual current account because the model only considers household saving.

2.3.4 Equilibrium

Equilibrium consists of the firm hiring labor and renting capital to maximize profits and each consumer selecting consumption and assets to maximize utility. Since labor supply is exogenously determined by the age distribution, the firm’s labor demand pins down the wage ($w$). We assume the interest rate equals the marginal product of capital net of the depreciation rate. The national demand and supply of assets need not be equal since the bank clears any excess on the international capital market.

2.4 Parameterization

During the time-span of our data the Chinese economy has been in transition. Our parameterization of the model accounts for this transitional nature in the settings for
TABLE 2.3

DECLINING LABOR SHARE

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor share</td>
<td>0.64</td>
<td>0.57</td>
<td>0.59</td>
<td>0.53</td>
<td>0.48</td>
</tr>
</tbody>
</table>

labor’s share $(1 - \alpha)$ and for adult children’s support $(\tau)$ for elderly parents. We begin with labor’s share.

Two features of labor’s share distinguishes China’s economy from most developed economies: the share has declined over time and in recent years, has been comparatively low. Hu and Kahn’s (1997) estimate of labor’s share during the post-reform era is 0.4 which is quite a bit lower than the 0.66 share exhibited in the U.S. Hsieh and Klenow (2009) examine data from 1998 to 2005 and find that the median labor share across all state-owned firms and large non state-owned (revenues in excess of 5 million yuan) firms is 0.3. Table 2.3 shows our own estimates using the Chinese national accounts data of labor’s share for selected years. As a result of the declining labor share, wage growth has generally not kept pace with GDP growth in recent years.

Taking into account our own calculations and the estimates in the literature, we allow for the declining labor share by setting $1 - \alpha = 0.6$ in the pre-reform years (1963-1978), then the share decreases by 0.02 per year between the years of 1979 and 1988 until it reaches 0.4 where it remains from 1989 onwards.

We now turn to the share of income $\tau$ transferred by workers to their elderly parents.

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9These estimates include non-wage compensation. Details are available upon request.
A traditional characteristic of the Chinese family system has been that children, especially males, should care for their elderly parents. Presumably, the role of male children in this regard is a primary factor that underlies the preference for boys and the resulting sex imbalance exploited by Wei and Zhang (2009). Our parameterization of \( \tau \) in the post-reform period is informed by the following. Xie and Zhu (2009) use a survey conducted in 1998 to find that the (unconditional) fraction of income contributed by urban men to their parents is 0.03. Surprisingly, they found little difference in the amounts given by urban women even though women earned substantially less than men. The (unconditional) fraction of women’s income contributed was 0.06. Lee and Xiao (1998) employ a 1992 survey of children’s support for elderly parents. Assuming a replacement rate of 0.66, their results imply an unconditional transfer rate of 0.082 in the urban areas. If broken down by gender, the transfer rate is 0.037 for men and 0.16 for women. Information on the \( \tau \) during the pre-reform period is scarce. As noted by Lee and Xiao, in those days, most people lived in the rural areas and belonged to collective production units with elderly persons receiving resources directly from the collectives. We view the payments from the collectives as the transfer share and set \( \tau \) to be 0.12 in the pre-reform period. From 1979 to 1981, \( \tau \) is reduced by 0.02 per year and remains at 0.05 from 1982 onwards. We set the post-reform \( \tau \) on the low side of the estimates because a nontrivial proportion of adults in urban areas receive financial support from their elderly parents, making net transfers small (Xie and Zhu 2009).

We take the Barro-Becker children in utility parameters, \( \mu = 0.65 \) and \( \eta = 0.76 \), from Manuelli and Seshadri (2010). We set the time discount rate \( (\beta) \) to 0.99 and the intertemporal elasticity of substitution \( (1/\sigma) \) to 0.53. The capital depreciation rate \( (\delta) \) is set to 0.10. Table 2.4 summarizes the parameter values.
### TABLE 2.4

**BASELINE PARAMETERIZATION**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight on children</td>
<td>( \mu )</td>
<td>0.65</td>
</tr>
<tr>
<td>concavity for children</td>
<td>( \eta )</td>
<td>0.76</td>
</tr>
<tr>
<td>labor’s share of output</td>
<td>pre-reforms ( (1 - \alpha) )</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>post-reforms</td>
<td>0.40</td>
</tr>
<tr>
<td>transfer share</td>
<td>pre-reforms ( \tau )</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>post-reforms</td>
<td>0.05</td>
</tr>
<tr>
<td>discount rate</td>
<td>( \beta )</td>
<td>0.99</td>
</tr>
<tr>
<td>coef. of relative risk aversion</td>
<td>( \sigma )</td>
<td>1.90</td>
</tr>
<tr>
<td>depreciation rate</td>
<td>( \delta )</td>
<td>0.10</td>
</tr>
</tbody>
</table>

#### 2.5 Results

Initial assets are set near zero (1.4243 in 2000 US dollars). When we get to the end of the sample, the 18 year old agent needs to look forward an additional 68 years to solve his/her problem in 2008. The future demographic data come from the United Nations projections. Future wage and interest rate observations are generated by assuming a gradual transition of the growth rate to a steady state rate of 2.0 percent with a half-life of adjustment of 12 years. The 1950s in China were a time of massive policy initiatives, reversals and disasters (e.g., the Great Leap Forward, the Great Famine). Due to the

\(^{10}\) Similarly to Chen et al.
volatility in the data at that time, we begin our simulation results after the Great Famine in 1963.

Our baseline simulation results using the parameterization from Table 2.4 are shown in Figure 2.5. As in the data, the model exhibits relatively low saving rates before the mid 1970s and a sharply rising saving rate around the time of the economic reforms. By 2008, the model generates a saving rate of 0.25 which is only slightly less than the 0.27 rate in the data. The model generates the saving boomlet and decline in the 1980s but does not exactly match up in terms of timing. From 1990 to 1995 the implied saving rate rises and matches the increase in the data. The saving rate in the data continues to increase through 1999 and is then flat until 2005. The model also generates a flat saving rate during those years, although at a lower level. The implied saving rate resumes its upward trend from 2005 onward. In short, the model is able, with varying degrees of success, to account for (i) the generally high rate of post-reform household saving, (ii) the trend break in the saving rate, and (iii) cyclical fluctuations in the saving rate.

Figure 2.6 shows 2009 saving rates by cohorts implied by the model. It displays the standard hump shape with the saving rate reaching its maximum with the cohort in the last year of employment. Cohorts aged 80 and older dissave.

Several facets of the model contribute to generating the implied saving dynamics. We now investigate the contributions of these factors by shutting off various features of the model.

*Experiment 1 (Varying family size).* See Figure 2.7. The line with ‘x’ markers is gen-

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11 The model generated saving rate fluctuates counter-factually from 1975 to 1977. These fluctuations disappear when the wage is smoothed as in Experiment 3 below.

12 Throughout the paper, we take labor supply decisions such as retirement as exogenous, keep life expectancies constant, and pay all workers the same wage. Altering these modeling choices could, of course, create other ways in which demographic change affects the saving rate.
Figure 2.5. Baseline results

erated by setting the parameter $\mu$ to zero, which kills off explicit valuation of dependent children’s consumption in household utility. Chen et al. (2006) and Ferrero (2010) do not consider children’s consumption, so this experiment compares closer to their models. Ignoring dependent children causes the saving rate implied by the model to be too high and for most of the sample it overstates the saving rate. The ‘no children’ saving rate starts increasing in 1970, prior to the acceleration in the late 1970s in the data. It reaches a peak of 0.28 in 1979 then trends downwards from that point. The ‘no children’ saving rate is too high and misses the timing of the trend breaks.

The series marked by inverted triangles is generated assuming a constant family size of $n = 2$ children per (single head of) household. The economy with big families usually generates an aggregate household saving rate that lies below our baseline rate. From 1964
to 1972, only a trivial saving rate emerges. The implied timing of the trend reversals in the ‘big family’ economy matches that of the baseline model. The conclusion from this experiment is that fewer (more) children in the family causes households to behave as if they are more (less) patient.

To see why this occurs, let us return to the preferences of parents with dependent children, equation (2.3.3). Here, $(c^ε_t)^{1-σ} / (1 - σ)$ is the per child utility which is scaled up by the function $μ (n_t)^η$ that is increasing in the number of children in the household. Since household utility is increasing in both the number of children $n_t$ and consumption per child $c^ε_t$, there are two factors to incentive larger families to expend resources on addi-
tional consumption instead of saving. The idea that increasing the number of dependent
children makes the household behave as if it is less patient is formalized in Proposition
1.

Proposition 1: (Effective Discount Rate) Let \( \bar{c}_{t+j} \) denote consumption of parents and
their children, \( \bar{c}_{t+j} = n_{t+j}c_{t+j} + c_{t+j} \). The first term of the utility function (2.3.3) can be
written as

\[
U_t = \sum_{j=0}^{42} \beta_j \frac{c_{t+j}^{1-\sigma}}{1 - \sigma}
\]

where \( \beta_j \) is the effective discount rate, such that

\[
\beta_j = \beta^j \left(1 + \left[\mu n_{t+j}^{\eta+\sigma-1} \right]^{1/\sigma}\right)\sigma
\]

is increasing in \( n_{t+j} \) if \( \eta + \sigma > 1 \).\(^{13}\)

\(^{13}\)We thank Joe Kaboski for suggesting Proposition 1. We note that Choi and Mark (2009) show
The effective discount factor under our parameterization of preferences is increasing in \( n \). This indicates that parents care more about total period consumption (\( \bar{c}_t \)) in times which they have more dependent children, and hence save less for the future. This can be seen as we inspect the consumption Euler equation in the parenting periods of life rewritten in terms of \( \bar{c} \), given as

\[
\frac{\bar{c}_t^{-\sigma}}{\bar{c}_{t+1}^{-\sigma}} = \beta_{t+1} \beta_t (1 + r_{t+1})
\]

where a higher \( n \) lowers the intertemporal marginal rate of substitution.

**Experiment 2 (No bequest motive).** Figure 2.8 shows the results from turning off the bequest motive. Cohorts in the last period of life consume the entire value of their accumulated assets and income support obtained from their adult children. As can be seen, our baseline results are robust to whether a bequest motive is in effect or not.

**Experiment 3 (Smoothed wages, reduced wage growth).** See Figure 2.9. We first smooth out wage fluctuations by passing the marginal product of labor through the Hodrick-Prescott (HP) filter (with the smoothing parameter set to 100). The implied saving rate obtained when workers receive the HP trend of wages is shown with ‘x’ markers. Eliminating the cyclical fluctuations in the wage does not impact the model in a substantive way. The implied saving rate and implied trend breaks are very similar to those in the baseline model. The series with triangle markers is generated by assuming that real wage growth is reduced by 80 percent. As expected, low wage growth induces high saving rates.

**Experiment 4 (Static expectations).** In solving the model, we have assumed that that variation in the time discount rate (\( \beta \)) across countries can explain the trending current accounts in Japan and the US. Our model is consistent with the Choi and Mark hypothesis, in that different age structures generate different time discount factors, as demonstrated by Proposition 1.
households have perfect foresight with respect to the evolution of the interest rate, wage, and demographics. Outside of economics, this may strike one as a heroic assumption. Even within economics, perfect foresight can seem a bit strong. A strongly contrasting assumption that we investigate is that households form static expectations. In this experiment we assume at each date, the household assumes that all future values of the exogenous variables are fixed at currently observed values. The results, displayed in Figure 2.10, show that assuming static expectations would be a poor modeling choice. The
implied saving rate is much too high and trends in the wrong direction after the reforms. While perfect foresight may be unrealistic, we draw on Friedman’s (1966) recommendation to view agents as behaving as if they have perfect foresight even though they may not necessarily possess this attribute.
Figure 2.10. Static expectations (experiment 4)

2.6 Conclusion

This chapter studies the ability of standard life-cycle considerations to explain the evolution of household saving in China from 1963 to 2008. Some of the more conspicuous facets of the saving rate data that the model is able to account for include its relatively low level prior to the economic reforms, its upward trend from 1978 to 2008, the cyclical drop and recovery of the saving rate in the late 1980s and its current high level.

Two aspects of the model are central to the analysis: First, young dependent children enter explicitly into household utility and second, the changing age distribution of the entire economy is represented. The rapid rate of labor income growth in recent years works to depress household savings. It thus follows from our analysis that the currently observed high saving rate is driven primarily by the reduction in family size resulting from population control policies and the relatively large size of the today’s working population.
Projecting forward, the model implies that as the Chinese population ages, and it is aging quite rapidly, the rising household saving rate should be arrested. It should follow also that large currently observed Chinese external surpluses, to the extent that they are driven by household saving, may also be a temporary phenomenon.
CHAPTER 3

ECONOMIC REFORMS AND THE EVOLUTION OF CHINA’S TFP IN THE STATE AND THE PRIVATE SECTORS

3.1 Introduction

Over the past 20 years, China has experienced one of the most remarkable growth episodes in modern economic history. Total factor productivity (TFP) has been a main engine of China’s growth, accounting for 50 percent of its 7.6 percent annual rise in output per worker in the non-agricultural economy from 1992-2007. This rise followed major economic reform that reduced barriers on private businesses. China has since transitioned from a predominantly state-run to a mixed economy of both private and state sectors. Immediately after economic reform in 1992, the private sector accounted for only 12 percent of non-agricultural employment. By 2007, this figure climbed to 52 percent. Additionally, TFP has been persistently higher in the private sector relative to the state sector.

The coincidence of the productivity surge and the reallocation of factor inputs from the state to the private sector suggests a causal link. This paper investigates the extent that reforms can quantitatively explain the productivity profiles observed in the data. I build a two-sector model – the private and the state sectors – capturing China’s economic transition from the removal of entry barriers on private businesses (reforms). In the model, I neither impose any exogenous productivity growth nor assume any exogenous
differences in TFP between the private and the state sectors. TFP growth arises solely from the reallocation of factor inputs following economic reforms. The quantitative analysis can account for 25 percent of China’s observed TFP growth in the non-agricultural economy from 1992-2007.

The model draws upon the Lucas (1978) span-of-control framework with two sectors whose main difference is access to external credit markets; the private sector faces financial frictions while the state sector does not. Individuals in both sectors choose the most profitable option between operating an establishment (entrepreneurship) and supplying their labor for a wage. Agents are heterogeneous in wealth and entrepreneurial talent. Individual talent evolves stochastically while wealth is determined by forward-looking saving decisions. I characterize financial frictions on individuals in the private sector as collateral constraints arising from poorly developed financial markets. The occupational choice for agents in the private sector therefore depends on both their entrepreneurial talent and assets. Are they talented enough to viably operate a business? If so, do they have enough collateral to finance their business?

The occupational choice plays a quantitatively important role in explaining both TFP differences and the reallocation of productive resources between sectors. The model can explain over one-fifth of the observed difference in TFP between the private and the state sector. TFP differences between ownership arise endogenously through a novel channel: a world with uniformly low initial wealth levels leads to only the most productive entrepreneurs entering the private sector. Intuitively, financial constraints force entrepreneurs to rely on self-financing to expand their capital to operate at a profitable scale. Entrepreneurs with high talent are able to profitably run their businesses with a relatively smaller capital stock than less talented individuals. As a result, only the most talented private entrepreneurs are able to overcome the constraints and start a busi-
ness. This is not the case for state firms who enjoy favorable access to credit markets. Financial frictions essentially “prop-up” TFP in the private sector by limiting entry to only the most talented entrepreneurs. This selection mechanism leads to differences in the composition of sector-level productivities whereby the state sector, although they do have productive enterprises, has disproportionately more low-productive firms than the private sector. To put this in loose terms, the state sector has some good, but they also have a lot of bad businesses while the private sector only has good ones.

In the main exercise, the model starts from an economy where all production is carried out by the state sector. Barriers to entry on private entrepreneurs are severe enough that all supply their labor for a wage. I simulate the model from an initial steady state and analyze the transitional dynamics following a permanent and unexpected elimination of barriers to private entrepreneurship (reforms) to a new mixed-economy steady state with both sectors active in production. Following the reforms, entrepreneurs with sufficiently high talent and assets to overcome the collateral constraints enter into production. A critical assumption is that individuals in the private sector start with initial low wealth levels. Collateral constraints slow the expansion of private establishments as the owners have to save to expand their capital use to a profit-maximizing scale. Reallocation of productive resources is a gradual affair, consistent with China’s growth experience.

TFP growth is fueled from three sources. First, the reforms introduce a wave of private entrepreneurs into the market. Selection due to financial frictions results in entry exclusively of the most productive entrepreneurs. Second, following entry, financial frictions cause private entrepreneurs to operate at an inefficiently small scale. As they accumulate collateral and expand, resources are directed toward more efficient use in productive private establishments, increasing aggregate productivity and real wages. Third, on the extensive margin, productivity growth is not only due to entry but also
exit of the marginally productive establishments. Rising wages induces the exit of less
talented entrepreneurs on two fronts: they reduce business level profits and the outside
option of becoming a worker becomes more attractive. In sum, the endogenous TFP
dynamics evolve gradually through the ongoing expansion of the private sector and exit
of marginally productive establishments.

The analysis also allows me to quantify the impact of financial frictions on long-run
TFP and aggregate output. I isolate this channel by varying the magnitude of financial
frictions. I show that the removal of financial frictions only raises aggregate TFP by 1.5
percent. This increase is small compared to similar recent studies. Buera and Shin (2010)
find that financial frictions can lower TFP by 24 percent and Buera, Kaboski, and Shin
(2011) find a 36 percent reduction. Previous works considered financial frictions across
all firms. In my model, the presence of the state sector limits the aggregate impact of
financial frictions. The magnitude of my findings are closer to Midrigan and Xu (2010)
who find financial frictions only reduce Korean TFP by 2 percent. However, they focus
on the ability of firms to overcome the constraints while I single in on China’s distinctive
institutional setup.

The impact of financial frictions, on the other hand, has a significant long-run impact
on aggregate output through its impact on capital deepening. In the model simulations,
GDP can increase as much as 28 percent by the removal of collateral constraints. Al-
though TFP is largely unaffected, the absence of financial frictions allows for the entry
of more private firms and they can operate with more capital intensity.

The remainder of the paper is as follows. I next discuss this study within the context
of the existing literature. Section 3.2 presents the empirical facts. In Section 3.3 I
present the model. I describe the model parameterization and analyze the simulation
results in Section 3.4 and Section 3.5 concludes.
3.1.1 Contact with the literature

Song, Storesletten, and Zilibotti (2011) consider a small-open economy, transitional growth model to explain China’s growth acceleration and acquisition of foreign assets. In their model, the private sector does not influence the equilibrium wage during the transition. In contrast, I contend that changing factor prices play a pivotal role in explaining China’s TFP dynamics. Specifically, rising wages from private sector expansion induces ongoing exit of the least productive establishments. Resource reallocation away from these establishments toward more productive ones raises TFP over time. In addition, I neither assume exogenous productivity growth nor exogenous differences between sectors. This allows me to both identify the direct impacts of reforms on productivity growth and the underlying elements leading to differences in TFP between sectors.

Hale and Long (2011) also explore the link between financial frictions and productivity differences between China’s state and private sector. The authors argue that private firms defy financial constraints by managing working capital more efficiently. In my model, TFP differences arise via selection into entry of only the most efficient firms. Other studies focus on alternative explanations for productivity differences between sectors: Bai, Yang, Xu, and Jin (2010) focus on lower productivity of state owned enterprises through excess employment and agency cost of management; Lin, Cai, and Li (1998) focus on poor performance of state owned enterprises arising from policy burdens imposed by the central government; and Brandt and Zhu (2001) create a model showing that state firms, on average, are less productive because the government will keep providing loans even if they make poor investment decisions.

This paper adds to a growing literature connecting aggregate TFP and micro-level distortions (Restuccia and Rogerson 2008; Buera, Kaboski, and Shin 2011; Guner, Ventura, and Xu 2008; Hsieh and Klenow 2009; Sandri 2010). This study is closer to Buera
and Shin (2010) who also study transitional economies facing imperfect financial markets. I extend Buera and Shin’s model by including a financially unconstrained (state) alongside a financially constrained sector (private) to capture China’s unique institutional setup. Jeong and Townsend (2006) model Thailand’s growth experience through gradual development of financial markets. In my model agents save collateral to relax the financial constraints, while credit markets remain undeveloped.

I add to the growth accounting literature that identifies the sources of China’s productivity and output growth (Perkins and Rawski 2008; Bosworth and Collins 2008; Young 2003). In the same vein, Dekle and Vandenbroucke (2010, 2011) and Brandt and Zhu (2010) incorporate the public (state) and private sector to measure productivity gains from resource reallocation between the two. I complement these papers by including micro-level production, which allows me to further analyze productivity gains on both the extensive and intensive margins. I find that both margins play a quantitatively important role in resource reallocation and aggregate TFP growth.

3.2 Data

This section presents the relevant empirical facts. I begin by detailing the sources and construction of the main data before discussing the events of China’s economic reforms. I then explore three main features of China’s transitional economy. First, I show that TFP growth followed the reallocation of resources towards the private sector after economic reforms in 1992. Second, I document two key dimensions by which the private and state sectors differ; access to credit markets and TFP. The state sector enjoys easier access to credit than the private sector but has lower productivity as measured by TFP. Third, I emphasize the relationship between these differences using provincial-level data; when the private sector has more difficulty accessing credit markets than the state sector, TFP
differences between the two are more pronounced.

3.2.1 Sources and definitions

The data comes from various issues of the China Statistical Yearbook (CSY). Young (2003) contends that using the implicit price deflators provided in the CSY overstates real GDP and investment (gross capital formation). Following his suggestions, I reconstruct and extend his series of the alternative deflators for GDP and investment. I use all other data series provided in the CSY without modification. Appendix A.1 describes the complete methodology on construction of the aggregate data.

I decompose output, investment, and labor in the non-agricultural sector into government and private ownership. Following Dekle and Vandenbroucke (2010, 2011), I define government ownership as the entirety of state-owned enterprises (SOEs), urban collectively owned units, and township and village enterprises (TVEs). The private sector consists of private enterprises, self-employed workers, foreign owned firms, and other types of ownership. See Appendix A for a further discussion on the classification of ownership.

Compared to the U.S., China’s government owned enterprises are active in most facets of the economy. SOEs alone are involved in a diverse range of businesses from energy, steel, and pharmaceuticals to architecture and design and film production. Throughout the paper, I refer to the government owned sector, which includes TVEs and collectively owned units, as the “state sector” to emphasize the clear differences in the size and economic role government owned enterprises play in China compared to places like the

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1 Due to revisions of output and prices in the service sector following the Chinese Economic Census in 2004, I use the implicit deflator for this sector reported by the CSY.

U.S. In short, the terminology is not technically accurate but it serves to distinguish the differences in ownership.

To construct China’s TFP series, I assume non-agricultural output depends on TFP, capital, and labor. Due to lack of time series data on labor hours, I calculate total labor $L_t$, as the number of employed people. I build the aggregate capital stock $K_t$ using the perpetual inventory method with annual depreciation rate 0.075. The initial capital stock is taken from Chow (1993) for 1978. Taking data on capital, labor, and output, China’s TFP series is constructed based on the Cobb-Douglas production

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha}$$

where $Y$ is output at time $t$, $A$ is the Solow residual (total factor productivity), and $\alpha$ and $(1 - \alpha)$ are the exponents on input factors. I let $\alpha = 0.50$, consistent with the average labor share of output (Brandt and Zhu 2010), and I assume that the factor shares are identical in the state and the private sectors.

### 3.2.2 China’s economic reforms and TFP growth

Although there were earlier attempts at reforms, China’s major steps toward initiating a vibrant private sector within a mixed economy took place in 1992. This section provides a brief history and summarizes the economic impacts of the 1992 reforms.

Prior to 1978, China’s economy was centrally planned. The government controlled prices, agricultural production decisions, and owned nearly all industrial production. The first wave of economic reforms beginning in 1978 broke up communal agricultural units and gradually relaxed price controls on selected products. Local governments were

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*I choose the depreciation rate at 0.075, between the 6 percent in Young (2003) and the 9.8 percent in Perkins and Rawski (2008).*
granted more autonomy leading to the expansion of TVEs – firms owned by local governments – in rural areas.

Across China, a small private sector developed but faced political discrimination. Various movements such as the campaigns against spiritual pollution in 1983 and 1984, the campaign against bourgeois liberation in 1987, and other movements demanding an “attack on speculation” challenged the legitimacy of private enterprises (Li, Meng, Wang, and Zhou 2008). However, the central government created several special economic zones (SEZs); select areas with a market-oriented economic system. The SEZs developed economic practices that fell outside central government economic policy which reigned throughout the rest of China.

In 1989, the Tiananmen Square Incident prompted turnover in Communist Party leadership which put further reforms on hold. In response to the stagnation of reforms, former Communist Party leader Deng Xiaoping made his famous Southern Economic Tour in early 1992. He traveled to Shenzhen SEZ and, upon witnessing its development under a market-oriented economy, he called on the country to emulate its example. Following his remarks, in late 1992 the Communist Party officially endorsed the “socialist market economy.” This marked a turning point in reforms and since then China has transitioned from a planned, state dominated economy to a mixed economy with both state and private enterprises in production.

The ignition of private sector expansion following the reforms in 1992 is highlighted in Figure 3.1 which shows the share of private employment and output in China’s non-agricultural economy. In unison with the economic reforms, the share of private sector employment accelerated from under 15 percent in 1992 to over half of the employment in 2007 and its output share nearly tripled over the same time frame.

The rising importance of the private sector has coincided with China’s aggregate
Figure 3.1. Private sector output and employment shares

TFP growth. In the left panel of Figure 3.2, I show the ratio of private sector TFP to state sector TFP (private-to-state TFP) which has averaged 1.82 since 1992. Aggregate productivity gains are, in part, a result of resource reallocation from the state to the more productive private sector. The right panel depicts the extent of China’s TFP gains which rose over 70 percent from 1992-2007. In a related study, Brandt and Zhu (2010) find that over a quarter of the increase in labor productivity is strictly due to the reallocation of labor from the state to private sector. Using a slightly different classification of ownership from this study, they estimate an average private-to-state TFP above 2 over this time frame.

My estimate of annual TFP growth, 3.4 percent, is close to 3.9 percent in Bosworth and Collins (2008), 3.4 percent in Perkins and Rawski (2008), and 3.9 percent in Brandt and Zhu (2010), all from 1993-2004.4 To place China’s experience in an international

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4The estimates of these authors are inclusive of agriculture.
context, Young (1995) reports annual TFP growth rates of 3 percent in Taiwan and between 2.4 and 2.6 percent in South Korea during their growth episodes from 1979-1989.

3.2.3 Differential access to credit in the state and the private sectors

In China, the state sector has easier access to financial markets than the private sector. Huang (2004) argues that China’s domestic credit markets have a “political pecking order” which gives preferential access to SOEs and collectively owned units. Using firm-level data, Guariglia, Liu, and Song (2011) find evidence of discrimination in access to credit for private sector firms and Poncet, Steingress, and VandeBussche (2010) document that private firms face severe financial constraints while SOEs tend to be unconstrained. Brandt and Li (2003) find evidence of discrimination by the Agricultural Bank of China on private sector firms. Naughton (2007) contends that the backing of TVE loans by local governments provides them with favorable access to external credit markets. As a result of difficulty obtaining formal credit, private firms have relied more
on retained earnings and other types of financing such as informal loans and FDI (Allen, Qian, and Qian 2007; Hèricourt and Poncet 2008).

As a signal of the differences in access to external financing, the return to capital has been substantially higher in the private sector than in the state sector. This can be seen in Figure 3.3 which traces the marginal product of capital by ownership. The difference in capital intensity between ownership is clearly reflected by the wide discrepancy in capital returns. Since 1992, the marginal return to capital has been 15 percentage points higher in the private sector than in the state sector.
3.2.4 Access to credit and private-to-state TFP

I have presented evidence of differences in TFP levels and access to external finance between the state and the private sectors. But is there a cross sectional relationship between these facts? I investigate this question using TFP and a measure of relative access to finance for 21 Chinese provinces.

First, I construct a measure of relative access to formal finance between sectors. I define private-to-state external financing as the ratio of the share of investment financed by the central government and domestic bank loans in the private sector to the corresponding share in the state sector. A log value below zero indicates that the private sector relies less on formal credit than the state sector, which is the case for 18 of the 21 observations. In Figure 3.4 I plot the log of private-to-state TFP against private-to-state external financing in 2002. The negative relationship of relative external financing on private-to-state TFP suggests that when private firms have the same access to credit as state firms, TFP differences go away. This does not suggest a casual relationship for there may be other, regional factors behind this correlation. The main takeaway is that the relationship is negative and statistically significant at the 5 percent level.

Ideally, informal financing and other lines of credit would be included in the relative external financing measure, but data on these are scarce at this level of aggregation. Dollar and Wei (2007) report that privately owned firms rely on family and friends for 8 percent of investment financing. Thus, the previous relationship may be biased downward. On the other hand, the external financing measure does not capture loans

---

5 Specifically $\frac{\text{Loans}_{\text{Private}}}{\text{Investment}_{\text{Private}}} / \frac{\text{Loans}_{\text{State}}}{\text{Investment}_{\text{State}}}$.

6 2002 is the most recent year that I can estimate TFP by ownership in the provincial data consistent with the method used in the aggregate data. See Appendix A.2 for details on the data sources.

7 I drop 2 outliers: Guizhou and Ningxia Provinces. Guizhou is China’s poorest province in terms of per-capita GDP and Ningxia accounts for less than 1 percent of aggregate GDP.
from local governments which may be an important source of financing for the state sector in particular. This may, in fact, bias the relationship upward. Unfortunately, the data does not allow me to separate these other external financing sources from internal sources like retained earnings and self-funded investment.

If in fact the private-to-state external financing measure provides an indication of the true differences in access to external credit, we would expect larger discrepancies in capital intensity between ownership with greater variation in relative access to financing. I explore this idea in Figure 3.5 which plots the log ratio of private-to-state capital-output ratios – a measure of relative capital intensity – to relative external financing. Relative external financing has a positive relationship on relative capital-output ratios, significant at the 10 percent level. The graph indicates that when private firms have the

Figure 3.4. Relative TFP against relative external financing
same access to credit as state firms, differences in capital intensities dissipates. In short, this relationship reflects that the relative external finance measure accounts for the main differences in access to credit.

To summarize, the expansion of the private sector followed the reforms in 1992. China’s impressive TFP growth coincided with the reallocation of productive resources towards the relatively more productive private sector. I next described two key differences between sectors; the state sector has better access to external credit markets but has lower TFP than the private sector. Using provincial data, I then presented an interesting relationship between the relative use of external financing in investment and relative TFP; in provinces where the private sector’s share of investment financed through
formal channels is relatively lower than the state sector, TFP differences are more pronounced. Given these empirical facts, I next build a model to explain these features of China’s transitional economy.

3.3 Model

I model an economy with two types of agents; those who are financially constrained and those who are not. Mapping the model to the data, the former corresponds to the private sector and the latter to the state sector.

All agents are heterogeneous in their entrepreneurial talent \( z \) and wealth. Entrepreneurial talent is drawn from a time-invariant discrete distribution \( \mu(z) \). Individual wealth is accumulated via saving.

In each period, all agents face an occupational choice: whether to work for a wage or to operate a business. Each agent is endowed with one unit of labor that can only be supplied to one activity. If he decides to operate a business, I refer to him as an entrepreneur. Although one may not consider operation of state firms as entrepreneurship, for clarity I define entrepreneurs in the state and the private sectors as state entrepreneurs and private entrepreneurs, respectively. Individuals are exogenously assigned to belonging to a sector. Entrepreneurs cannot move from one sector to the other, however, workers can supply their labor to any business regardless of its sectoral classification.

3.3.1 The private sector

The private sector consists of a measure \( N \) of infinitely lived agents. Agents are heterogeneous in entrepreneurial talent \( z \) and wealth, the latter is determined by the individual’s assets \( a \). I define \( G(a, z) \) as the joint distribution function of private sector wealth and entrepreneurial talent. Each individual’s entrepreneurial talent follows a
stochastic process where he retains his ability from one period to the next with a probability $\gamma$ and loses his ability with a probability $1 - \gamma$, in which case he redraws a new ability from the distribution. The persistence of ability can be interpreted as the rate of change in the market structure that renders an individual’s current talent unprofitable. I characterize the private sector based off Buera and Shin (2010).

**Preferences** Individual preferences are characterized by the CRRA utility over consumption $c$ of a single good

$$
E \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma}
$$

where $\beta \in (0, 1)$ is the subjective discount factor and $\sigma$ is the coefficient of relative risk aversion.

**Production** The unit of production is the establishment operated by a private entrepreneur. Production of the final good $y$ requires a combination of capital $k$ and labor $l$ with an entrepreneurial talent $z$ and is described by the production function $f(k, l)$. The function $f$ is increasing in $z$, $k$, and $l$ and exhibits decreasing returns to scale in $k$ and $l$. In the quantitative analysis, I draw from the Lucas (1978) span-of-control model with production technology

$$
y = zk^\alpha l^\theta
$$

where $\alpha, \theta \in (0, 1)$ and $\alpha + \theta < 1$. Decreasing returns to scale implies that $(\alpha + \theta)y$ is the input factor share and profits are $(1 - \alpha - \theta)y$.

Next, I discuss the markets for factor inputs and the private entrepreneur’s problem. Each individual has access to a competitive financial intermediary who receives deposits and rents capital to entrepreneurs. I consider only the case where agents cannot borrow
for consumption purposes, $a \geq 0$. The interest rate on deposited assets $a$ is $r$. The assumption of the perfectly competitive intermediary dictates that the capital rental rate is $r + \delta$, where $\delta$ is the depreciation rate.

Each private entrepreneur faces a limitation on his capital rental given by the collateral constraint $k \leq \lambda a$ where the parameter $\lambda$ dictates the magnitude of financial frictions. For example, when $\lambda = 1$ all capital has to be self-financed ($k = a$). On the other hand when $\lambda = \infty$, access to credit is unlimited. This constraint can be motivated from a limited commitment problem and is commonly employed in the literature on financial frictions.

Each establishment hires labor at wage $w$. Labor is mobile between sectors; an individual worker in the private sector can work for an establishment in the state sector and vice versa. In equilibrium, the wages in the two sectors are equal.

Conditional on operating an establishment, a private entrepreneur maximizes profit taking the rental rate and wage as given. Formally, the profit function is defined as

$$\pi = \max_{l,k} \left\{ zk^{\alpha}l^{\theta} - wl - (r + \delta)k \right\} \quad (3.3.3)$$

subject to

$$k \leq \lambda a. \quad (3.3.4)$$

The indirect profit function is therefore $\pi(z, w, r)$.

**The Private Agent's Problem** An individual chooses sequences of consumption $c$ and saving in a non-state of nature risk free asset $a$, along with the decision to become a worker or an entrepreneur. He will decide to become an entrepreneur if his profit exceeds the market wage. This decision jointly depends on his entrepreneurial talent.
and whether his wealth is sufficient to overcome the collateral constraint. I follow Buera and Shin (2010) and characterize the occupational choice by a single policy function. An individual with entrepreneurial talent $z$ will operate an establishment if his current assets are greater than or equal to a threshold asset level $a(z)$ that solves $\pi(a(z); z, w, r) = w$.

The private individual’s problem is to maximize (3.3.1) subject to

$$c_t + a_{t+1} \leq \max \{ \pi(a(z), w_t, r_t), w_t \}$$

(3.3.5)

where the $\max$ operator captures the occupational choice.

3.3.2 The state sector

In the state sector, there is a single representative household comprised of $S$ members. Similar to the private sector, every period individuals face an occupational choice between working for a wage or operating an establishment. However, the state sector differs from the private sector in two ways. First, although entrepreneurial talent is drawn from the same distribution as in the private sector, persistence of talent in the state sector is permanent, i.e., $\gamma = 1$. This reflects the fact that Chinese state firms in major industries such as utilities, energy, financial services, etc., have a monopoly on the “low hanging fruit” which allows them to survive over time. Second, as explained in the previous section, the state sector has easier access to credit than the private sector. In the model, I assume that the state sector has complete access to capital rental markets.

Preferences Utility in the state sector follows the same functional form and preference parameters as the private sector. The household maximizes utility over total
household consumption $C$ given as

$$\sum_{t=0}^{\infty} \beta^t S \frac{(C_t/S)^{1-\sigma} - 1}{1 - \sigma}$$

(3.3.6)

where each household member consumes an equal share of the household’s aggregate consumption. Since the persistence of talent $\gamma$ is permanent and there are no aggregate shocks in the economy, the household faces a perfect foresight problem.

**Production** Production of the final good $y$ at each state establishment requires combining capital $k$ and labor $l$ with an individual talent $z$ with the same technology as in the private sector (3.3.2).

A state entrepreneur has access to the same competitive financial intermediary as one in the private sector. However, they have perfect access to capital rental. In the context of the collateral constraints, this is equivalent to $\lambda = \infty$. Like the private sector, I abstract from borrowing for consumption purposes ($a \geq 0$). State entrepreneurs also hire workers at a wage $w$ in the same labor market as their private sector counterparts.

Contingent on operating an establishment, an individual with a talent $z$ solves (3.3.3) and receives the indirect profit $\pi(z, w, r)$.

**The Household’s Problem** Each individual decides whether to operate an establishment or to work for a wage. Whether one is an employer or an employee, individuals within a household pool their collective income and the household chooses sequences of consumptions that maximize utility. If an agent chooses to be a worker, he contributes a wage $w$ to the collective income of the household. If he operates an establishment, he contributes $\pi(z, w, r)$ instead. His occupational choice is the most lucrative option. Since an individual in the state sector faces perfect capital rental markets, given factor prices, their occupational choice depends solely on individual talents. Formally, an agent
chooses to operate an establishment if his individual talent is greater than or equal to a unique threshold \( z \) that solves \( \pi(z, w, r) = w \).

The household’s problem is to maximize the lifetime utility \( \text{[3.3.6]} \) subject to the budget constraint

\[
c_t + a_{t+1} \leq \sum_{z \geq z} \mu(z) \pi(z; w_t, r_t) + \sum_{z < z} \mu(z) w_t + (1 + r_t)a_t
\]

where the lower case variables represent per-capita notation.

### 3.3.3 Equilibrium

In equilibrium, the market for capital and labor must clear. Let the demand for capital and labor for a private entrepreneur with assets \( a \) and talent \( z \) be \( k(a; z, w_t, r_t) \) and \( l(a; z, w_t, r_t) \). Next, let \( k(z; w_t, r_t) \) and \( l(z; w_t, r_t) \) be the capital and labor demands of a state entrepreneur with a talent \( z \). Market clearing in the capital market requires

\[
N \sum_{z \in Z} \mu(z) \left[ \int_{a(z, w_t, r_t)}^\infty k(a; z, w_t, r_t) \, dG_t(a, z) - \int_0^\infty a \, dG_t(a, z) \right] + S \left[ \sum_{z \geq z} \mu(z) k(z; w_t, r_t) - a_t \right] = 0
\]

where the first term in each bracket is total capital demand by the private and the state sector, respectively, and the second term is capital supply (total assets).

Market clearing in the labor market requires

\[
N \sum_{z \in Z} \mu(z) \left[ \int_{a(z, w_t, r_t)}^\infty l(a; z, w_t, r_t) \, dG_t(a, z) - G_t(a(z, w_t, r_t), z) \right] = 0
\]
\[ +S \left[ \sum_{z \geq z} \mu(z) l(z; w_t, r_t) - \sum_{z < z} \mu(z) \right] = 0 \]

where the left term in each bracket is total labor demand by the private and the state sector, respectively, and the right term is labor supply (total workers).

I now define a competitive equilibrium where a variable with an asterisk indicates an equilibrium value.

*Given a sequence of prices \( \{w_t^*, r_t^*\}_{t=0}^{\infty} \), for all \( t \geq 0 \), the following holds in a competitive equilibrium:*

1. *for the private sector, the sequences \( \{c_t^*, a_{t+1}^*, l_t^*, k_t^*\}_{t=0}^{\infty} \) solves the individual’s problem (3.3.1);*
2. *for the state sector, the sequences \( \{c_t^*, a_{t+1}^*, l_t^*, k_t^*\}_{t=0}^{\infty} \) solves the household’s problem (3.3.6);*
3. *the goods market clears;*
4. *the markets for capital and labor clear (Equations (3.3.8) and (3.3.9) hold);*
5. *financial intermediaries make zero profits.*

### 3.4 Quantitative Analysis

In this section, I first parameterize the model to characterize China’s economy. I then conduct the transition from production being carried out by state establishments to a mixed economy with active state and private entrepreneurs. I begin the exercise where individuals in the private sector face barriers to operating an establishment. I model these restrictions on private production as an output “distortion,” defined as \( \tau \), representing all obstacles to production, \( (1 - \tau)z^\alpha l^\theta \). Prior to reforms, the production
technology for all individuals in the private sector is subject to $\tau = 1$. This initial value of $\tau$ captures an economy where state entrepreneurs are the only producers.

Reforms are introduced by the unexpected, permanent change from $\tau = 1$ to $\tau = 0$, which is the only exogenous change I impose on the economy. Once the reform takes place, everyone realizes the change is permanent. Reforms essentially “open up” the economy to a second sector. Following the “opening up,” labor flows freely between the two sectors but financial constraints limit the capital flows between the two. As previously discussed, reforms may have been, in fact, more gradual, but this simplified characterization highlights the impact of major reforms in 1992. In any case, the data suggest that the reforms were drastic, exemplified by the immediate reallocation of labor and production following the 1992 reforms.

3.4.1 Parameterization

I discipline the quantitative analysis by choosing parameter values that match key moments in the data. In total, I specify values for 10 parameters.

- Three technology parameters $\alpha, \theta,$ and $\delta$.
- Two parameters describe the process for entrepreneurial talent $\gamma$ and $\eta$. Specifically, I assume the distribution of $z$ follows a truncated and discretized Pareto distribution with p.d.f. $\eta z^{-(\eta+1)}$ for $z \geq 1$ where $\eta$ determines the dispersion of ability across individuals.
- Two preference parameters $\beta$ and $\sigma$.
- The size of the state and private sectors $S$ and $N$.
- The magnitude of collateral constraints $\lambda$.

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8I truncate the Pareto distribution by finding $\bar{z}$ that solves $G(\bar{z}) = 1 - 0.00005$ where $G(\cdot)$ is the c.d.f. of the Pareto distribution. This cutoff ensures that the mass above $\bar{z}$ is probabilistically very small.
Some of the model parameters are chosen with values common in the literature. I let the subjective discount factor $\beta = 0.96$, a common value for annual models, and the coefficient of relative risk aversion is set to $\sigma = 1.5$. I use $\delta = 0.075$ for the one year depreciation rate.

The remaining seven parameters are set to match moments in the data specific to this study and are summarized in Table 3.1. To determine the dispersion of talent parameter $\eta$, I match the distribution of individual talent $\mu(z)$ to the US establishment size distribution measured by employment due to the lack of comprehensive Chinese establishment-level data. I choose $\eta$ by simulating the steady state of the model without financial frictions and the state sector to match the US establishment size distribution because the US has relatively well developed financial markets and a large private sector. It has long been documented that US firm size can be well approximated by the Pareto distribution (Simon and Bonini 1958; Steindl 1965; Ijiri and Simon 1977). The matching of the US and China talent distribution is under the assumption that the same technological blueprints available in the US are available in China. Given the technology and preference parameters, I set $\eta$ of the talent Pareto distribution $\eta z^{-(\eta+1)}$ at 4.44. This matches the model employment share of the largest 12 percent of establishments with the US in 2007, 0.72.\footnote{The size distribution from the US Bureau of Labor Statistics is reported in bins. The 12 percent figure is the closest I can estimate to the top 10 percent of establishments.}

I set the persistence of individual talent $\gamma$ equal to 0.895, leading to an annual exit rate of establishments of 10 percent in the model. This is consistent with the exit rate of establishments in the US as reported in Buera and Shin (2010).

Next, I let $\theta = 0.50$ to match the 50 percent labor share of output in China. The profit share of output $1 - (\alpha + \theta)$ largely determines the income distribution. Therefore,
### TABLE 3.1

PARAMETER VALUES

<table>
<thead>
<tr>
<th>Target Moments</th>
<th>Chinese Data</th>
<th>Model</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Income Share</td>
<td>0.50</td>
<td>0.50</td>
<td>$\theta = 0.50$</td>
</tr>
<tr>
<td>1992 Gini coefficient</td>
<td>0.24</td>
<td>0.24</td>
<td>$\alpha + \theta = 0.82$</td>
</tr>
<tr>
<td>2007 share of private labor</td>
<td>0.52</td>
<td>0.51</td>
<td>$\frac{S}{N} = 0.04$</td>
</tr>
<tr>
<td>2007 external fin./GDP</td>
<td>1.59</td>
<td>1.53</td>
<td>$\lambda = 1.4$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Target Moments</th>
<th>US Data</th>
<th>Model</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 12 percentile employment share</td>
<td>0.72</td>
<td>0.72</td>
<td>$\eta = 4.44$</td>
</tr>
<tr>
<td>Establishment exit rate</td>
<td>0.10</td>
<td>0.10</td>
<td>$\gamma = 0.895$</td>
</tr>
</tbody>
</table>

I infer the value of $\theta$ by targeting China’s 1992 income Gini coefficient.

Since there is no data on the wealth distribution in 1992, I set the initial distribution of assets in the model to match the income Gini coefficient in the data. Specifically, agents within the same sector have the same asset level, however the level is higher in the state sector than in the private sector.

The remaining parameters $N$, $S$, and $\lambda$ are set to match moments of China’s transitional economy. I simulate the transition by changing the output “distortion” on the private sector from $\tau = 1$ to $\tau = 0$. I fix the number of simulated private agents to $N = 150,000$ and adjust the size of the state sector $S$ to match the private sector’s share of employment of 52 percent in 2007.

For the magnitude of the collateral constraint $\lambda$, I target China’s external finance to GDP ratio in 2007 of 159 percent. External finance is the sum of domestic and foreign
bank credit, private bond market capitalization, and stock market capitalization. I let $\lambda = 1.4$ which gives an external finance to GPD ratio of 153 percent. This number is slightly lower than the 2007 figure in the data but higher than in 2006.

3.4.2 Baseline model results

In this section, I analyze the transition from an initial steady state where the only establishments belong to the state sector ($\tau = 1$) to a mixed economy with both private and state entrepreneurs ($\tau = 0$). I first show the growth in TFP as a result of the modeled reform along with the basic underlying intuition, and then examine the mechanisms in detail. To be consistent with the TFP calculations in the data, I aggregate capital and labor and use the Cobb-Douglas production function to back out TFP, assigning equal shares to both inputs.

Figure 3.6 presents the transition dynamics of TFP, private employment share, private-to-state TFP, and factor input prices. The solid line corresponds to the China data and the dashed lines to the model results. In Panel A, we see that TFP continues to evolve after the initial rise following reforms in 1992 even though there are no additional exogenous changes. By 2007, the model accounts for 25 percent of the observed TFP growth since reforms.

Three mechanisms contribute to the TFP growth. First, the reforms introduce a wave of entrepreneurs with above average talents. Talented private entrepreneurs with enough assets to overcome the collateral constraints and operate at a profitable level enter into production. Financial frictions, however, impede entry of the less talented. High-talent

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10I follow Buera, Kaboski, and Shin (2011) to calculate external finance. I use the data from the International Monetary Fund’s *International Financial Statistics* (IFS) and Beck and Demirguc-Kunt (2009). The market value of the stock market capitalization overstates the book value which is conceptually closer to financed capital in the model. I multiply the stock market capitalization by the average book-to-market ratio in the data, 0.35. This calculation does not account for private consumer credit, so the actual value of borrowing for investment is most likely smaller.
Figure 3.6. Transition in the baseline economy
individuals profitably operate a business using less capital, so their occupational choice is dictated less by financial constraints compared to less talented individuals. In contrast, individuals in the state sector do not face this barrier to entry, so there are relatively more low-talent entrepreneurs active in this sector. This selection mechanism results in a relatively larger share of talented entrepreneurs in the private sector than in the public sector, generating a difference in the composition of entrepreneurial talent between these sectors. This ultimately leads to persistent differences in TFP (Panel C) with the private sector displaying higher TFP. Thus, aggregate TFP increases due to the exclusive entry of the most talented private entrepreneurs.

Second, aggregate TFP growth largely comes from the reallocation of resources from the state sector to the more productive private sector (Panel B). Following entry, financial frictions cause private entrepreneurs to operate at an inefficiently small scale. As private entrepreneurs accumulate wealth to increase collateral and approach the profit-maximizing scale, this sector expands and gradually attracts more labor. In the calibration I targeted the private sector employment share in 2007 only, but the simulated series mirrors the time-path of labor reallocation in the data.

Third, productivity growth is due not only to entry of but also exit of the marginally talented entrepreneurs. Ongoing productivity growth causes a rise in the equilibrium wage (Panel D), which induces the exit of less productive enterprises on two fronts. First, business level profits decline. Second, the outside option of being a worker becomes more attractive.

Now, I explore these mechanisms in more detail.

**TFP Differences Between the Private and the State Sector** In this section, I explore the mechanisms that lead to the differences in TFP on the extensive margin. I
focus on the micro-level occupational choice to capture the differences in entrepreneurial talent between sectors. Figure 3.7 shows that throughout the transition the average talent, normalized by the pre-reform level, is higher in the private sector than in the state sector. The differences in talent composition arise from financial frictions that alter the occupational choice rules for the private sector.

To further investigate these differences, I consider the occupational decision rules for both sectors in Figure 3.8 which plots assets $a$ against entrepreneurial talent $z$. First, for an agent in the private sector, the decision to become an entrepreneur depends jointly on his talent and wealth. The threshold asset level $a$ at a given entrepreneurial talent $z$ is given by $a(z)$. To the right of the cutoff, the agent operates an establishment and to the left he becomes a worker. The downward slope of the decision rule indicates that

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11 This figure plots the model occupational choice in the final stationary steady state.
more talented individuals require fewer assets to enter entrepreneurship.

Second, for agents in the state sector, the occupational choice cutoff only depends on individual talent. The vertical line at $\bar{z}$ shows the cutoff for the state sector. It is worthwhile to point out that an individual in the private sector would never choose to be an entrepreneur if his talent was below $\bar{z}$ no matter how wealthy he may be.

The difference in the occupational decision rules illustrates a barrier to entrepreneurship due to financial constraints that particularly affects the less talented. For example, a private agent at point $A$ would not choose to become an entrepreneur since he is unable to overcome the collateral constraint. In contrast, a state agent at point $A$ would become an entrepreneur. As a result, the share of low-talent entrepreneurs is smaller in the private sector than in the state sector. This mechanism generates a variation in the composition of talent between sectors.
In Figure 3.9 I show the steady state probability density functions (p.d.f.) of entrepreneurial talent in each sector to highlight the compositional differences of talent between the two. The point where the distribution starts corresponds to $z$ from the previous figure. Observe that close to $z$ on the right, the state sector has a large mass of active entrepreneurs while the private sector does not. Individuals in the private sector in this range of talent cannot save the necessary collateral to operate at a profitable scale. In the absence of collateral constraints, these distributions would be identical.

The overall difference in private-to-state TFP is a result of two opposing factors. On the one hand, collateral constraints cause private entrepreneurs to operate at an inefficiently small scale, suppressing TFP. On the other hand, the composition effect – selection of the most talented entrepreneurs – raises TFP. However, the latter effect dominates the former which keeps private sector TFP relatively high. I measure these individual effects in Section 4.4.
The magnitude of the compositional effect of talent between sectors is influenced by the persistence of ability $\gamma$. If $\gamma$ equals 1, all private agents’ talents remain indefinitely relevant. In this scenario, all potential private entrepreneurs with talent $z > \underline{z}$ eventually overcome the collateral constraints and the steady state composition of talent will be the same in both sectors. At a low persistence of talent, since asset accumulation takes time, saving to overcome the collateral constraints may be futile because an agent’s current ability may become obsolete before he can profitably become an entrepreneur. In the sensitivity analysis section, I show that along the transition path this does not play a quantitatively large role on the main aggregates. It does, however, matter in the long run.

Interest rates also impact an individual’s ability to overcome the financial constraints. Following reforms, the interest rate in the model moves from 4.15 percent in 1992 to 3.6 percent in 2007. With lower interest rates, private agents become more impatient ($((1 + r)\beta < 1)$, rendering them less willing to save in order to overcome collateral constraints. This disproportionally affects the least talented as they already require more wealth to start a business.

Interest rates initially fall from the decline of capital demand in the state sector. State entrepreneurs exit and production shifts towards the less capital intensive private sector. Over time, interest rates continue to fall as private entrepreneurs increase savings to self-finance. Additionally, when the persistence of talent $\gamma < 1$, under the permanent income hypothesis, private entrepreneurs save to smooth consumption for future periods when they will most likely be workers. These forces work in tandem to decrease interest rates.

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12 In the model, only the top 4 percent of private agents meet the talent requirement ($z > \underline{z}$) to become an entrepreneur. Thus, even though it is possible for a potential private entrepreneur to draw a higher talent if he loses his current talent, it is more likely that such an agent would become less talented.
Expansion of the Private Sector Following the entry of private entrepreneurs on the extensive margin, aggregate TFP growth also arises from the expansion of these firms on the intensive margin. Financial constraints cause private entrepreneurs to operate an inefficiently small scale, but as time progresses they save collateral to expand their capital use. Figure 3.10 illustrates the evolution of capital intensity, measured as the capital-output ratio, for both sectors in the left panel and for the entire economy to the right. The increase in capital intensity in the private sector reflects self-financing. The model predicts a faster rise in capital intensity in the private sector and a slower rise in the state sector compared to the data. However, the simulations clearly show differences in the capital-output ratios between sectors which is driven by variation in access to credit. Other factors not present in the model may account for the disparities in the model-data trends. For instance, many state firms benefit from subsidized inputs (Prasad 2009), a channel I do not explore.
The fall in the aggregate capital-output ratio is an indicator of more efficient resource use because TFP and output grow following the reforms. As the less capital intensive private sector expands, aggregate capital intensity falls yet GDP grows by 20 percent.

**Exit of the Marginally Talented Entrepreneurs** On the extensive margin, productivity gains also come from the exit of the least talented, marginal entrepreneurs. As the private sector expands, the growth in productivity raises the equilibrium wage which induces exit, i.e., \( z \) shifts to the right. Exit is particularly pertinent for the state sector as this is the only mechanism that changes their composition of entrepreneurial talent. I next compare the exit of state enterprises in the model to the data.

The data used includes all state owned manufacturing and construction firms with sales over 5 million RMB from 1998-2009. Figure 3.11 traces the number of establishments in the model normalized by the pre-reform number and firms in the data normalized by 1998.\(^{13}\) Because of the shortened sample size, I overlap the two series with \( time = 0 \) as 1992 in the model and 1998 in the data. Despite the differences in classification (firms vs. establishments) and timeframe, both series point out the salient dismantling of inefficient state owned companies. The closure and declining profitability of state firms occurs because the rise of the private sector increases wages, and wages erode profits.

**Discussion** In summary, TFP growth following the 1992 economic reforms arises from three sources. First, only the most talented entrepreneurs enter. Second, as the private sector expands, resources are reallocated to the more productive private sector. Third, as wages rise, the least talented entrepreneurs exit.

\(^{13}\)I smooth the model series using the HP filter with \( \lambda=100 \) to capture the trend.
Figure 3.11. Number of state firms

Two main features of the TFP dynamics stand out. For one, the model can account for 25 percent of total TFP growth in China from 1992-2007 without imposing any exogenous TFP growth. The increase in simulated TFP does not include growth in human capital, adoption of new technologies, or other sources of productivity growth. Instead, the model generates TFP growth entirely from both the structural changes that closely correspond to the 1992 economic reforms and from the financial constraints that characterize an important sectoral difference in the Chinese economy.

Also, TFP differences evolve endogenously without assuming any exogenous discrepancies in productivity between the state and the private sectors. In 2007, the model accounts for 22 percent of the average private-to-state TFP and the explanatory power
increases to 26 percent in the steady state. This provides an alternative, unexplored channel that relies on selection into entrepreneurship based on empirically motivated differences in access to financial markets across sectors.

3.4.3 Sensitivity analysis

I now conduct a sensitivity analysis by describing three alternative cases: (1) no financial constraints, (2) permanent persistence in talent, and (3) a small open economy with an exogenous world interest rate. In each experiment, I retain the baseline model parameterization except for the parameter in question. These alternative scenarios are plotted in Figure 3.12 against the baseline parameterization.

First, consider the case of perfect capital rental markets $\lambda = \infty$. In the baseline model, TFP dynamics continue to evolve after the initial reform as the private entrepreneurs accumulate the collateral to increase the scale of production. This is not the case in the perfect credit economy; given factor prices, all establishments immediately reach their profit-maximizing scale. In addition, the occupational decision rule is identical for both sectors. The distributions of entrepreneurial talent are the same, captured by the private-to-state TFP equaling 1 in all periods. Also, the private sector employment share immediately reaches its long-run value, in stark contrast to the baseline model. Interest rates, however, continually change. They first rise due to an increased demand for capital. As private entrepreneurs save to insure against future changes in their individual talent, interest rates begin to gradually fall below the initial rate.

Next, suppose there is permanent persistence in talent $\gamma = 1$. In this scenario, agents face a standard perfect foresight problem with financial constraints. The results are qualitatively similar to the baseline economy. As discussed in the previous section, in the long run all private entrepreneurs eventually overcome the collateral constraints and
Figure 3.12. Sensitivity analysis

private-to-state TFP and the private sector employment share will be the same as in the perfect credit economy. In the short-run, however, selection into entry from the financial constraints still exists. Additionally, the interest rate returns to its initial level in the long run because agents have no precautionary savings motive.

Finally, consider the small open economy model with a constant interest rate \( r = 0.04 \). I lower the interest rate from the initial \( r = 0.0416 \) to invoke the impatience condition \((1 + r)\beta < 1\) to avoid infinite asset accumulation which would otherwise occur in a set-
ting with precautionary motives. In this experiment, capital rental markets need not clear domestically because excess saving or borrowing will be absorbed in international markets. Again, these results are similar to the baseline economy, however the private sector expands at a slightly faster rate. With higher interest rates, the impatience condition is less severe so entrepreneurs are more willing to acquire the necessary collateral to operate an establishment, i.e., the occupational decision rule is less distorted by financial frictions. In reality, China is neither a small-open economy nor completely closed. If the model was expanded to characterize China as a large open economy, one may think that the model dynamics may lie between the small open economy and the baseline cases, which turn out to be similar.

3.4.4 Financial frictions on China’s economy in the long run

I next quantify the long run impacts of financial frictions faced by private entrepreneurs on TFP and GDP. Consider first the impacts on TFP in the aggregate economy and at the sector level. The y-axis in Figure 3.13 shows the stationary steady state TFP for different values of $\lambda$, normalized by TFP in the perfect credit case ($\lambda = \infty$). The empirical counterpart of $\lambda$, private-to-state external financing, is shown on the x-axis and the carrot marks the baseline parameterization. It is clear that TFP differences between sectors are increasing in financial frictions. At the baseline parameterization, removal of financial frictions lowers TFP by 10 percent in the private sector and raises state sector TFP by 11 percent. The discrepancies in TFP between sectors largely cancel each other out as the aggregate TFP only increases by 1.5 percent.

Variations in sectoral TFP can be explained by distortions on the intensive and extensive margins. In the state sector, the monotonic rise in TFP is solely attributable to changes on the extensive margin. As financial constraints are removed, there is an influx
of private entrepreneurs and the expansion of productive scale changes factor prices. In particular, wages rise 20 percent from the baseline parameterization which drives the marginal state entrepreneurs into becoming workers. In the absence of financial frictions, fewer entrepreneurs are active in the state sector but the overall talent composition is higher.

In the private sector, financial frictions distort both the extensive and intensive margins. On the intensive margin, private entrepreneurs who face binding credit constraints operate at inefficiently small scales. On the extensive margin, they distort the occupational decision rules. Figure 3.14 quantifies the impact of these margins on private sector TFP. The solid line shows the deviation, in percent, of private sector TFP for a given \( \lambda \) from TFP in the perfect credit economy. The dashed and dotted lines show the percentage point contribution of the extensive and intensive margin distortions, respectively, on the percent deviation of TFP. The sum of the two lines equals the deviation of TFP (the solid line).

Figure 3.13. Long run impacts of financial frictions on TFP
Figure 3.14. Impact of intensive and extensive margin distortions on private sector TFP

I measure the intensive margin distortions by holding fixed the pool of private entrepreneurs and the total amount of labor and capital at each value of $\lambda$ and I distribute capital among them to equalize their marginal products. The dotted line shows that the inefficient allocation of capital under financial lowers private sector TFP. In the baseline economy, the misallocation of capital lowers TFP by 10 percent. The remaining contribution, distortions on the extensive margin, raises TFP through the selection of entry of only the most talented private entrepreneurs. TFP is 20 percent higher through this mechanism in the baseline parameterization. Overall, extensive margin distortions are the dominant factor that keeps private sector TFP above the perfect credit case.

Although the aggregate efficiency gains in TFP from relaxing financial frictions are small, the output gains are substantial. Figure 3.15 shows GDP and capital use for different values of $\lambda$, again normalized by the perfect credit case. As financial frictions are relaxed, more private entrepreneurs enter and they operate at larger scales. For
example, the steady state capital-output ratio is 2.9 in the baseline parameterization and increases to 3.4 under perfect credit markets. The rise in GDP results from a combination of more establishments and increased capital intensity.

These results suggest the following long-run implications of relaxing financial constraints in China’s economy. First, the model predicts that aggregate efficiency gains, measured by TFP, would change very little, but output would substantially increase through an influx of establishments and increased capital use. Second, we may expect TFP levels in the private and the state sectors to become more similar. At the aggregate level, this would appear as the state sector “catching up” to the private sector, but in fact it is a selection effect, not the increased productivity of existing state establishments. Third, relaxation of financial constraints may lead to slower growth in private sector TFP,
but existing establishments would actually operate more efficiently.

3.5 Conclusion

China’s growth acceleration has followed the emergence of the private sector after the major reforms in 1992. This paper developed a quantitative model explaining a main engine of China’s growth, total factor productivity, following a removal of production barriers on private entrepreneurs. Without assuming exogenous productivity growth, the reallocation of factor inputs can account for 25 percent of the total change in TFP from 1992-2007.

A key component of the model is the differences in financial frictions faced by the private and the state sectors. I show that financial frictions faced by individuals in the private sector results in the selection of only the most talented entrepreneurs which leads to differences in the composition of entrepreneurial talent between the sectors. This endogenous selection mechanism accounts for 22 percent of TFP differences between the state and the private sectors. It follows from the analysis that aggregate TFP growth arises from the reallocation of productive resources from the state to the more productive private sector after reforms.

Projecting forward, the model suggests that China can benefit from large output gains with the development of financial institutions. Interestingly, there would only be small gains in TFP. Although existing establishments would operate more efficiently with financial development, the influx of less productive enterprises would keep TFP from rising.
A.1 Construction of the Data

In this appendix, I first begin by discussing the classification of ownership before explaining the construction of the aggregate and provincial data.

In the government (state) sector, I include state-owned enterprises (SOEs), urban collectively owned units, and township and village enterprises (TVEs). The private sector consists of private enterprises, self-employed workers, foreign enterprises, and other types of ownership.

There is often a blurred line between government and private ownership in China. In fact, shareholding and limited-liability corporations, which I include in the private sector, are commonly privatized SOEs. In many cases the government retains a stake in these corporations, although usually not to the extent of SOEs. Also, I include TVEs in the government sector which are owned by local governments. These firms face competitive pressure from other TVEs and operate similarly to private corporations. However, local governments back TVE loans which gives them easier access to external credit markets (Naughton 2007). Since I focus on differences in access to credit between government and private sectors, these are more appropriately categorized as belonging to the government sector.
A.1.1 Aggregate data

**GDP Deflators** The CSY separates GDP by the primary, secondary, and tertiary sectors. The primary sector consists of agriculture, fisheries, forestry, and mining. I refer to this as the agricultural sector and I classify the non-agricultural sector as the sum of the secondary (industry and construction) and tertiary (service and transportation) sectors. Young (2003) claims real GDP is overstated because the implicit GDP deflators reported by China’s National Bureau of Statistics (NBS) understates inflation. He instead proposes an alternative set of deflators based on final goods prices.

For the secondary sector, I follow Young and use the ex-factory price index. This deflator grows 6.1 percent annually from 1985-2009 compared to 4.8 percent from the implicit deflator. For the tertiary sector, Young suggest the consumer services price index as an alternative to the implicit deflator. However, following the 2005 economic census the NBS revised data in the tertiary sector. The consumer services price index used by Young is based off the unrevised series, so I instead use the implicit deflator based on the revised data which is 22 percent higher than the unrevised series.

**Investment** I use gross fixed capital formation (GFCF) from the CSY. To net out primary sector investment, I use data from Hsueh and Li (1999) who report primary sector GFCF for 26 provinces. I next use fixed asset investment as my investment series, a slightly different series that GFCF based on enterprise surveys, which separates fixed investment by ownership. I assume that the ratio of primary sector GFCF to total GFCF is the same for the fixed asset investment series, and I subtract primary sector investment from the series. For 1996-2007, I use primary sector investment from the CSY and various issues of the *China Statistical Yearbook of Fixed Asset Investment*. Three years are absent from these reports, so I assume that the share of primary sector investment in these missing years is the average of the previous and next year.
Next, I calculate the investment deflator following Young (2003) and Brandt and Zhu (2010) based on separate deflators for equipment and structures. Having the real investment series, I construct the capital stock using the perpetual inventory method with 7.5 percent annual depreciation. I begin the series from Chow’s (1993) capital stock in 1978.

**Employment** Employment by ownership and broad economic sector is reported in the CSY. I use data from the *China Labour Statistical Yearbook 2009* and subtract primary sector employment for each ownership classification. The NBS made an upward adjustment in the employment series in 1990 following new information from the population census in 2000. Data prior to 1990 is unrevised, so I report the employment series from 1990 onward.

**GDP by Ownership** The CSY does not report output by ownership in the non-agricultural economy for urban areas, however it does in rural areas. I divide output by ownership in urban areas using average wage data by ownership and the total number of employees by sector. Following Brandt and Zhu (2010), I assume that wages are proportional to their average value products and the labor shares are identical across ownership. I then infer the division of output based on this measure in urban areas. In rural areas, the NBS reports output by TVEs and other ownership types until 2005. For 2006 and 2007, such data is not available. Instead I construct an out-of-sample forecast of real TVE output based on TVE output growth regressed on GDP growth, TVE employment growth, and a time trend. I then add the rural and urban data to obtain the division of output for the whole economy.

A.1.2 Provincial data

For the provincial data, I focus only on 2002, the most recent year where the data
allows me to separate output by ownership at the provincial level. TFP calculations only require GDP and employment in 2002, but a long investment series is needed to estimate the capital stocks. I calculate employment, investment, and GDP by ownership and province in the same way as the aggregate data. For the GDP deflators in the secondary and tertiary sectors, I use the province-specific implicit deflators reported in the CSY. Investment data are deflated using province level price indexes on investment goods from 1993-2007. Data prior to 1993 is unavailable as well as data for Tibet of Chongqing. I follow Brandt, Tomb, and Zhu (2011) and estimate an out-of-sample forecast of the provincial deflators based on regressing GDP deflators and year and province fixed effects on provincial investment deflators. With the real investment series at hand, I assume that an individual province’s share of investment from 1978-1985 is proportional to that province’s share of the aggregate capital stock in 1978.

I obtain total loans by ownership and province from the individual provincial statistical yearbooks and the China Yearbook of Fixed Asset Investment 2003. These sources do not include loans for TVEs, so I assume that they use the same proportion of loans for investment as the urban cousins – urban collectively owned units. Data for this series is only available for 23 of the 31 provinces.

A.2 Limited enforcement constraint

I motivate the collateral constraint with a limited enforcement problem which has been widely utilized in the literature on financial frictions. Assume that a private entrepreneur with assets $a$ who rents capital $k$ can deny repayment to the intermediary the share $1/\lambda$ of the rented capital. If he denies repayment, he loses his deposited assets. The parameter $\lambda$ measures the strength of enforcement where a lower value reflects a lower degree or enforcement. In this scenario, the intermediary would limit the amount of rented capital
to ensure the entrepreneur has the incentive to repay in full. This requires that an individual’s assets are greater than denying repayment, \( k/\lambda \leq a \).

A.3 Numerical solution method

In this appendix, I describe the numerical solution method for the model transitional dynamics. I first find the initial steady state by solving the private individual’s problem (3.3.1) and the state household’s problem (3.3.6). In this economy agents face no uncertainty and I simply find the wage and interest rate that clears the labor and capital markets, respectively.

Next, I solve for the transitional dynamics and the final stationary steady state after the removal of the output distortion on private entrepreneurs \((\tau = 0)\) at time \( t = 0 \). The aggregate problem is solved by finding wage and interest rate sequences such that labor and capital markets clear in all periods. I solve the equilibrium for each period following these steps:

1. Choose a number of transition periods \( T \) that is sufficiently long enough for the model to converge to a new stationary steady state.

2. Guess a wage sequence \( \{w_t\}_{t=0}^{T} \) and an interest rate sequence \( \{r_t\}_{t=0}^{T} \).

3. Compute the value functions for the state and the private sectors at time \( T \). Iterate the value functions backwards from time \( T \) to 0. Simulate \( N + S \) individuals for \( T \) periods using the optimal policy functions and the initial distribution of assets and talent as given. I choose \( N + S = 156,000 \). Examine if the labor market clears in each period. Update the wage transition sequence and repeat this step until the labor market clears in each period.

4. After the labor market clears, again compute the value functions for each sector at time \( T \). Iterate backwards the value functions from time \( T \) to 0 and simulate \( N + S \) individuals. Check if the capital market clears in each period, that is, capital demand equals aggregate assets. Update the interest rate transition sequence and repeat this step until the capital market clears in each period.
5. Repeat steps 3 and 4 until labor and capital markets both clear in each period.

For each model economy except for the small open economy model in Section 3.4.3 I choose $T = 150$. In the small open economy model, I choose $T = 400$ as the transition takes longer than in the other model economies.

A.4 Comparison of the establishment size distribution in the model with the data

I compare the model establishment size distribution with the US data in accompanying figure. It plots the log of establishments greater than a particular employment size against size for the actual size distribution. The dashed line is the size distribution from the model without credit constraints and the solid line is the US data. Establishment employment size is reported in discrete bins by the US Bureau of Labor Statistics Quarterly Census of Employment and Wages. Visual inspection reveals that it does not account for the concavity in establishment size distribution, but overall it fits relatively well.

![Figure A.1 Establishment size distribution in the model and data](image)

Figure A.1 Establishment size distribution in the model and data


