CHAPTER 1

Business Cycles, Consumption, and Risk Sharing: How Different Is China?☆

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Abstract
Can standard business cycle methodology be applied to China? In this chapter, we address this question by examining the macroeconomic time series and identifying dimensions in which China differs from economies (such as Canada and the United States) that are typically the subject of business cycle research. We show that 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.

Keywords: China, business cycles, consumption, risk sharing

1. Introduction

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 large in an absolute terms and is poised to overtake Japan as the world's second largest. Its sustained growth in real per capita GDP, at an average of 8.6% from 1978 to 2007, is high by any standard.[1] While there has been

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[1] Source: China National Bureau of Statistics.

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a good deal of economic research done on China, most of it has been on microeconomic issues. Given the pace of globalization and China's role in international economics, surprisingly little research on China has been done on the macroeconomic side by academic economists.

There may be several reasons for this, but two possibilities jump to mind. The first concerns doubts about data quality. In one example of potential measurement error, in revising PPP exchange rates used to deflate nominal GDP, the World Bank revised the real GDP data for China downwards by about 40%. On the other hand, following the 2004 Chinese Economic Census, the National Bureau of Statistics (NBS) revised GDP from 1993 to 2004 upward so that by 2004, nominal and real GDP were modified to be 16% and 6% higher, respectively. Whether one believes in the accuracy of these revisions or not, the magnitude of the revisions serves to underscore some of the uncertainty surrounding the data. A second possibility stems from China's ongoing transition from a centrally planned to a market-based economy but with continued heavy involvement of the government. Researchers may be skeptical as to whether a transitional economy such as China's is appropriate for analysis by the current generation of business cycle models. These models are typically solved as approximations around the steady state, but one can question whether China has converged to the steady-state growth path. In this sense, China may be "too different" from the typical country that macroeconomists study with the standard toolkit of business cycle models.

In this chapter, we examine the extent to which China's macroeconomy is suitable for business cycle modeling. Using the available data, we address whether China is sufficiently similar or different, say in comparison with Canada and the United States. Of course, if we find that China is too different for business cycle modeling, it is possible that the underlying cause is data quality. In any event, it is beyond our manpower resources and our expertise to do anything about data quality issues and understanding the macroeconomics of China is too important to wait until the "high-quality data" are available.

We focus on two issues. First, we investigate the extent to which the cyclical properties of the post-reform Chinese economy (1978–2007) can be understood with a very basic real business cycle model. The model we use is nearly identical to Mendoza (1991), who studied the Canadian economy from 1946 to 1985. The only part of the model that is specific to China are the parameters of the exogenous processes (government spending and productivity) that we estimate from the Chinese data. Otherwise, we employ the same parameter values as Mendoza 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 we address 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 that we employ 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, we conduct a formal test of the risk-sharing assumption. We follow Crucini's (1999) study of risk sharing across the US states and among G-7 countries. By employing the same methodology as Crucini, we can directly compare our results for China with his results for the United States 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.[2] We find the degree of risk sharing across Chinese Provinces is much lower than that across the US states.[3] 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 3 presents an informal examination of the provincial level data. The formal test of the risk-sharing hypothesis and comparison of our results to

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[2] See Pierfederico *et al.* (1996) and Ostegaard *et al.* (2002) who test the risk-sharing hypothesis across the United States, and Lewis (1996) and Canova and Ravn (1996) who test the risk-sharing hypothesis internationally.

[3] While our primary focus is on risk sharing during the post-reform years, we also conduct our analyses on pre-reform data from 1954 to 1977. This analysis finds that consumption risk was shared even less under central planning than that 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.

Crucini's for the United States and G-7 countries is undertaken in Section 4, and Section 5 concludes.

2. *Does the business cycle framework work for China?*

In this section, we investigate the extent the cyclical properties of the post-reform Chinese economy be understood with a very basic real business cycle model.

The model we employ is a variant of Mendoza (1991) and Uribe and Schmidt-Grohe (1994). It is a one-good small open economy model with a representative consumer/producer who seeks to maximize expected lifetime utility,

$$E_t \sum_{j=0}^{\infty} \beta^j \frac{(c_{t+j} - (h_{t+j}^{\omega}/\omega))^{1-\gamma} - 1}{1-\gamma}$$

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 τ_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

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

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 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,

$$\ln(g_t) = (1-\rho_g)\ln(\bar{g}) + \rho_g \ln(g_{t+1}) + \varepsilon_t^g,$$
$$\ln(a_t) = \rho_a \ln(a_{t-1}) + \varepsilon_t^a,$$
$$r_t = (1-\rho_r)\bar{r} + \rho_r r_{t-1} + \varepsilon_t^r,$$

where $\varepsilon_t^g (\overset{\text{iid}}{\sim} N(0, \sigma_g^2)$, $\varepsilon_t^a (\overset{\text{iid}}{\sim} N(0, \sigma_a^2)$, and $\varepsilon_t^r (\overset{\text{iid}}{\sim} N(0, \sigma_r^2)$. The subjective rate of time preference is set to the long-run (steady-state) interest rate such that it equals $(1+\bar{r})^{-1}$. 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,[4]

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

The model is completed by imposing the national income accounting identity

$$y_t = c_t + i_t + g_t + tb_t,$$

where tb_t is the trade balance. Given the solution of the model, construction of auxiliary 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.

2.1. Calibration and simulation

The data that we employ in our 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 ϕ 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 reports the parameter values that we use. We take ω from Mendoza (1991) and ψ from Schmitt-Grohe and Uribe (2003). We set the discount factor $\beta = (1+\bar{r})^{-1}$ where $\bar{r}$ is the mean world real interest rate. The values for γ, α, and δ are

[4] Mendoza achieves a stationary steady state by assuming that the subjective discount factor is endogenous.

Table 1. Parameter values

	Parameter	Value		Parameter	Value
	β	0.978		ρ_a	0.600
	ω	1.45		ρ_g	0.809
	λ	2		ρ_r	0.434
Preferences	α	0.33	Exogenous processes		
	δ	0.1		σ_a	0.017
	ψ	0.00074		σ_g	0.010
	ϕ	2		σ_r	0.010
				$\bar{r}$	0.023
Bonds (SS)	$\bar{b}$	−0.05		$\bar{g}$	0.140

all standard in the business cycle literature (recall that this is an annual model).

We examine four versions of the model that 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.
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 2 shows implied volatility of the key variables from the model and in the data since 1978.[5] 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 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 mall 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 3 reports (model) implied and data values of the first-order autocorrelation of the macro time series. Keeping government spending

[5] We are working with a stationary model so the data have all been passed through the Hodrick-Prescott filter.

Table 2. Volatilities: Open economy (1978–2007)

Series	Data	All shocks	No government	Domestic shocks	Productivity only
$\sigma(y)$	0.048	0.050	0.049	0.050	0.049
$\frac{\sigma(c)}{\sigma(y)}$	1.167	0.877	0.660	0.883	0.721
$\frac{\sigma(i)}{\sigma(y)}$	1.792	1.687	1.703	1.677	1.682
$\frac{\sigma(h)}{\sigma(y)}$	0.458	0.664	0.662	0.664	0.663
$\frac{\sigma(s)}{\sigma(y)}$	1.500	1.237	2.003	1.273	1.882
$\frac{\sigma(g)}{\sigma(y)}$	0.958	0.904		0.910	
$\sigma\left(\frac{nx}{y}\right)$	0.027	0.016	0.014	0.017	0.015
$\sigma\left(\frac{ca}{y}\right)$	0.033	0.013	0.015	0.012	0.013

Table 3. Autocorrelations: Open economy (1978–2007)

	Data	All shocks	No government	Domestic shocks	Productivity only
GDP	0.730	0.722	0.724	0.720	0.719
Consumption	0.685	0.787	0.763	0.793	0.790
Employment	0.454	0.747	0.739	0.745	0.744
Investment	0.685	0.424	0.409	0.425	0.417
Saving	0.764	0.701	0.691	0.695	0.681
Current account/ GDP	0.664	0.612	0.884	0.606	0.868
Net exports/GDP	0.667	0.755	0.870	0.750	0.893

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 is 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 4 examines the co-movements of the macro variables. Consumption, investment, and saving all co-move 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 cyclicality of the external balances comes from the fact that government spending is procyclical. The other difficulty in the model is that the predicted co-movements between saving and consumption are much higher than in the data.

Table 4. Correlations: Open economy (1978–2007)

Series	Data	All shocks	No government	Domestic shocks	Productivity only
$\rho(y,c)$	0.834	0.933	0.985	0.916	0.942
$\rho(y,i)$	0.800	0.812	0.817	0.826	0.824
$\rho(y,s)$	0.829	0.994	0.993	0.992	0.993
$\rho(c,i)$	0.437	0.705	0.759	0.703	0.719
$\rho(c,s)$	0.384	0.910	0.987	0.879	0.907
$\rho(s,i)$	0.890	0.827	0.832	0.849	0.857
$\rho(y,g)$	0.391	0.399		0.398	
$\rho\left(\frac{nx}{y},y\right)$	−0.098	0.058	0.529	0.025	0.439
$\rho\left(\frac{ca}{y},y\right)$	−0.167	0.020	0.534	0.021	0.510

Table 5. Results for Canada, 1946–1985

Variable	Data volatility	Model volatility	Data autocorrelation	Model autocorrelation
GDP	2.81	2.81	0.615	0.615
Consumption	2.46	2.25	0.701	0.689
Saving	7.31	5.58	0.543	0.629
Investment	9.82	9.89	0.314	−0.017
Hours	2.02	1.94	0.541	0.615
Productivity	1.71	0.87	0.372	0.615
TB/Y	1.87	1.97	0.663	0.032

Source: Mendoza (1991).

To compare how China's business cycle differs from developed economies, Table 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, 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, we 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. We now turn to an investigation of this idea.

3. Informal 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. We refer to "provinces" as regions classified as provinces, autonomous regions, and municipalities. These exclude Hong Kong and Macau. These are annual observations spanning from 1954 to 2004 and have not been subjected to the NBS revisions.[6,7] Nominal values are deflated with the aggregate price deflator. We also deflated provincial nominal figures using provincial price deflators. The main results are unchanged by doing this. We are primarily interested 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 that allows us to assess 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, 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

[6] Provincial data is reported by each Provincial Statistical Bureau, not the NBS. So, the dates of revisions to provincial accounts data are staggered.

[7] 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.

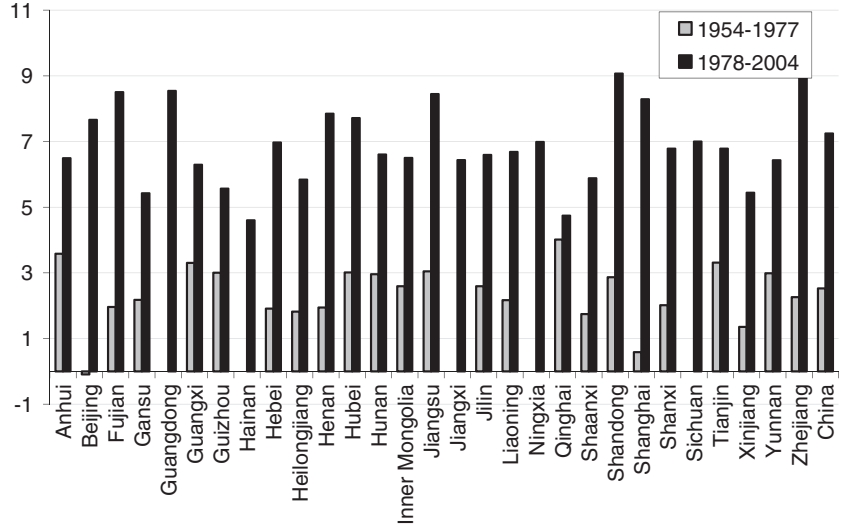

Fig. 1. Per capita consumption growth rates.

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, eight 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, its 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 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 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%.

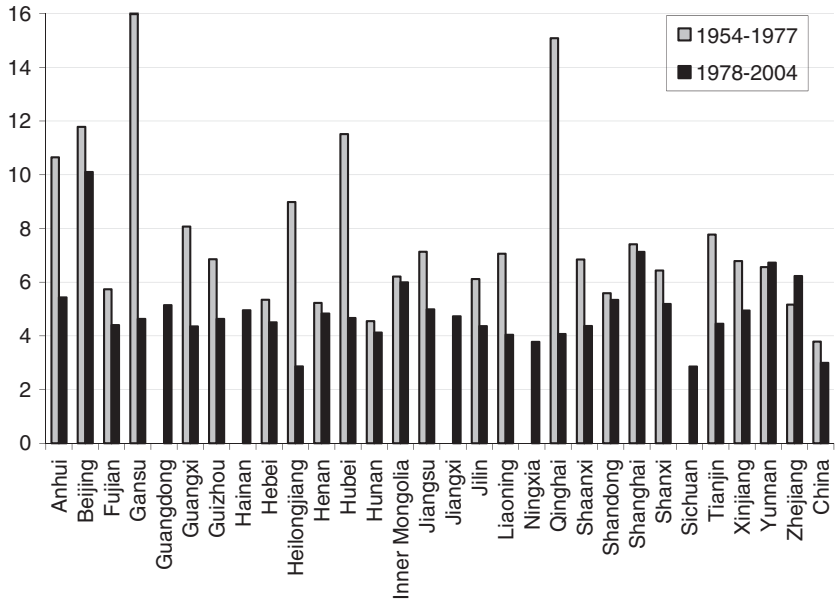

Fig. 2. Volatility of per capita consumption growth.

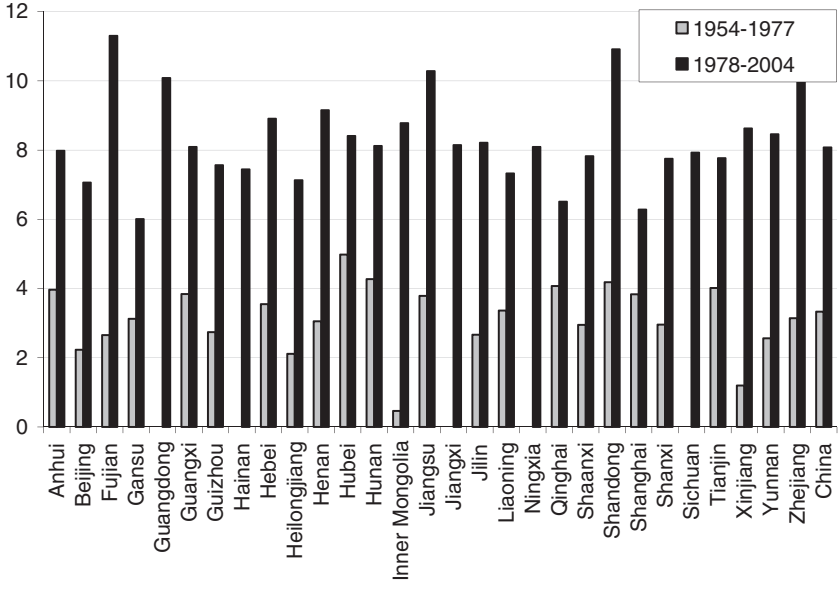

Fig. 3. Growth rate of output.

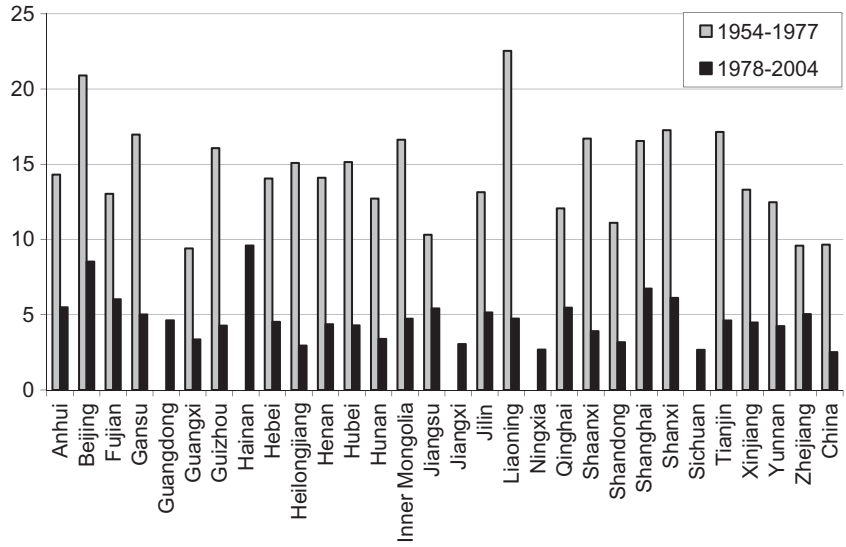

Fig. 4. Volatility of output growth.

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 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 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 United States during the years (1969–1983) before the "Great Moderation."

To get an idea of the degree of integration or coordination across provinces, Figure 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 6. For the United States, the correlation average is 0.7 from 1969 to 1983 and 0.56 from 1984 to 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 where a full menu of

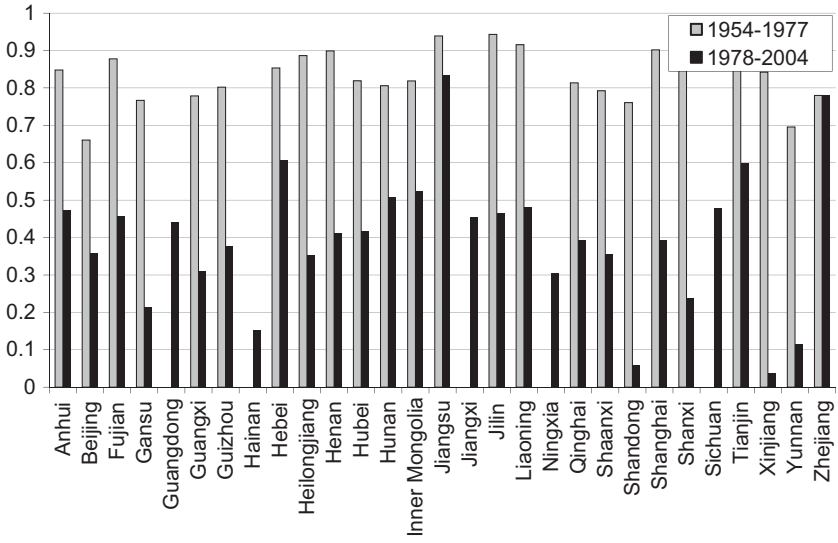

Fig. 5. Correlation between provincial aggregate output growth.

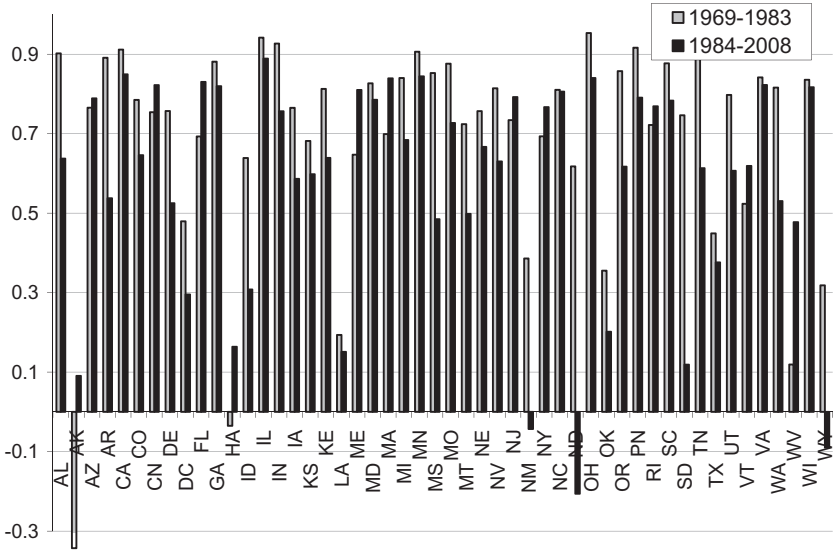

Fig. 6. Output growth correlations in the United States.

state-contingent assets is 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

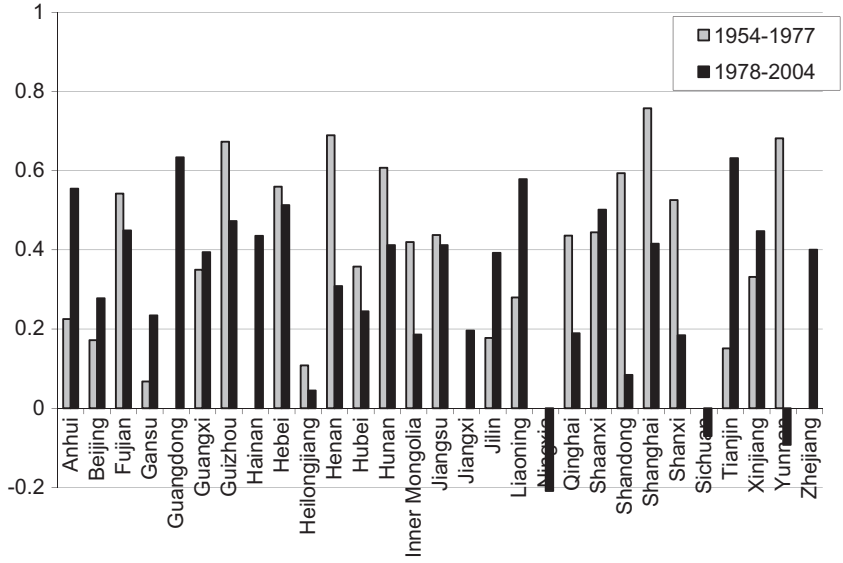

Fig. 7. Correlation between provincial and aggregate consumption growth.

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 7. It displays the correlation between provincial and aggregate per capita consumption growth, which should be close to 1 under perfect insurance.[8] 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.

[8] 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.

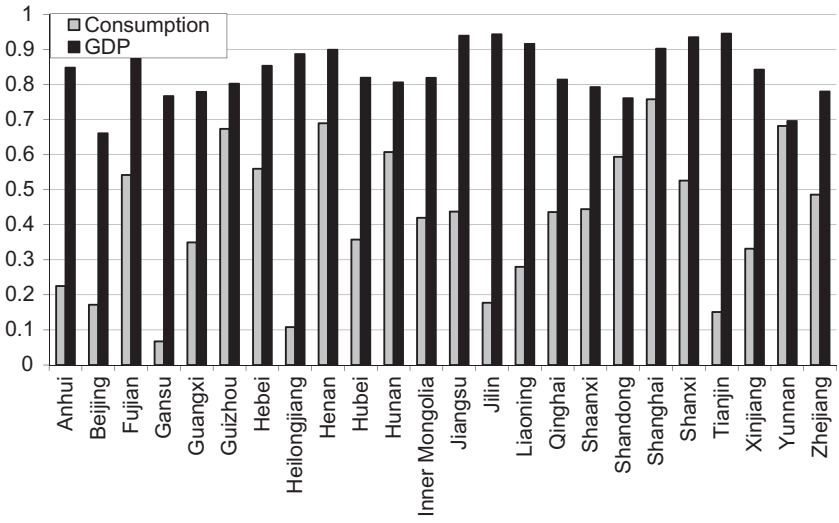

Fig. 8. Correlation between provincial and aggregate growth 1954–1977.

The degree of risk sharing across countries is a topic also studied by international economists.[9] In the international economics literature, a widely documented fact, known as the "consumption correlation puzzle," is that the correlation of consumption growth 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 outputs. It is against this backdrop that we present in Figures 8 and 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

[9] 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.

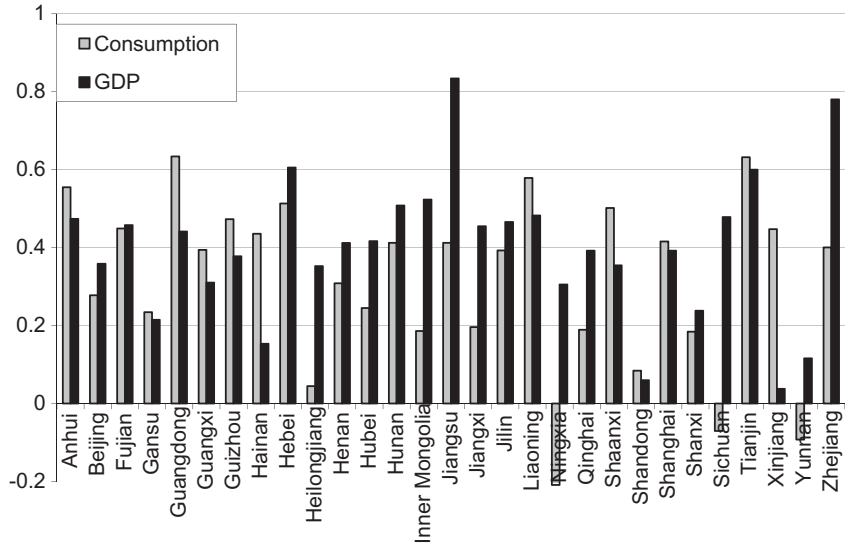

Fig. 9. Correlation between provincial and aggregate growth 1978–2004.

countries in this dimension with an average consumption correlation of 0.32 against an average output correlation of 0.40.

4. A test of the perfect risk-sharing hypothesis

In this section, we employ a methodology used by Crucini (1999) to formally test the risk-sharing hypothesis across Chinese provinces. Since Crucini applied the same test to US states and G-7 countries, we can use our results to assess the degree of within country risk-sharing in China to that in the United States 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, Δc_{jt}, on the change of aggregate consumption, ΔC_t, will yield a unit-valued slope coefficient and that coefficients on any additional regressors will be zero. Let Δy^p_{jt} be the innovation (unexpected change) to province j's permanent income. Crucini (1999) suggest running the regression

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

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.

Table 6. Tests of perfect risk sharing on 24 Chinese provinces

Income model	$\bar{\lambda}$	Average S.E. ($\bar{\lambda}$)	Values R^2	No. of provinces for which a 95% confidence interval contains the value of λ such that			
				$\lambda = 1$	$0 < \lambda < 1$	$\lambda = 0$	$\lambda = 0$ or 1
1954–1977							
I	0.45	0.43	0.38	6	2	8	8
II	0.39	0.40	0.42	6	1	9	8
III	0.33	0.38	0.43	5	2	11	6
1978–2004							
I	0.50	0.32	0.26	9	2	5	7
II	0.49	0.32	0.27	8	1	7	8
III	0.43	0.31	0.27	6	1	10	7

As in his paper, we consider three alternative estimates of this variable. Income model I assumes that provincial and aggregate income growth, Δy_{jt} and ΔY_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, Δy^p_{jt}.

For each income model specification, we estimate 24 regressions of Equation (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 6.

We do not get exceedingly precise estimates of λ 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).

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

To compare China to within United States and international G-7 risk sharing, Table 7 reproduces Crucini's results. Since state level consumption data is unavailable for the United States, 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 United States. Perfect insurance cannot be rejected for 33 states (66% of the sample) using income model III.

Table 7. Tests of perfect risk sharing on US states and G-7 countries

Income model	$\bar{\lambda}$	Average S.E. ($\bar{\lambda}$)	Values R^2	No. of provinces for which a 95% confidence interval contains the value of λ such that			
				$\lambda = 1$	$0 < \lambda < 1$	$\lambda = 0$	$\lambda = 0$ or 1
US states, 1972–1990							
I	0.94	0.31	0.51	31	3	2	9
II	0.84	0.34	0.50	29	2	3	13
III	0.88	0.32	0.50	33	3	2	10
G-7 countries, 1972–1990							
I	0.60	0.26	0.45	2	2	2	1
II	0.44	0.44	0.57	1	2	4	0
III	0.37	0.37	0.57	1	2	4	0

The international story, at least among the G-7 during the 1970s and 1980s, 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 United States and about at the same level across industrialized countries in the 1970s and 1980s. 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.[10]

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.

5. *Conclusion*

To answer the questions posed in the introduction, we do find that China's macroeconomics are different from developed countries that are usually

[10] Xu (2008) employs the Crucini test but employs household survey data spanning 1980–2004 and reaches conclusions similar to ours.

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 1970s and 1980s. 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 United States.[11]

Uncited References

Asdrubali *et al*., 1996; Cooley and Prescott, 1995; King *et al*., 1988.

Statistical Appendix

The sources of the Chinese provincial and aggregate data are:

- All China Marketing Research Co., Ltd (2004).
- NBS of China. The China Statistical Yearbook (2005, 2006, 2007, 2008). China Statistics Press, Beijing.

The data set contains 31 provinces for which only 24 cover the entire sample 1954–2004.

List of 24 provinces (1954–2004): Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Henan, Hubei, Hunan, Guangxi, Guizhou, Yunnan, Shaanxi, Gansu, Qinhai, Ningxia, and Xinjiang.

Gross State Product data in the United States comes from US Bureau of Economic Analysis at http://www.bea.gov/regional/gsp/.

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