Provincial and Regional Capital Mobility in China: 1978-2006

February 18, 2011

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Abstract

We examine provincial and region capital mobility in China and track how the degree of mobility has changed over time from 1978 to 2006, during periods of economic reform. The effects of fiscal and redistributive activities of different levels of government in China on private capital mobility are taken into account. Our results show that there is a significant improvement in capital mobility over time in China, particularly for private capital in the more developed regions. The central and provincial governments, via their taxation, spending, and transfers, loosen the relationship between private saving and investment and appear to promote capital mobility, particularly for less developed regions.

JEL classification: C22, C23, F21

Keywords: Feldstein-Horioka, intra-national capital mobility, saving-investment relationship, Chinese capital market integration

1 Introduction

How to assess the degree of capital mobility or capital market integration for a country or region? Other than testing the similarity of rate of returns on capital in different countries, Feldstein and Horioka (1980) (here after FH (1980)) evaluates the degree of capital mobility across national boarders by estimating the saving-retention rate, or the saving-investment correlation, using cross sectional data of OECD countries. They argue that if capital mobility is high among these countries, incremental savings in one country would seek investment opportunities with the highest possible returns around the world, which would result in national savings being uncorrelated with national investment. Otherwise, domestic saving would have no where to go but be invested in domestic market, which

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Acknowledgment: We thank Gregory Chow, Carsten Holz, Cheng Hsiao, Nelson Mark, and Mingming Jiang for helpful comments and suggestions. All remaining errors are ours.

lead to the perfect correlation between national saving and investment that indicates zero degree of capital mobility. Their estimation result shows that saving retention rate in OECD countries is quite high and not significantly different from 1. This indicates that degree of capital mobility of these countries is quite low, which contradicts the general consensus that capital mobility among these industrialized nations are high. Their study has since spurred a huge number of papers on this topic.

Many subsequent papers which employ cross-sectional data also confirmed the results of FH(1980). For example, Feldstein (1983), Murphy (1984), Caprio and Howard (1983), among others, obtain high correlations between national saving and investment for OECD countries.

Using time series data, Obstfeld (1989) shows that saving retention rates are high for OECD countries and they actually rose during the time period 1949-1984. Frankel (1986) obtains similar results for the U.S.. Tesar (1991) confirms that domestic saving-investment correlations are high in OECD countries and shows that this result remains the same in both the short and long-run.

As this high saving-retention rate is a stylized fact found in empirical studies, many have attempted to explain it and try to reconcile it with free capital mobility. Murphy (1984) argues that this high saving-retention rate may be due to the existence of large countries, as they could influence world interest rate and thus influence investment and saving. Obstfeld (1989) shows that this may be the result of endogenous private sector's responses to exogenous shocks such as population growth and productivity shocks. He also presented a simple life-cycle model which could generate high saving-investment correlation compatible with free capital mobility assumption. Tesar (1991) gives an excellent summary on those theoretical models. Similar works including Cantor and Mark (1988), Mendoza (1991), Backus et al. (1992), and Baxter and Crucini (1993).

Frankel (1986, 1992) argues that high saving-retention rate may not be due to capital immobility but due to the fact that real interest parity does not hold. Summers (1989) and Roubini (1989) argue that government policy such as budget deficits targeting may have caused the high correlation between saving and investment. Bayoumi (1990) develops this argument and concludes that current account targeting is likely to be the cause of high saving-investment correlation despite that capital is mobile among OECD countries.

Sinn (1992) challenges the results of FH(1980) as they use time-averaged cross sectional data. Sinn (1992) argues that this may bias the estimates of saving-retention rate upwards as government faces inter-temporal budget constraints and cannot run current deficit permanently. Coakley et al. (1996) presents empirical results to show that current accounts in OECD countries are stationary. At the same time, saving and investment are cointegrated, which substantiates their arguments that high saving-retention rate obtained by previous studies such as FH(1980) is primarily due to current account solvency, not due to low capital mobility. Argimón and Roldán (1994), and Jansen and Schulze (1996) also produce similar results to ECM countries and to Norway, respectively.

Apart from empirical evidence from cross sectional and time series studies, panel studies in assessing capital mobility using FH(1980) framework provide mixed results. By using panel data set of OECD countries and estimating a fixed effects model, Krol (1996) obtains estimates of saving-retention rate that are substantially lower than FH(1980). He then concludes that capital is mobile and panel estimation provides more accurate results. Jansen (2000) challenges Krol (1996)'s results as he includes Luxemburg in his sample, which is not conformable with previous literature. Jansen (2000) obtains considerably higher saving investment correlation from fixed effects model of panel OECD dataset when Luxemburg is excluded. He shows that even in 1990s, this correlation is still much above 0, amounts to around 0.55 for OECD countries.

Meanwhile, Coiteux and Olivier (2000) reconcile the findings of Krol (1996) and FH(1980) by estimating the saving-retention rate using panel cointegration method and error correction model. Their result shows that in the long run, as current account solvency is binding, saving-retention rate is substantially higher than zero, around 0.63. However in the short-run, it is rather low, lying between 0.14 and 0.33, indicating that capital is quite mobile.

By applying the Dynamic OLS (DOLS) and Fully-Modified OLS (FMOLS) panel cointegrating vector estimation methods of Chiang and Kao (2001) to OECD countries, Ho (2002) shows that the estimated saving-retention rate is rather low for industrialized nations. Meanwhile, he also shows that whether or not Luxemburg is included does not influence the estimation results very much. These panel cointegration techniques have also been used by Kim et al. (2005) on a group of Asian countries. They find that capital mobility in Asia is improving from 1960-1979 to 1980-1990. Other studies which also use panel cointegration technique include Hoffmann (2004), Pelgrin and Schich (2008), and Evans et al. (2008). Table 1(b) provides a brief summary of the above mentioned studies on OECD countries.

In addition to those mentioned above that focus on evaluating international capital mobility using national saving and investment, many have also done similar works on evaluating capital mobility within national borders. For example, Bayoumi and Rose (1993) and Thomas (1993) have estimated saving and investment correlation rate for U.K., Yamori (1995) and Dekle (1996) for Japan, Sinn (1992) for the U.S., and Helliwell and McKitrick (1999) and Thomas (1993) for Canada. They reach the same conclusion that saving-retention rates obtained from regional data (or prefecture data) inside those industrialized countries are low and insignificantly different from 0, which indicates that capital market is fully integrated and the degree of capital mobility is quite high in these countries. Table 1(c) provides a brief summary of those intra-national studies of saving-retention rate.

When it comes to capital mobility across provinces in China, a more recent study by Boyreau-Debray and Wei (2004) apply the FH(1980) framework to study the provincial capital mobility in China. They obtain a saving-retention rate estimate of around 0.5 using provincial saving and investment data spanning from 1952 to 2001. They conclude that there is no improvement in the provincial capital mobility across China over the period. Li (2010) employs the panel cointegration method to the provincial data of China and obtains similar estimates of the saving retention rates (see Table 1(a) for a summary of the estimates). Moreover, he reaches the same "imperfect capital mobility" conclusion as in Boyreau-Debray and Wei (2004). Both studies found a moderate degree of provincial capital mobility within China, which is at a similar level as that *across* the OECD countries but is at a significantly lower level than that within each OECD country (see Table 1(b) and Table 1(c) for a summary of the inter-country and intra-country estimates of the saving retention rate for OECD countries, respectively.) In other words, the barriers to provincial capital mobility in China are still as high as those across the OECD countries.

The purpose of this paper is to assess the degree of provincial and regional capital mobility in China. It contributes to the Feldstein-Horioka literature in the following *four* aspects: *first*, we decompose the provincial data of China from 1978 to 2006 into government and private components to gauge how economic reform affects the degree of total and private capital mobility, the latter of which is of more interest to us[2]. *Second*, by utilizing bootstrap panel cointegration estimation technique by Chang (2004) and Chang et al. (2006), we explicitly take into account of the cross-sectional dependence in panel data[3]. *Third*, we examine capital mobility for individual regions, and for different groups of regions (for a comparison and contrast between more developed coastline regions and less developed inland regions) in China. *Forth*, we track detailed changes over time in the level of provincial and regional capital market integration.

The rest of this paper is organized as follows. In Section 2 we present the estimation results from simple FH (1980)-like time-averaged cross-sectional data of provincial saving and investment in China from 1978-2006. This part serves as a preliminary exercise for us before we jump into the more sophisticated method in the subsequent sections. It also serves as a robustness check for further results.

From Section 3 to Section 5, we apply panel cointegration techniques to the non-stationary saving and investment data of 26 provinces[4] from 1978 to 2006 to estimate the saving and investment correlation across provinces under the framework of FH (1980). In Section 3 we present the model and give a brief literature review on those panel cointegration works in FH (1980) framework. Section 4 presents the econometric methodology, and Section 5 discusses the data set as well as the empirical results. Section 6 concludes.

To preview the results, we find that capital mobility is relatively low in China for the whole sample period 1978-2006. However, from the first sub-period of 1978-1992 to the second sub-period of 1993-2006, we observe a significant improve of private sector capital mobility across provinces and regions, and capital market becomes more integrated. The rolling window estimation results confirms this improvement by showing that from 1993 to 2006 the saving-retention rate for private sector declines from above 0.5 (with conventional significance level) to around 0.2 (statistically insignificant at conventional level). Further, this improvement of capital mobility is more obvious for the developed regions along the east and southern coastline of China. The central and provincial governments, via their taxation, spending and transfers, loosen the relationship between private saving and

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[2] See Thomas (1993) and Dekle (1996) for a similar decomposition. Note that this distinguishes our paper from the papers by Li (2010) and Boyreau-Debray and Wei (2004) which do not decompose the total saving and investment data into the private and government components.

[3] Li (2010) also takes into account of the cross sectional dependence in one estimator called the Common Correlated Effects Mean Group Estimator (CMG)(Pesaran, 2006). However the weakness of this method lies in the fact that it assumes a rather simple structure of the cross sectional dependence. More on this could be found in Section 4.

[4] There are altogether 31 administrative provinces in China excluding Hong Kong and Macau, and we include 26 provinces in our sample for which we have complete data for 1978-2006. Detailed discussion on data availability is presented in Appendix 1.

investment and appear to promote capital mobility particularly for less developed regions. There are considerable differences between more and less developed regions in terms of capital market integration.

2 A Simple Cross Sectional Analysis

In this section, we use the time-averaged cross sectional data to estimate the saving-retention rate across provinces in China from 1978-2006 through the original framework used by FH (1980). Section 2.1 explains the data. Section 2.2 presents the estimation results.

2.1 Data

Data for the years 1978-2006 of the 26 provinces is collected from China Economic Information Database and China statistical year book[5], and supplemented by the provincial statistical yearbooks when necessary. The total investment is divided into the private and government components. The provincial saving (S) is calculated using equation 1:

$$S = GDP - C_p - G = \underbrace{(GDP - C_p - T)}_{S_p} + \underbrace{(T - G)}_{S_g} \tag{1}$$

where S_p and S_g denote the provincial private and government savings[6] respectively. The government investment, I_g, is taken as the "Expenditure for Capital Construction". The private investment is taken as the difference between the total investment and the government investment, that is, $I_p = I - I_g$, where I, I_p and I_g denotes the total, private and government investment, respectively.

2.2 Estimation Results

Figure 1(a), 1(b) and 1(c) plot the total, private and government investment rates against the saving rates for the whole sample. Fig. 1(b) indicates a positive relationship between the provincial private saving and investment rates across China while Fig. 1(c) indicates a negative relationship for the government counterpart. The negative coefficient for the government component can be due to the reallocation of capital from the more productive regions (the higher saving regions) to the less productive ones (the lower saving ones) by the government to support investment in the latter regions (Boyreau-Debray and Wei, 2004). Combining the private and government components yield a total in Fig. 1(a) that shows no apparent relationship between the investment rate and saving rate.

Figure 2 and 3 show the same set of graphs for the first subsample (1978-1992) and second subsample (1993-2006) respectively. We divide the sample at 1993 because of two

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[5] More detailed discussion on data could be found in Appendix 1.

[6] Here the local government's savings are augmented by transfers from the central government to reflect the actual funding available to the local governments. This amount was notable after the tax redistribution reform in 1994. For detailed information please refer to Appendix 1.

major reasons. First, up to the early 1990s, the government had been using a system of credit ceilings for controlling the money supply. Under this system, within and between-bank transfers were limited. After the mid 1990s, within and between-bank transfers were likely to have increased as bank were given more autonomy (Boyreau-Debray and Wei, 2004)[7]. Second, during 1978-1992, reforms were characterized by a carefully controlled decentralization. This means that a free market economy coexisted side-by-side with a centrally planned economy. From 1993 onwards, market had "grown out of the plan", which means that the focus of reforms had shifted towards building a market-friendly institution[8]. This change in the institutional setting has a direct impact on the freedom of capital flow and decisions on capital allocation across provinces. Fig. 2 (b) shows a positive relationship between the private sector saving and investment rates for the first subsample, and Fig. 3 (b) indicates that this positive relationship is less apparent in the second sub period.

We perform a closer analysis by estimating the saving retention rate in the following regression as in FH (1980):

$$\left(\frac{I}{Y}\right)_i = \alpha + \beta \cdot \left(\frac{S}{Y}\right)_i + \varepsilon_i \tag{2}$$

where $\frac{I}{Y}$ and $\frac{S}{Y}$ denote the investment/GDP and saving/GDP ratios respectively. Table 2 reports the OLS estimates based on the period averaged data.

The OLS estimation results provided in Table 2 indicates that the saving retention rate (captured by $\widehat{\beta}$) differs vastly for different components of the investment and saving rates. As indicated in Panel A, the rate is not significantly different from zero in the relationship between the total investment and saving rates, regardless of the sample periods. This presents a puzzle because it indicates that the provincial capital mobility is high even in the late 1970s and early 1980s despite the segmentation of the provincial capital market caused by the lack of market-directed capital flow. We approach this puzzle by decomposing the total investment and saving rates into the private and government components. As indicated in Panel B and C, the saving retention rate shows up to be significantly positive for the private component in the period prior to 1992, but is significantly negative for the government component in the same period. Putting these findings together suggests that the low saving retention rate in the "total" relationship is spurious in the sense that it is mainly dragged down by the inclusion of the government component. This result is similar to that of Dekle (1996), which finds that the saving retention rate at the prefecture level of Japan is biased down when the government component is not singled out. Similar findings are also obtained by the regional studies of Thomas (1993) for UK and Canada in the 1970s and 1980s.

More specifically, the saving retention rate of the private sector is 0.565 for the first subperiod, which is statistically significant at the 1% level. In the second subperiod,

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[7] As stated in Boyreau-Debray and Wei (2004), there are three main channels to transfer capital across provinces. One is through cross-province domestic investment, another is through bank lending, and the third one is through bond or stock market. As stated in Allen et al. (2005), the banking system dominates the financial system in China. The bank credit to GDP ratio in 2000 was 1.11, which was higher than most developed countries.

[8] For more details, see Fan (1994) and Naughton (2007).

it reduces to 0.238 and is no longer significant at the conventional significance levels. This suggests that the provincial private capital market has become more integrated over time. Our results differ from those of Boyreau-Debray and Wei (2004) which, somewhat surprisingly (as Boyreau-Debray and Wei themselves put it), find no improvement in the provincial capital mobility in China despite the progresses in market reforms and opening-up of the economy. The difference can be attributed to three factors: first, we do exactly the original Feldstein-Horioka regression, that is, we perform the cross-sectional regression on time-averaged observations rather than panel analysis. This allows us to see if the FH regression results are consistent with the results from more sophisticated panel techniques like those of Boyreau-Debray and Wei (2004) and Li (2010), and the subsequent analysis of this paper. It also facilitates the comparison between our analysis and those of the other intra-country studies in the literature, like that of Dekle (1996) and Thomas (1993). Second, we use a longer time series for the post-reform period compared with Boyreau-Debray and Wei (2004) (our data covers up to 2006 while that of Boyreau-Debray and Wei covers up to 2001). Third, we decompose the data into the private and government components and we find that the private component demonstrates a significant improvement in provincial capital mobility after the 1990s.

Nevertheless, one caveat is that the standard FH regression may be subject to measurement errors or endogeneity problem (see Obstfeld, 1996, p.65). Endogeneity can arise because labor migration between provinces could alter the response of saving and investment to disturbances. Moreover, provinces within countries tend to be more specialized in their production activities than are across countries. These tend to induce comovements in provincial saving and investment. To rectify these problems, we apply instrumental variable estimation using per capita GDP as the instrument (see Dekle, 1996). The relevancy of the instrument is supported by the high R-squares in the regression of the saving rates on the instrument (see Panel C and D of Table 3).

The results of the IV estimation are reported in Table 3 and they are largely consistent with the findings in Table 2. Panel A indicates that the saving retention rate based on the total investment and saving rates is statistically close to zero. The rates for the private component are 0.5, 0.566 and 0.449 for the whole period, 1st sub period and 2nd sub period respectively. The first two are statistically significantly different from zero at the 5% and 1% level respectively, while the value for the latter sub period is not statistically significant at 5% level. This indicates an increase in capital mobility from the first to second sub period.

A rolling window estimation of the saving retention rate in China (see Figure 4) further confirm a rising trend of the provincial capital mobility in China after the mid 1990s. Using a window size of 15 years, we find that the saving retention rate dropped substantially from above 0.5 prior to the 1990s to around 0.2 in the mid 2000s, signifying a notable improvement of provincial capital mobility. This experience was shared by the UK a couple of decades ago, with the saving retention rate declined remarkably from 0.24 in the subperiod of 1976-1980 to nearly zero in the subperiod of 1981-85 (Bayoumi and Rose, 1993).

However, the rolling window estimation indicates a temporary decline in the capital mobility between 1992 and 1995. This is partly due to government's policy to tighten bank lending to investment for the purpose of curbing inflation around 1993 to 1996. As a result, investment has to rely more heavily on saving rather than bank lending. After 1997, there was continuous improvement in the degree of capital mobility over time.

2.3 Summary of FH (1980) results

By estimating the saving retention rate in the Feldstein and Horioka framework, we find that the rate estimated using the total investment and saving (with the private and government components combined) tends to have a downward bias, signifying an overestimation of the degree of capital mobility. The bias comes from the fact that the government sector often has a negative saving retention rate, which drags down the positive rate for the private sector. After decomposing the total investment and saving rates into the private and government components, we find that the saving retention rate for the private sector is significantly positive for the whole sample period (1978-2006) and the first subperiod (1978-1992) but not significant for the second subperiod (1993-2006). This reflects a notable improvement in the provincial private capital mobility in the last decade. The rolling window estimation of the saving retention rate also confirms the continuous improvement in the provincial capital mobility, except for a temporary period during 1993 to 1996 when the government adopted some tightening measures on investment to curb inflation.

In the next section, we will turn to panel cointegration estimation technique to directly handle the nonstationary saving and investment series across provinces and regions in China.

3 The Panel Model of Investment and Saving

Krol (1996) estimates the following fixed effect model using a panel data set of 21 OECD countries:

$$IR_{it} = \alpha + \lambda_t + f_t + \beta \cdot SR_{it} + \varepsilon_{it} \tag{3}$$

IR_{it} stands for the investment rate of country i at time t, and SR_{it} for saving rate.

The use of panel data allows him to control for business cycle and country size effect without explicitly averaging the data.

Ho (2002) tests for the cointegration between the investment and saving rates by first estimating eq. 4 using cointegrating vector estimation method DOLS and FMOLS by Chiang and Kao (2001) and then tests if the residual series $\widehat{\varepsilon}_{it}$ is stationary.

$$IR_{it} = \alpha + \beta \cdot SR_{it} + \varepsilon_{it} \tag{4}$$

If capital mobility is low, saving and investment tend to be strongly cointegrated with $\beta = 1$ If capital mobility is high, saving and investment tend to be weakly cointegrated (with β significantly below 1) or even not cointegrated at all.

While Ho (2002) assumes homogeneous cointegrating vector for each individual country, Mark et al. (2005) estimates eq. 4 allowing for heterogeneous cointegrating vector for a group of industrialized countries. They apply Dynamic Seemingly Unrelated Regression (DSUR) and conclude that for most countries in their sample, the estimated $\widehat{\beta}$ is not significantly different from 1.

This and the subsequent section of this paper assesses the provincial and regional capital mobility in China by using the same equation as in Mark et al. (2005). However, there are at least two major differences between cross-country capital mobility and cross-provinces capital mobility. First, unlike national countries, provinces are not subject to the current account solvency constraint which generally biases upward the saving-investment correlation. Second, while the assumption of uncorrelated errors across countries is generally made in the studies on cross-country capital mobility, such assumption is less appropriate for provincial study as provinces in the same country are often subject to the same central government policy shocks and other nation-wide common shocks (see Boyreau-Debray and Wei, 2004). The existence of these (often unobservable) common factors across provinces renders those standard panel tests derived under the cross-sectional independence assumption (like Pedroni 1999, 2004, Levin et al. 2002 and Im et al. 2003[9]) invalid for provincial study[10]. For this reason, we relax this assumption and estimate the cointegration relationship between provincial saving and investment by using panel tests that allows for cross-sectional dependence.

4 Panel Econometric Technique

In this section we discuss the econometric technique that we employ in the analysis. In the extant literature, there are several panel unit root and cointegration tests that have allowed for cross-sectional dependence, among which include O'Connell (1998), Maddala and Wu (1999), Choi (2001), Wu and Wu (2001), Phillips and Sul (2003), Bai and Ng (2004), Chang (2004) and Cerrato and Sarantis (2007).

In O'Connell (1998), feasible generalized least squares (FGLS) correction is used to deal with cross-sectional dependence. His specification is based on a covariance matrix that may arise with random time effects as in random effects models $u_{i,t} = \theta + \varepsilon_{i,t}$ where $\theta \sim i.i.d, \varepsilon_{i,t} \sim i.i.d$ and θ and $\varepsilon_{i,t}$ are mutually independent. However, the weakness lies in the fact that it assumes homogeneous serial correlation and the same speed of convergence for all sections. Phillips and Sul (2003) use a specification similar to that of a one-way random effect model in which a time specific factor common to all cross-sections is present in the error term. Choi (2001) utilizes a two-way error-component model assuming that each cross-section is influenced homogeneously by the single factor. Wu and Wu (2001) first use SUR method to jointly estimate the augmented Dickey and Fuller (ADF) equation of the data for all sections, then construct the panel unit root test statistics using bootstrap. They use the same bootstrap procedure as in Maddala

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[9] Im et al. (2003) propose handling possible correlation across units by subtracting cross-sectional means from the observed data. This is also the practice that Li (2010) uses to deal with cross-sectional dependence. However, as pointed out by Cerrato and Sarantis (2007), a limitation of this approach is that it is based on the assumption of homogeneous cross-sectional dependence, which is rather unrealistic.

[10] Maddala and Wu (1999) argued that if the error terms are not independent and normal distributed due to the existence of cross-sectional dependence, the asymptotic distributions of panel unit root tests are unknown.

and Wu (1999) to preserve the structure of correlation of the data. Cerrato and Sarantis (2007) follow Maddala and Wu (1999) and Wu and Wu (2001) in assuming a general form of cross sectional dependence and use bootstrap unit root procedure for panel unit root test. However, their subsequent analysis of finite sample properties shows that their test statistics would be reasonably sized when only T is large enough. That is to say, T has to be more than or at least equal to 220. If T is small than 220, the size distortion is very large.

In our paper, Chang (2004)'s method is used for several reasons. First, her model takes a general form in that it encompasses both heterogeneous serial correlation and cross sectional dependence. Second, it has been shown that the finite sample property of the bootstrap test statistics are reasonably sized even when T is much less than 220. Since the time period of our sample is 1978 to 2006 and the time dimension T is far less than 220, Chang (2004)'s method is particular appropriate for our study. Third, Chang (2004)'s method is based on a bootstrap procedure so that the distribution of the test statistics rely less on the asymptotic properties. In the next sub-section, we provide more details about Chang (2004)'s bootstrap unit root tests for dependent panels.

4.1 Model Specification and Construction of Test Statistics

Consider the following panel model generated as first-order autoregressive regression:

$$\Delta y_{it} = \alpha_i \cdot y_{i,t-1} + u_{it}, i = 1, \ldots, N, t = 1, \ldots, T \tag{5}$$

Under the null of unit root, $\alpha_i = 0$ for all i in eq. 5. The alternative is $\alpha_i < 0$ for some i.

The error term u_{it} in model 5 is specified as a general linear process:

$$u_{it} = \pi_i(L)\varepsilon_{it} \tag{6}$$

where L is the usual lag operator and $\pi_i(z) = \sum_{k=0}^{\infty} \pi_{i,k} z^k$. Here heterogeneity is allowed through letting $\pi_i(z)$ vary across i. Cross-sectional dependence is allowed through the contemporaneous cross-correlation of ε_{it}. Define the time series innovation $(\varepsilon_{it})_{t=1}^{T}$ by $\varepsilon_t = (\varepsilon_{1t} \quad \ldots \quad \varepsilon_{Nt})^{'}$, and let $E\varepsilon_t = 0$, $E\varepsilon\varepsilon^{'} = \Sigma$. Thus, u_{it} in model 5 could be approximated by a finite order AR process:

$$u_{it} = \alpha_{i,1} u_{i,t-1} + \ldots + \alpha_{i,p_i} u_{i,t-p_i} + \varepsilon_{it}^{p_i} \tag{7}$$

where $\varepsilon_{it}^{p_i} = \varepsilon_{it} + \sum_{k=p_i+1}^{\infty} \alpha_{i,k} u_{i,t-k}$. Applying eq. 7 to eq. 5 and imposing the null of unit root, we obtain:

$$\Delta y_{it} = \alpha_i y_{i,t-1} + \sum_{k=1}^{p_i} \alpha_{i,k} \Delta y_{i,t-k} + \varepsilon_{it}^{p_t} \tag{8}$$

Chang (2004) develops the unit root test based on the above autoregression of Δy_{it} augmented by $y_{i,t-1}$, where p_i is chosen by using order selection such as AIC and BIC. Eq. 5 could also be written in the following matrix form with each individual unit encompassing all its T observations:

$$\underbrace{\begin{pmatrix} \Delta y_1 \\ \vdots \\ \Delta y_N \end{pmatrix}}_{(NT\times 1)} = \underbrace{\begin{pmatrix} y_{l,1} & & 0 \\ & \ddots & \\ 0 & & y_{l,N} \end{pmatrix}}_{(NT\times N)} \underbrace{\begin{pmatrix} \alpha_1 \\ \vdots \\ \alpha_N \end{pmatrix}}_{(N\times 1)} + \underbrace{\begin{pmatrix} X_1^{p_i} & & 0 \\ & \ddots & \\ 0 & & X_N^{p_N} \end{pmatrix}}_{(NT\times(\sum_{i=1}^{N} p_i))} \underbrace{\begin{pmatrix} \beta_1^{p_1} \\ \vdots \\ \beta_N^{p_N} \end{pmatrix}}_{((\sum_{i=1}^{N} p_i)\times 1)} + \underbrace{\begin{pmatrix} \varepsilon_1^{p_1} \\ \vdots \\ \varepsilon_N^{p_N} \end{pmatrix}}_{(NT\times 1)} \tag{9}$$

or more compactly[11]:

$$\Delta Y = Y_l \cdot \alpha + X_p \cdot \beta_p + \varepsilon_p \tag{10}$$

Chang (2004) develops four test statistics of the null of unit root based on system GLS and OLS estimation of eq. 10. They are grouped as F-type and k-type tests. The F-type tests include one based on the feasible system GLS estimator $\widehat{\alpha}_{GI}$ of α in eq. 10 and another based on the system OLS estimator of α in eq. 10. Both of them are presented as follows:

$$F_{GLS} = \widehat{\alpha}_{GT}^{'} \left(var(\widehat{\alpha}_{GT})\right)^{-1} \widehat{\alpha}_{GT} = A_{GT}^{'} B_{GT}^{-1} A_{GT} \tag{11}$$

where:

$$\begin{aligned}
&\widehat{\alpha}_{GT} = B_{GT}^{-1} A_{GT},\\
&A_{GT} = Y_l^{'}(\tilde{\Sigma}^{-1} \otimes I_T)\varepsilon_p - Y_l^{'}\left(\tilde{\Sigma}^{-1} \otimes I_T\right) X_p \left(X_p^{'}\left(\tilde{\Sigma}^{-1} \otimes I_T\right) X_p\right)^{-1} X_p^{'}\left(\tilde{\Sigma}^{-1} \otimes I_T\right)\varepsilon_p,\\
&B_{GT} = Y_l^{'}(\tilde{\Sigma}^{-1} \otimes I_T)Y_l - Y_l^{'}\left(\tilde{\Sigma}^{-1} \otimes I_T\right) X_p \left(X_p^{'}\left(\tilde{\Sigma}^{-1} \otimes I_T\right) X_p\right)^{-1} X_p^{'}\left(\tilde{\Sigma}^{-1} \otimes I_T\right) Y_l
\end{aligned}$$

where $\tilde{\Sigma}$ is a consistent estimator of the covariance matrix Σ.

OLS based F type test statistics is calculated by eq. 12:

$$F_{OLS} = \widehat{\alpha}_{OT}^{'} \left(var(\widehat{\alpha_{OT}})\right)^{-1} \widehat{\alpha}_{OT} = A_{OT}^{'} M_{FOT}^{-1} A_{OT} \tag{12}$$

where:

$$\begin{aligned}
\widehat{\alpha}_{OT} &= B_{OT}^{-1} A_{OT},\\
A_{OT} &= Y_l^{'}\varepsilon_p - Y_l^{'} X_p \left(X_p^{'} X_p\right)^{-1} X_p^{'}\varepsilon_p,\\
B_{OT} &= Y_l^{'} Y_l - Y_l^{'} X_p \left(X_p^{'} X_p\right)^{-1} X_p^{'} Y_l,\\
M_{FOT} &= Y_l^{'}\left(\tilde{\Sigma} \otimes I_T\right) Y_l - Y_l^{'} X_p \left(X_p^{'} X_p\right)^{-1} X_p^{'}\left(\tilde{\Sigma} \otimes I_T\right) Y_l\\
&\quad - Y_l^{'}\left(\tilde{\Sigma} \otimes I_T\right) X_p \left(X_p^{'} X_p\right)^{-1} X_p^{'} Y_l\\
&\quad + Y_l^{'} X_p \left(X_p^{'} X_p\right)^{-1} X_p^{'}\left(\tilde{\Sigma} \otimes I_T\right) X_p \left(X_p^{'} X_p\right)^{-1} X_p^{'} Y_l
\end{aligned}$$

Theoretically speaking, $\widehat{\alpha}_{OT}$ is less efficient than $\widehat{\alpha}_{GT}$ in this context, which leads to the GLS-based test F_{GLS} to be more powerful than the OLS based test F_{OLS}. However, Chang (2004) observes that F_{OLS} often performs better than F_{GLS} when T is small and N is relatively large.

A consistent estimation of the covariance matrix Σ is constructed through estimating the following eq. 13 using single equation OLS:

$$u_{it} = \tilde{\alpha}_{i,1}^{p_i} u_{i,t-1} + \ldots + \tilde{\alpha}_{i,p_i}^{p_i} u_{i,t-p_i} + \tilde{\varepsilon}_{it}^{p_i} \tag{13}$$

From eq. 13 we obtain the residual vectors:

$$\tilde{\varepsilon}_t^{p} = \left(\tilde{\varepsilon}_{1t}^{p_i}, \ldots, \tilde{\varepsilon}_{Nt}^{p_N}\right)^{'}, t = 1, \ldots, T.$$

---

[11] Dimensions of the matrices and vectors in eq. 10 are presented in eq. 9 just below each item.

Then Σ is estimated by $\tilde{\Sigma} = T^{-1}\sum_{t=1}^{T}\tilde{\varepsilon}_t^p\tilde{\varepsilon}_t^{p'}$. The F-type test F_{GLS} and F_{OLS} listed above in Chang (2004) are two tailed tests. They reject the null of unit root $\alpha_i = 0$ for all i when $\alpha_i \neq 0$ for some i, which includes cases when $\alpha_i < 0$ and $\alpha_i > 0$. In order to avoid the negative effect on the power of the tests arising from this two tailed tests, Chang (2004) proposed a modification:

$$\widehat{\alpha}_{GT} \cdot *1\{\widehat{\alpha}_{GT} \leq 0\} = \begin{pmatrix} \widehat{\alpha}_{GT,1}1\{\widehat{\alpha}_{GT,1} \leq 0\} \\ \vdots \\ \widehat{\alpha}_{GT,N}1\{\widehat{\alpha}_{GT,N} \leq 0\} \end{pmatrix}$$

$$\widehat{\alpha}_{OT} \cdot *1\{\widehat{\alpha}_{OT} \leq 0\} = \begin{pmatrix} \widehat{\alpha}_{OT,1}1\{\widehat{\alpha}_{OT,1} \leq 0\} \\ \vdots \\ \widehat{\alpha}_{OT,N}1\{\widehat{\alpha}_{OT,N} \leq 0\} \end{pmatrix}$$

Thus, based on the modified $\widehat{\alpha}_{GT}$ and $\widehat{\alpha}_{OT}$, Chang (2004) develops 2 other K-type tests respectively:

$$\begin{aligned} K_{GLS} &= \left(\widehat{\alpha}_{GT} \cdot *1\{\widehat{\alpha}_{GT} \leq 0\}\right)' \left(var(\widehat{\alpha}_{GT})\right)^{-1} \left(\widehat{\alpha}_{GT} \cdot *1\{\widehat{\alpha}_{GT} \leq 0\}\right) \\ &= \left(A_{GT} \cdot *1\{\widehat{\alpha}_{GT} \leq 0\}\right)' B_{GT}^{-1} \left(A_{GT} \cdot *1\{\widehat{\alpha}_{GT} \leq 0\}\right) \end{aligned} \tag{14}$$

$$\begin{aligned} K_{OLS} &= \left(\widehat{\alpha}_{OT} \cdot *1\{\widehat{\alpha}_{OT} \leq 0\}\right)' \left(var(\widehat{\alpha}_{OT})\right)^{-1} \left(\widehat{\alpha}_{OT} \cdot *1\{\widehat{\alpha}_{OT} \leq 0\}\right) \\ &= \left(A_{OT} \cdot *1\{\widehat{\alpha}_{OT} \leq 0\}\right)' B_{OT}^{-1} \left(A_{OT} \cdot *1\{\widehat{\alpha}_{OT} \leq 0\}\right) \end{aligned} \tag{15}$$

Since the K-type test statistics eliminate the problem of rejecting the null against explosive alternatives, they are expected to have more power than the F-type tests.

4.2 Bootstrap Panel Unit Root Tests

Chang (2004) shows that the limit distributions of the above-mentioned panel unit root tests depends on various nuisance parameters arising from the cross-sectional dependence among different sectors. As such, sieve bootstrap method is employed.

To construct the bootstrap tests, Chang (2004) generates the bootstrap samples (ε_{it}^*), (u_{it}^*) and (y_{it}^*). In generating (ε_{it}^*), Chang (2004) generates the N-dimensional vector $(\varepsilon_t^*) = (\varepsilon_{1t}^*, \ldots, \varepsilon_{Nt}^*)'$ by resampling from the distribution of the centered residual vectors $\left(\tilde{\varepsilon}_t^p - T^{-1}\sum_{t=1}^{T}\tilde{\varepsilon}_t^p\right)$ from eq. 13. This will make sure the cross-sectional dependence among units is preserved for (ε_{it}^*).

Then, (u_{it}^*) is generated recursively from (ε_{it}^*) as in eq. 16:

$$u_{it}^* = \widehat{\alpha}_{i,1}^{p_i}u_{i,t-1}^* + \ldots + \widehat{\alpha}_{i,p_i}^{p_i}u_{i,t-p_i}^* + \varepsilon_{it}^* \tag{16}$$

where $\left(\widehat{\alpha}_{i,1}^{p_i}, \ldots, \widehat{\alpha}_{i,p_i}^{p_i}\right)$ are the coefficient estimates from the fitted regression equation eq. 7. We use the first p_i value of (u_{it}) as initial values of (u_{it}^*).

Finally, (y_{it}^*) is obtained from:

$$y_{it}^* = y_{i0}^* + \sum_{k=1}^{t}u_{ik}^* \tag{17}$$

Following Chang (2004), we compute bootstrap test statistics $F^*_{OLS}, F^*_{GLS}, K^*_{OLS}, K^*_{GLS}$ using the estimated population parameter $\widehat{\Sigma}$.

To implement this bootstrap test, we compute $c^*_T(\lambda)$ such that $P\{F^*_{GLS} \leq c^*_T(\lambda)\} = \lambda$ for any prescribed size level λ. The bootstrap test F^*_{GLS} rejects the null of unit root hypothesis if $F^*_{GLS} > c^*_T(\lambda)$.

4.3 Bootstrap Panel Cointegration Estimation

For the cointegration parameter estimation, we use four different estimators. The first group of estimators are: homogeneous OLS estimator, and Mark and Sul (2003) panel Dynamic OLS estimator. This group of estimators share the common trait of homogeneity in parameter estimation. The second group of estimators are: Mark et al. (2005)'s DSUR estimator with heterogeneous estimators across sectors, and Park (1992)'s CCR estimation. This group of estimators relaxes the homogeneity restrictions of the first group and assumes heterogeneity among different sections.

When we obtain the estimation results of the cointegrating vector, we could obtain the correspondent residuals. We then implement Chang (2004)'s panel bootstrap unit root test upon these residuals to see if the two variables —saving and investment— are cointegrated or not.

5 Data and Estimation Results

5.1 Data

We've explained in Section 2.1 of the data we use. To briefly review that, total investment, government expenditure and revenue, and GDP series from 1978 to 2006 of 26 province-level administrative areas (provinces for short) in China are taken from China Economic Information Database and China Statistical Yearbook to form a balanced data panel. Saving rate is calculated from equation 1 in Section 2.1.

Further, to examine regional differences in capital mobility, we group the provinces into 9 regions based on their geographic vicinity, level of economic development, and the Chinese central government's regional groupings and estimate β for each region. These regions are (Beijing, Tianjin, Hebei), (Shanxi, Shandong), (Guangdong, Hainan, Fujian), (Shanghai, Jiangsu, Zhejiang), (Hubei, Hunan), (Guangxi, Guizhou, Yunan), (Liaoning, Jilin, Heilongjiang), (Anhui, Henan), and (Shaanxi, Gansu, Qinghai, Xinjiang, Inner Mongolia).

As in Section 2.2, we split the whole sample period into two subsamples, 1978-1992 and 1993-2006, to account for possible changes in the degree of capital mobility over time. Also, we break the total data down to private and government components to examine the degree of private capital mobility across China[12].

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[12] Detailed explanation of data could be found in Appendix 1.

5.2 Panel Unit Root Test Results

Before we present the cointegration estimation results for provincial investment and saving in China, we first report in Table 4 the results of Chang (2004)'s bootstrap unit root tests for dependent panels on these series. The F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are not significant for either investment or saving series under consideration. For example, for the total investment rate in the second row in Table 4, F_{OLS} statistics is 17.042, corresponding p-value is 1.000, which indicate that the null of unit root in the dependent panel cannot be rejected. The p-values for other test statistics are also high above the conventional significance level. This lends strong support that investment and saving rate at provincial level in China is non-stationary. This validates the subsequent cointegration estimation that we are going to proceed to.

5.3 Cointegration Estimation Results on Investment and Saving

We now turn to the cointegration estimation and testing results for the provincial and regional investment and saving rate in China. As we explained in Section 3, strong cointegration of saving and investment with a cointegration vector close to (1,-1) indicate low degree of capital mobility as provinces and regions are constrained by their own savings pool to fund their investment. When saving-retention rate is close to 0 (as opposed to the one close to 1 mentioned-above), and saving and investment are weakly cointegrated, or even not cointegrated at all, this indicates that capital mobility is high.

5.3.1 Total Investment and Saving

Table 5 reports the cointegration estimation and testing results for total investment and saving. In Table 5(a) and Table 5(b), the constraint of homogeneity of cointegrating vector is imposed. They report the cointegration test results when the residuals are obtained by OLS and by Panel Dynamic OLS (PDOLS) from Mark and Sul (2003) respectively. In Table 5(a), we observe from the third row that saving and investment is cointegrated with correlation coefficient 0.577 for the whole sample period. The bootstrap panel unit root test for dependent panel on the residuals shows that both F_{OLS} and K_{OLS} are 22.2268 with at least 5% significance level. F_{GLS} and K_{GLS} are significant at 1% level. This shows that investment and saving are strongly cointegrated across different regions in China, which reflects limited degree of capital mobility. In the 1st subperiod, saving-retention rate is 0.384 with F_{GLS}, K_{OLS} and K_{GLS} all significant at 5% level, while F_{OLS} is not significant at conventional level. For the 2nd subperiod, the estimated saving-retention rate is 0.601, with F_{GLS}, K_{OLS} and K_{GLS} significant at less than 5% level, and F_{OLS} not significant at conventional level. As both series are nonstationary, OLS standard errors are not valid for statistical significance reference.

Table 5(b) reports estimation and testing results from PDOLS. For the whole sample period, saving and investment are strongly cointegrated with correlation coefficient estimate at 0.607, which is statistically significant at 1% level. Bootstrap panel unit root test for dependent panel shows that all four test statistics: F_{OLS}, K_{OLS}, F_{GLS} and K_{GLS} are significant at 1% level, which strongly reject the null of no cointegration. In the 1st subperiod, saving and investment are still strongly cointegrated with the estimated coefficient at 0.448. However, in the 2nd subperiod, evidence for this cointegrating relation is weakened. The estimated saving-retention rate is 0.020 and is not significant at conventional level. And except for F_{GLS} and K_{GLS}, F_{OLS} and K_{OLS} are not significant at 5% level. This results show evidence that capital mobility across different regions in China improves over the two sample periods, as saving-retention rate declines from close to 0.5 to close to 0, and cointegration between saving and investment becomes weakened over time.

Table 5(c) presents results from Dynamic Seemingly Unrelated Regression (DSUR) from Mark et al. (2005), which assume heterogeneous cointegrating vector among different regions. The results show that for all the nine regions in China, saving and investment are strongly cointegrated with correlation estimation ranging from 0.303 for Guangdong, Fujian, Hainan (Pearl River Delta Region), and 1.276 for Shanghai, Jiangsu, Zhejiang (Yangzi River Delta Region).

Table 5(d) presents results from Canonical Cointegration Regression (CCR) from Park (1992) with heterogeneous cointegrating vector. The results show that except for Beijing, Tianjin, Hebei (Capital Region), and Shanghai, Jiangsu, Zhejiang(Yangzi River Delta Region), all other regions have statistically significant cointegration coefficient. And the bootstrap test shows strong cointegration relation between regional saving and investment.

In order to observe more clearly the time trend of saving investment correlation across regions as well as provinces, Figure 5(a) depicts the rolling-window OLS estimation of saving-retention rate with window length of 15 years. For $\widehat{\beta}^{OLS}$ for 26 provinces and 9 regions, we observe a downward trend after around 1994. However, $\widehat{\beta}^{OLS}$ for 9 regions shows an upward trend after 2000, while $\widehat{\beta}^{OLS}$ for 26 provinces remains relatively flat.

Figure 5(b) depicts the rolling-window PDOLS estimation of saving-retention rate with window length of 15 years. It is clear that for $\widehat{\beta}^{PDOLS}$ for both 26 provinces and 9 regions, the estimates generally exhibit a downward trend over the period. This provides evidence that regional and provincial capital mobility in China is improving over time. This lends some support that economic reform implemented by the government is effective in forming an integrated national capital market.

To sum up, results reported in Table 5 provide strong evidence that provincial saving and investment in China are cointegrated over the sample period 1978-2006, and the saving-retention rate is significantly different from 0. However, from the 1st subperiod to the 2nd subperiod, this cointegrating relation has been significantly weakened. And the estimated saving investment correlation declines from around 0.5 to nearly 0 (PDOLS). These results show that provincial capital mobility in China is improving over the sample period and national capital market is becoming more integrated.

5.3.2 Private Investment and Saving

We turn next to the cointegration test results for private saving and investment in China.

Table 6 reports the cointegration estimation and test results for private saving and investment, where government saving and investment are excluded. We report estimation results with homogeneous cointegrating vector in Table 6(a) and Table 6(b), and estimation results with heterogenous cointegrating vector in Table 6(c) and Table 6(d). In Table 6(a) and Table 6(b), bootstrap cointegration test statistics are reported with the application of OLS and PDOLS estimation methods respectively.

In Table 6(a), $\widehat{\beta}^{OLS}$ is 0.937 over the sample period with all four bootstrap test statistics significant at 5% level. This is higher than the saving-retention rate for the overall saving and investment reported in Table 5(a). This provides strong evidence that degree of capital mobility for private sector is low over the whole sample. And like the results we have shown in Section 2.2, government components tend to bias down the estimated saving-retention rate β.

For the 1st subperiod in Table 6(a), $\widehat{\beta}^{OLS}$ is 0.868. The bootstrap test statistics F_{GLS} and K_{GLS} are significant at 1% level, K_{OLS} is marginally significant at 10% level. This result provides reasonable evidence that in the 1st subperiod from 1978 to 1992, private sector capital mobility is low and private capital market is yet to be integrated across regions in China. For the 2nd subperiod 1993-2006, the estimated saving-retention rate declines from 1st subperiod's 0.868 to 0.621. The cointegration test statistics K_{OLS} and K_{GLS} are significant at 10% level, while the other two are not significant at all. This provides further evidence that in the 2nd subperiod, saving and investment are not as strongly cointegrated as they are in the 1st subperiod. With this and the decrease of $\widehat{\beta}^{OLS}$ from 1st to 2nd subperiod, it is reasonable for us to conclude that degree of capital mobility becomes higher in the 2nd subperiod for private sector.

In Table 6(b), we report cointegration test results with PDOLS estimation methods.

For the whole sample period, $\widehat{\beta}^{PDOLS}$ is 0.968 and is significant under both parametric and non parametric standard errors. All four bootstrap test statistics are significant at 1% level. This corresponds to what we obtain in row 2 of Table 6(b). It provides further support that private sector capital mobility is limited over the whole sample period from 1978-2006. For the 1st subperiod, the estimated saving-retention rate is 0.883 and is statistically significant. Bootstrap test shows that F_{GLS} and K_{GLS} are marginally significant at 10% level, while F_{OLS} and K_{OLS} are not significant. In the 2nd subperiod, the estimated saving-retention rate declines dramatically to 0.213 and is not statistically significant at conventional level. The bootstrap test statistics are significant at 5% level except for F_{OLS}, which is marginally significant at 10% level. This lends reasonable support to the conclusion we obtain from Table 6(a) that private capital mobility is improving from the 1st to the 2nd subperiod.

In Table 6(c) and Table 6(d), we report the estimation and cointegration bootstrap test results with heterogeneous cointegrating vector. In Table 6(c) we report the results from applying DSUR, and in Table 6(d) we report the results from using CCR. Both table shows strong cointegrating relation between regional saving and investment across sample periods.

In order to observe the time trend of the private saving and investment correlation over the sample period, we depict rolling-window estimation of $\widehat{\beta}$ with window length of 15 years in Figure 6.

In Figure 6(a), $\widehat{\beta}^{OLS}$s for both 26 provinces and 9 regions are depicted.. It shows a clear downward trend from around 1995 onward. Figure 6(b) depicts the $\widehat{\beta}^{PDOLS}$ for both 26 provinces and 9 regions. It also shows a clear downward trend around 1995. This further confirms our previous conclusion that the private capital market is becoming more integrated in the last decade.

To sum up, the results of Table 6 and Figure 6 provide strong evidence to show that private saving-retention rate declines for the past two decades. Thus, capital mobility for private sector is improving. When we compare this results with what we obtain for private investment and saving in Section 2.2 from cross-sectional time-averaged data, they are generally consistent in showing that private saving-retention rate declines from the 1st to the 2nd subperiod. Further, Figure 6 and Figure 4 show similar downward trend for private sector saving-retention rate from 1992 to 2006.

5.3.3 Comparison of Total and Private capital mobility across Time and Regions

Figure 7(a) and Figure 7(b) plot rolling window estimation of $\widehat{\beta}^{OLS}$ for total and private investment and saving together for both 9 regions and 26 provinces. In a similar way Figure 8(a) and Figure 8(b) plots rolling window estimation of $\widehat{\beta}^{PDOLS}$ for total and private investment and saving together for both 9 regions and 26 provinces.

For all the four figures mentioned above, we observe that $\widehat{\beta}$ exhibits downward trend for private sectors. Further, these plots reveal that most of the improvement in total capital mobility is driven by greater mobility in private capital sector. The discrepancy between private $\widehat{\beta}$ and total $\widehat{\beta}$ is likely due to the effects of government fiscal and redistributive policies that are accounted for in Section 2. We also observe that as time goes, the discrepancy between Total and Private $\widehat{\beta}$ becomes smaller and the two saving-retention rates tend to converge at the end of the sample period. This may reflect that government fiscal and redistribution policy now only have limited role to play in promoting regional and provincial capital mobility across China.

In Table 7 we group the estimation of saving-retention rate from DSUR and CCR for Total and Private together and display them side-by-side for comparison. It is clearly shown that for most regions (except for region 1. (Beijing, Tianjin and Hebei) and region 4. (Shanghai, Jiangsu and Zhejiang), private $\widehat{\beta}$ tends to be larger than total $\widehat{\beta}$, which substantiates what we obtained from Figure 7 and Figure 8. Furthermore, it is also clearly shown that there are significant differences among the 9 regions, particularly between the more developed regions (the first four regions in Table 7) and the less developed ones (the last five regions). In the full sample, the private saving-retention rate is 0.500 (DSUR) and 0.519 (CCR) for Region 7.(Guangdong, Hainan, Fujian) while that for Region 6.(Hubei, Hunan) is 1.525 (DSUR) and 1.874 (CCR). Such large differences also arise in estimates based on the total saving and investment data. This highlights the importance of taking into account regional differences.

Refer to Table 6(d) for private sector, for the more developed regions, the saving retention rate falls sharply from the first to the second period. For example, the estimate based on private data for the region 2.(Shanxi, Shandong) is 0.888 and significant at 1% level in the first period; it decreases to 0.276 and no longer is statistically different from zero in the second period. Similar pattern is observed for the other three developed regions 1.(Beijing, Tianjing, Hebei), 4.(Shanghai, Jiangsu, Zhejiang), and 7.(Guangdong, Hainan, Fujian) except that the saving-retention rate for the last region is marginally significant at 1% level.

Figure 9(a) presents the rolling PDOLS estimates of the total and private saving-retention rate for these four developed regions 1, 2, 4, 7. Private capital mobility improves right from 1992, the start of our rolling estimation time window. In the 2000s, the private capital market among these four regions has a comparable level of integration as those in Canada during 1961-1989 and Germany during 1970-1987 based on the results in Thomas (1993). The gap between private and total capital mobility narrows over time until the early 2000s, after which it appears that most of the improvement in the total capita mobility is driven by greater mobility in private capital. Our results is different from Boyreau-Debray and Wei (2004) and Li (2010) in that we do observe a significant improvement in cross province and cross regional capital mobility in China, while these two studies didn't.

In Figure 9(b), the gap between private and total capital mobility for the less developed regions is greater than that for more developed regions (Figure 9(a)). Poor regions tend to receive larger transfers (as a share of their GDP) from the central government and have high public investment rate, resulting in a sizable difference between private and total saving-investment correlations. It appears that government fiscal and redistributive policies induce greater capital mobility for regions. Both private and total capital mobility in the five less developed regions (Region 3, 5, 6, 8, 9) do not exhibit any improvement until the early 2000s. The private saving retention rate begins to decrease in 2002 while total saving-retention rate does so in 2004. The gap between the two essentially disappears after 2004. Overall, private capital market in the less developed regions appears to be more integrated in the 2000s than in the 1990s although the improvement is less pronounced than that in the more developed regions.

6 Conclusion

This paper examines the degree of capital mobility at provincial and regional level in China from 1978 to 2006, during which China started its market-oriented economic reform and transformed itself from a central-planning economy to more or less a market economy.

First, from a simple FH (1980) regression on cross-sectional time averaged data of provincial level saving and investment, we find considerable improvement in private capital mobility across China from the 1st subperiod 1978-1992 to the 2nd subperiod 1993-2006.

Secondly, we measure capital mobility in China in a cointegration setting in FH(1980) framework. The results show that total saving and investment across provinces and regions are strongly cointegrated for most of the time with relatively high saving-retention rate. From the 1st to the 2nd subperiod, the estimated saving-retention rate decreases, which shows that degree of capital mobility is increasing over time. For private saving and investment, they are strongly correlated over the whole sample period with cointegrating coefficient close to 1. From the 1st to the 2nd subperiod, saving-retention rate declines significantly for private sector. When comparing the estimates of private sector with the total one, we observe that the saving-retention rate for private sector is higher than the total one, which shows that government behavior in saving and investment may have alleviated the barrier of capital mobility and to some extend facilitated the capital mobility across China.

Finally, we compare degree of private capital mobility between more developed regions in China and less developed regions in China across time. China's economic growth has been driven mainly by rapid development along the export-oriented coastal regions, contributing to a widening economic gap across regions in China. Such a gap represents a serious obstacle to the objectives of promoting a more balanced and domestic-driven growth. Our results show that there are significant regional differences in the level of private capital market integration. Private capital mobility in the more developed regions shows persistent and significant improvement since at least early 1990s, and in the early 2000s becomes comparable to that in some developed countries in the 1970s and 1980s. In the less developed regions, government public investment and transfers seems to promote total capital mobility. Private capital mobility in these regions only improves in the 2000s and appears to be below the level achieved in the more developed regions. Government policies in 2000 aimed at rebalancing the economic development landscape may have fostered capital market integration in China although there are other possible contributing developments such as the banking reform in 2000 and WTO accession in 2001.

Appendix 1: Data Explanation

Table A1 listed the 31 provinces in mainland China from which we obtain provincial level data on saving, investment, gross domestic products, government expenditure, private consumption and population, etc. Among them, 26 provinces have balanced data over the whole sample period 1978-2006.

To obtain government investment and saving data, we have the following equation:

$$S \equiv GDP - C_p - G = (GDP - T - C_p) + (T - G) = S_p + S_g \tag{A1}$$

Here S, S_p, and S_g stand for total saving, private sector saving and government saving respectively. In practice, government taxation and purchase are proxied by government revenue and government expenditure at provincial level according to data availability. We shall emphasize that the above-mentioned data only include local government investment and saving while no central government effect has been considered. However, central government plays quite a non-negligible role in saving and investment at provincial level in China, as it is still an economy with an influential and powerful central government. It makes all provinces subject to common policy shocks. One of the most important one is the taxation distribution reform in 1994. This reform states that local government submits a substantial part of their revenue to central government. Central government then redistributes part of this across provinces, which is the transfer system between central and local governments. If we ignore this transfer and adopt only the local government revenue and expenditure, it will leads to the omission of a substantial part of local government revenue accordingly. As a result, we will subtract local government transfers to central government and add the central government transfers to local government to adjust local government revenue.

Figure A1 shows the necessity for this adjustment. Before we adjust the transfer between local and central government, overall budget surplus for 30 provinces in China over 1978-2006 runs to persistent deficit after 1994. When we make the adjustment, local government roughly makes balanced budget till 2006. As for investment, total investment is comprised of fixed capital formation and change of inventory. It is a little bit tricky to obtain local government investment data because statistical year books at both national and provincial level either do not directly provide this data, or do not provide them in a complete way. As a result, we take the item under local budgetary expenditure called "Expenditure for capital construction" as a proxy for government investment. We then subtract this item from the overall investment to obtain private investment series.

In order to evaluate capital mobility across regions, Table A2 show the way we group provinces into regions. We group them according to geographical vicinity, level of economic development, as well as central government's economic region grouping.

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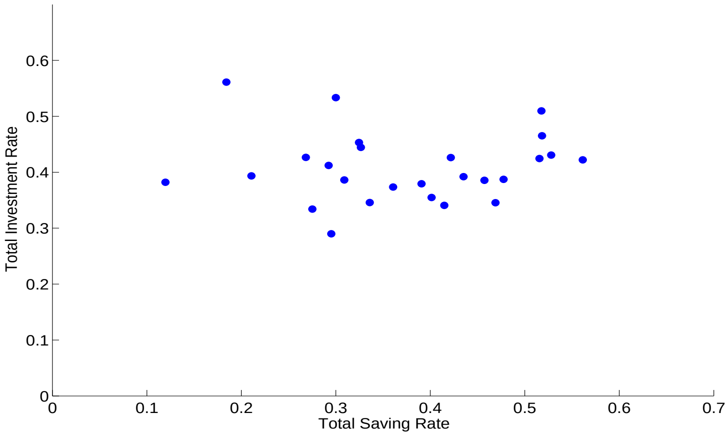
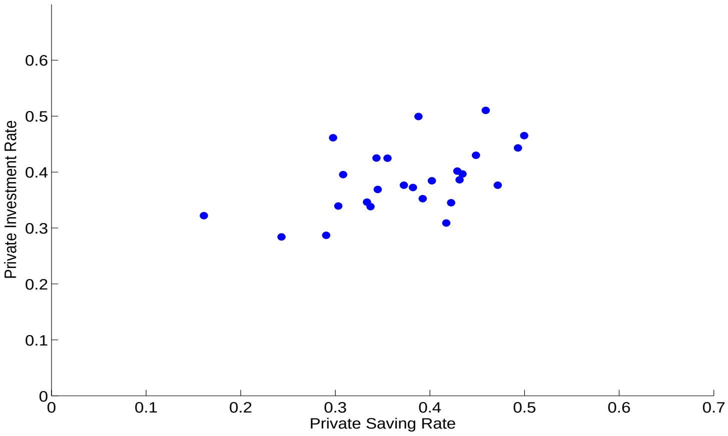
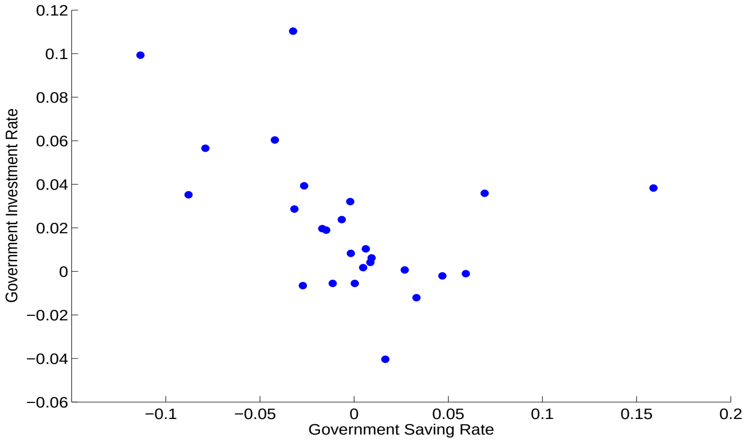
Figure 1: Scatter Plot of the Investment and Saving Rate for the Whole Sample Period



(a) Total Investment vs. Total Saving

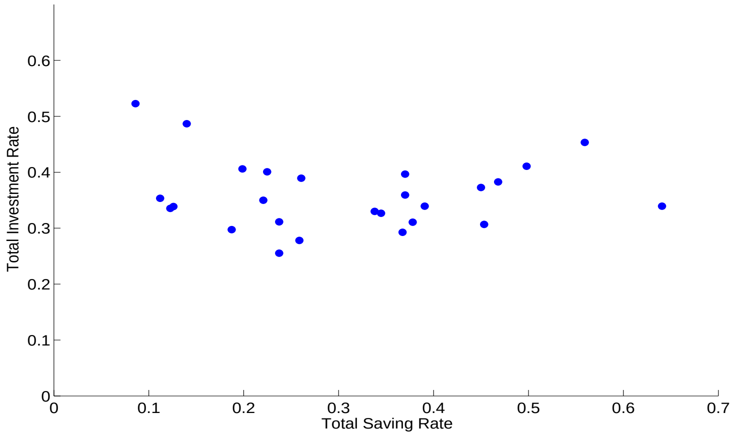


(b) Private Investment vs. Private Saving

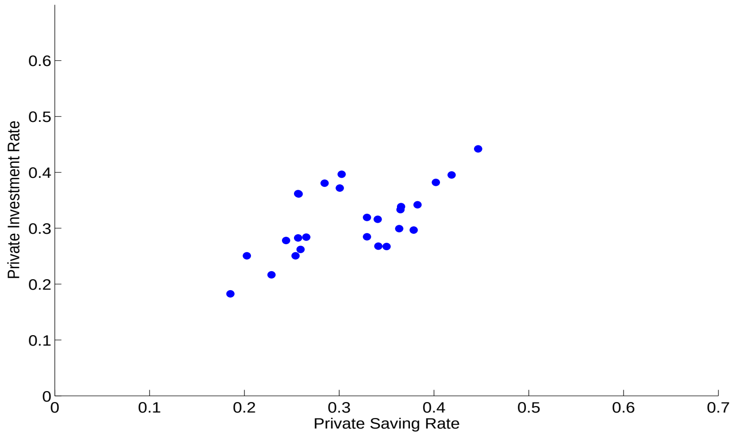


(c) Government Investment vs. Government Saving

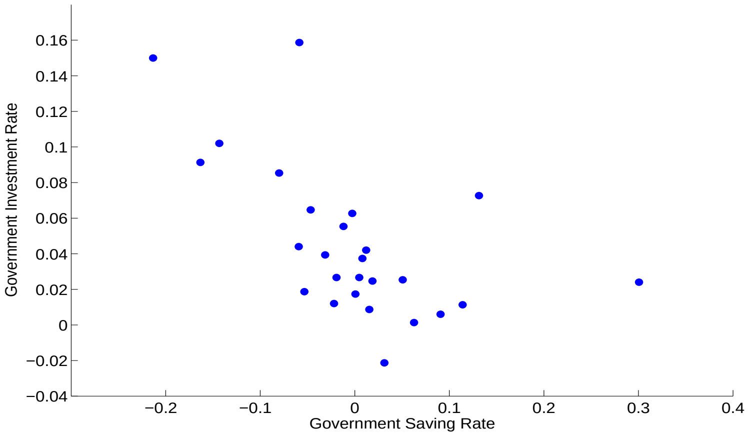
Figure 2: Scatter Plot of the Investment and Saving Rate for the 1st sub period



(a) Total Investment vs. Total Saving

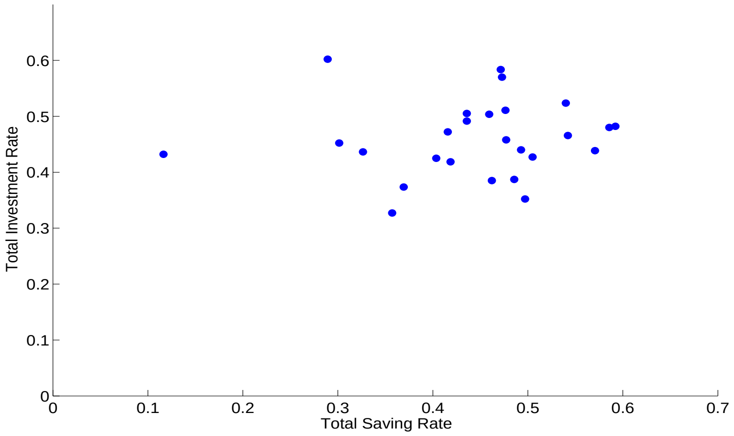


(b) Private Investment vs. Private Saving

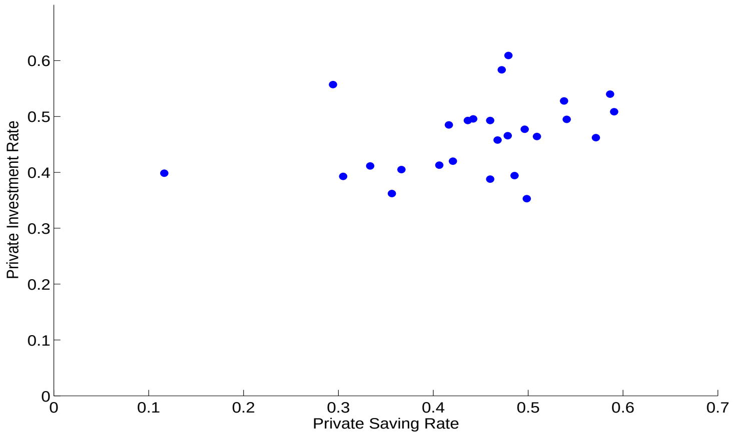


(c) Government Investment vs. Government Saving

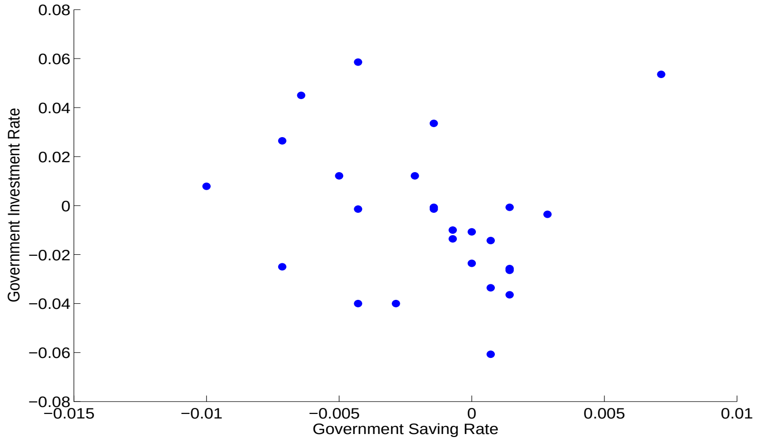
Figure 3: Scatter Plot of the Investment and Saving Rate for the 2nd sub period



(a) Total Investment vs. Total Saving

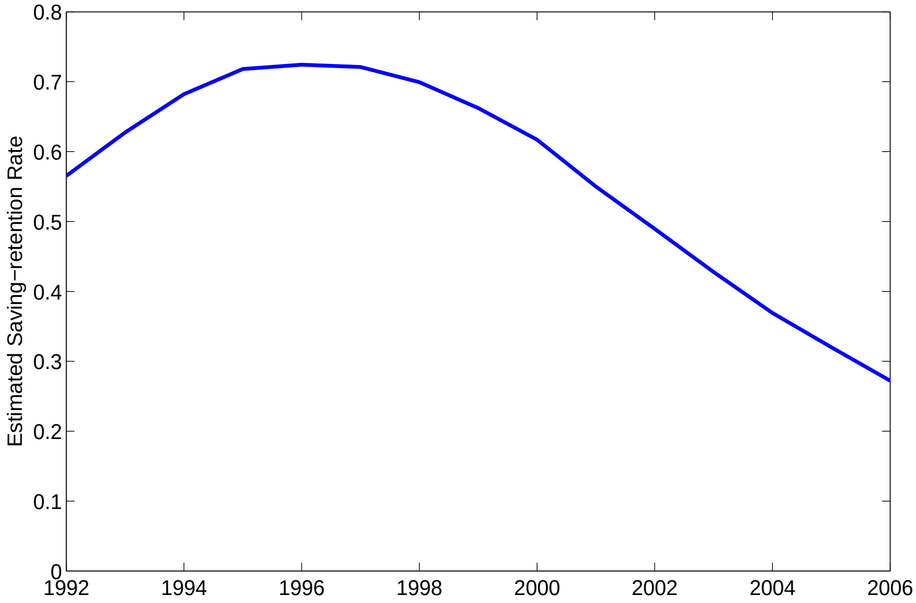


(b) Private Investment vs. Private Saving



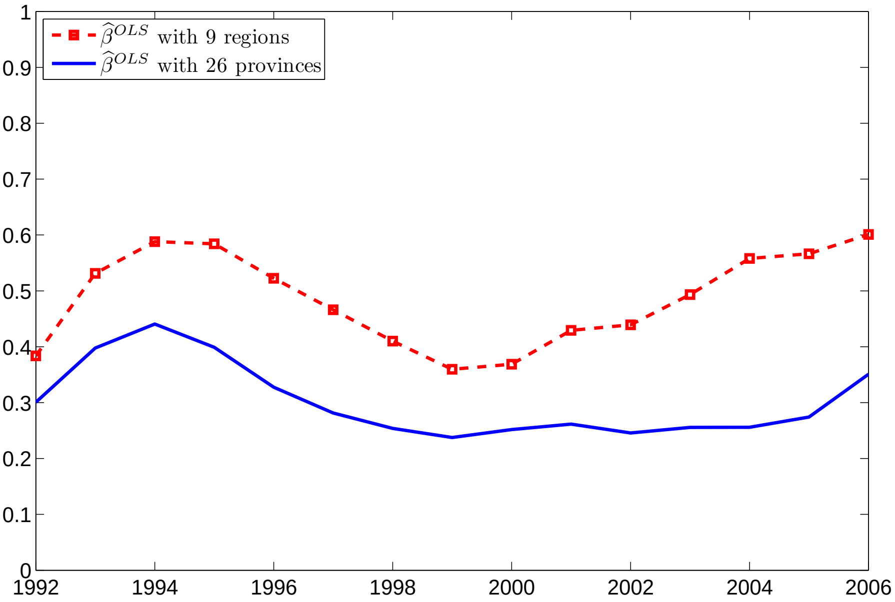
(c) Government Investment vs. Government Saving

Figure 4: Rolling Window Estimation of the Saving-retention Rate ($\widehat{\beta}$)

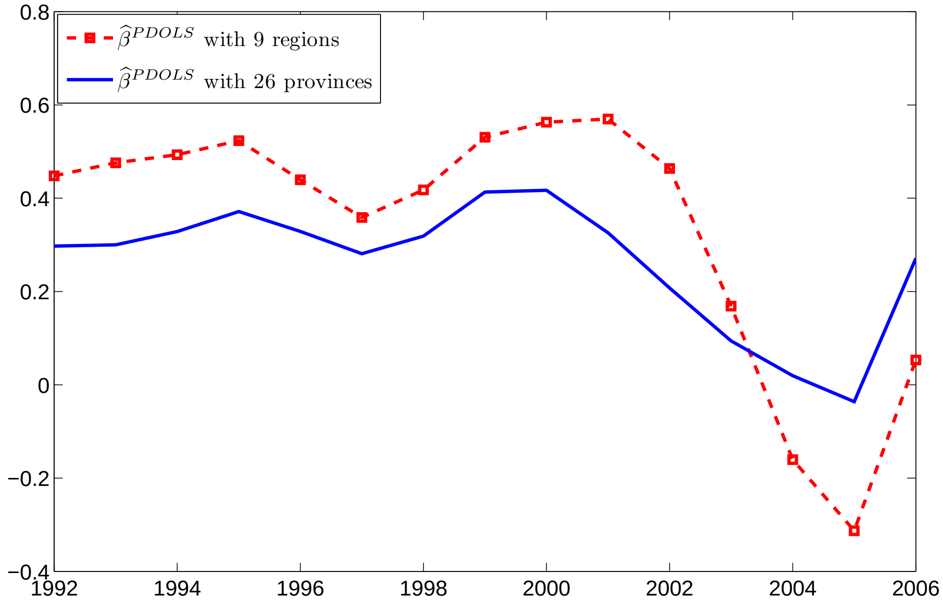


The window size for the rolling window estimation is 15 years.

Figure 5: Rolling Window Estimation of β for Total Investment and Saving



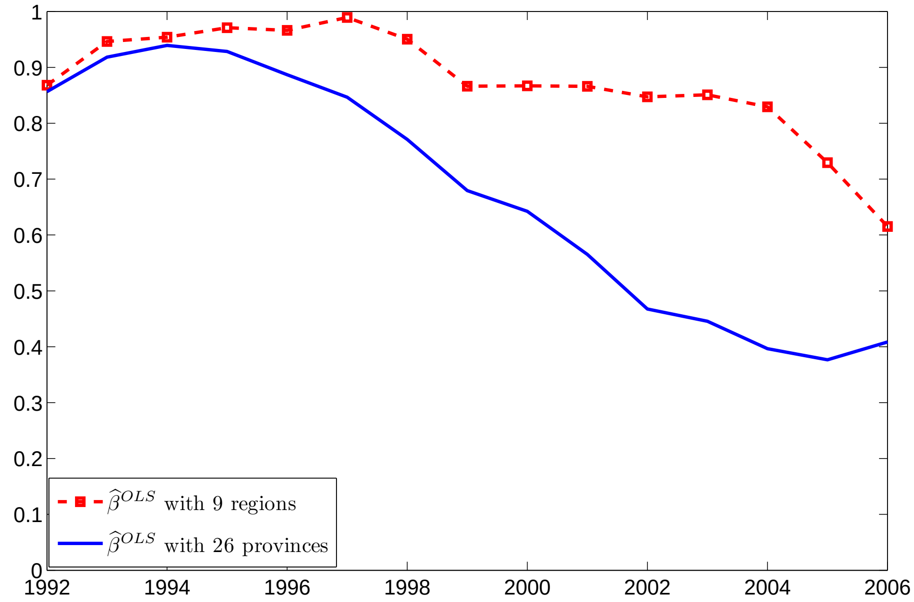
(a) Rolling Window Estimation of $\widehat{\beta}^{OLS}$



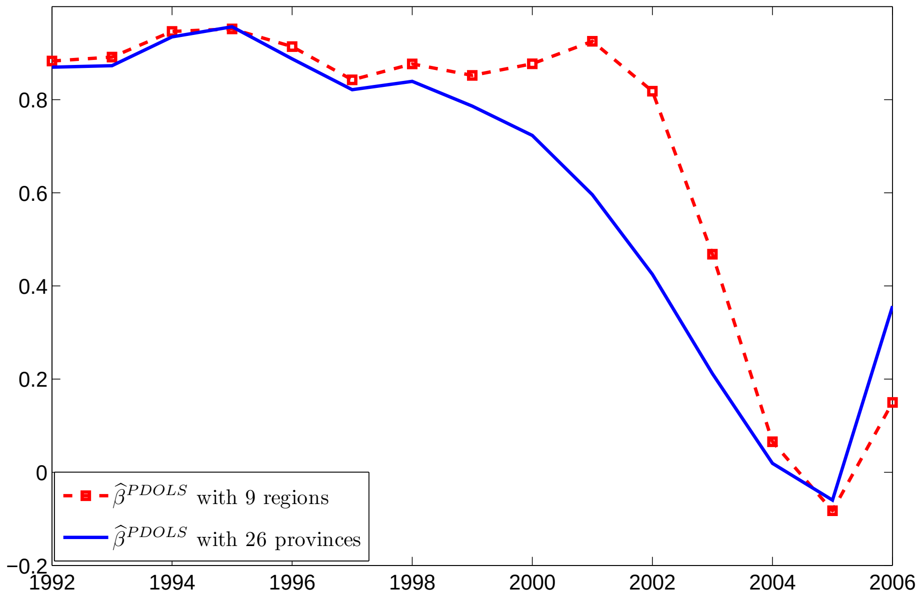
(b) Rolling Window Estimation of $\widehat{\beta}^{PDOLS}$

The window size for the rolling window estimation is 15 years.

Figure 6: Rolling Window Estimation of β for Private Investment and Saving



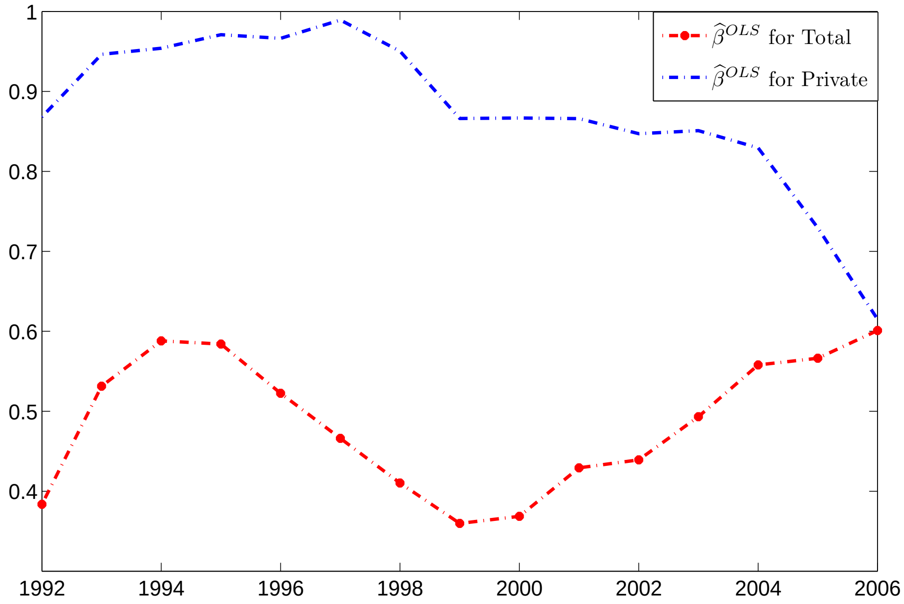
(a) Rolling Window Estimation of $\widehat{\beta}^{OLS}$



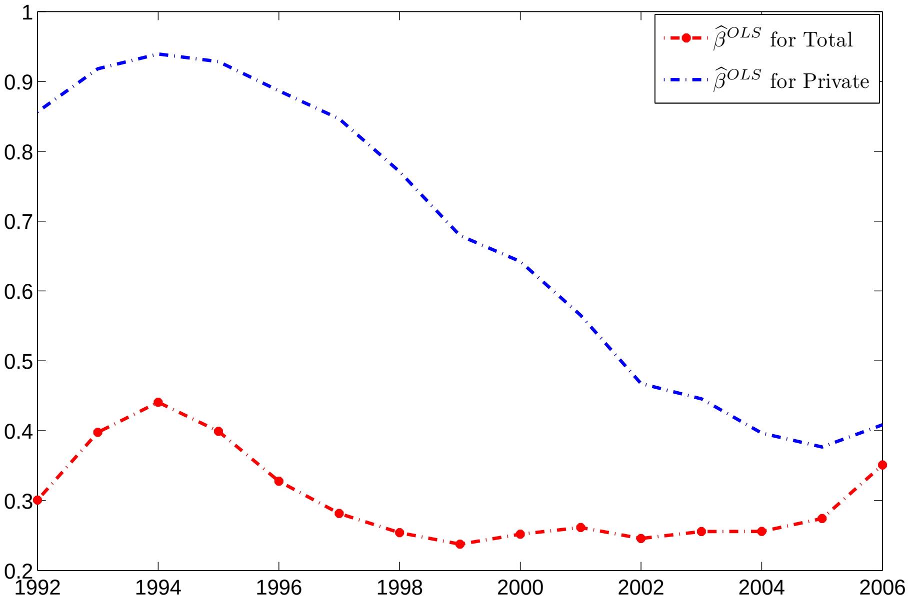
(b) Rolling Window Estimation of $\widehat{\beta}^{PDOLS}$

The window size for the rolling window estimation is 15 years.

Figure 7: Comparison of $\widehat{\beta}^{OLS}$ for Total and Private Sector



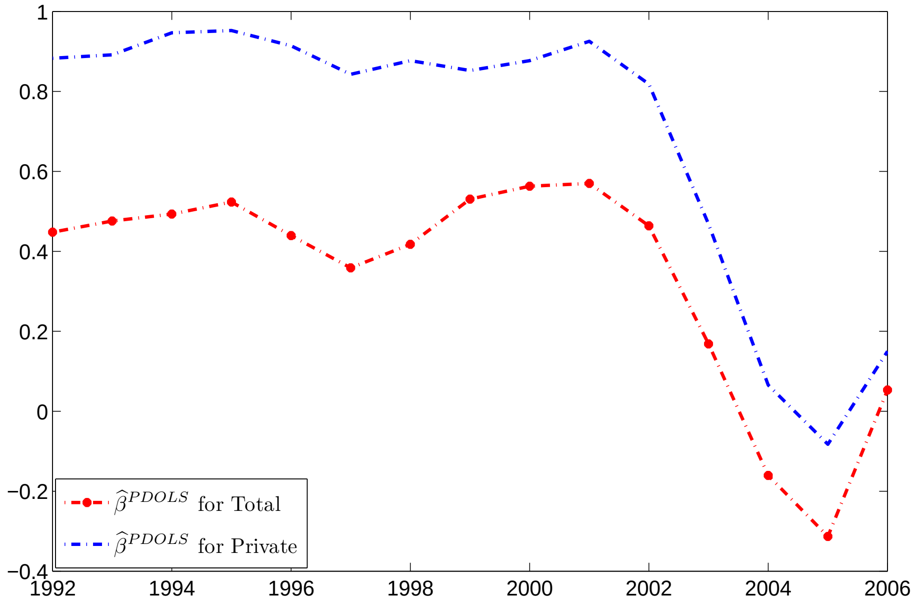
(a) $\widehat{\beta}^{OLS}$ for 9 regions



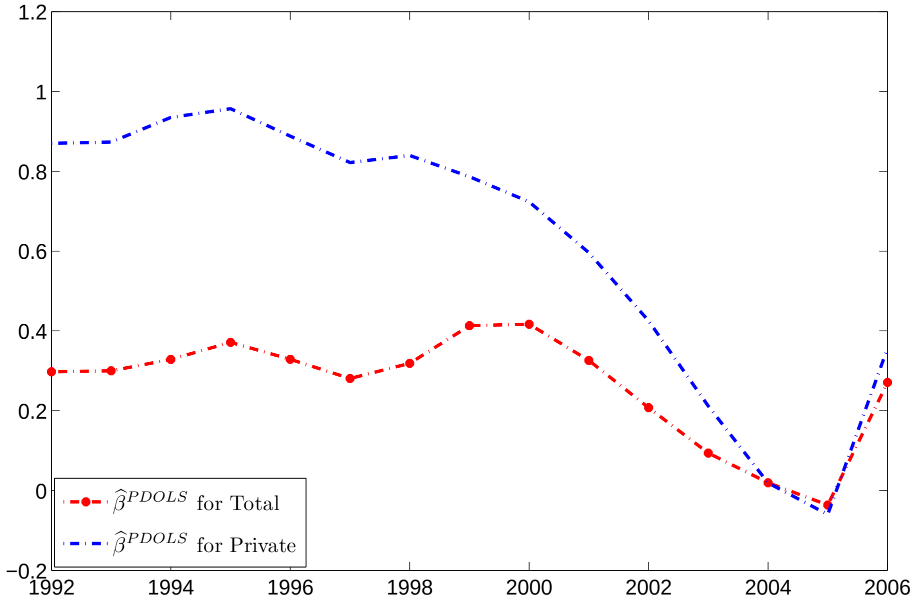
(b) $\widehat{\beta}^{OLS}$ for 26 provinces

The window size for the rolling window estimation is 15 years.

Figure 8: Comparison of $\widehat{\beta}^{PDOLS}$ for Total and Private Sector



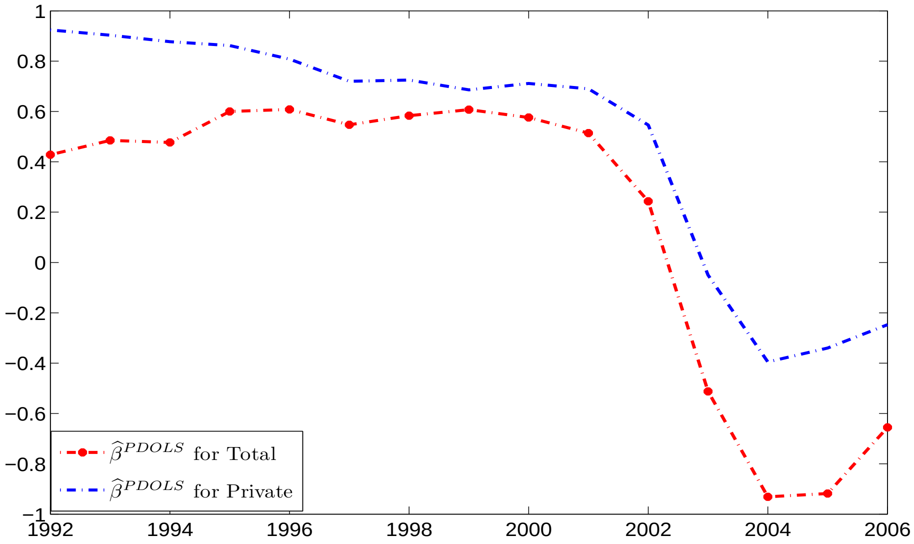
(a) $\widehat{\beta}^{PDOLS}$ for 9 regions



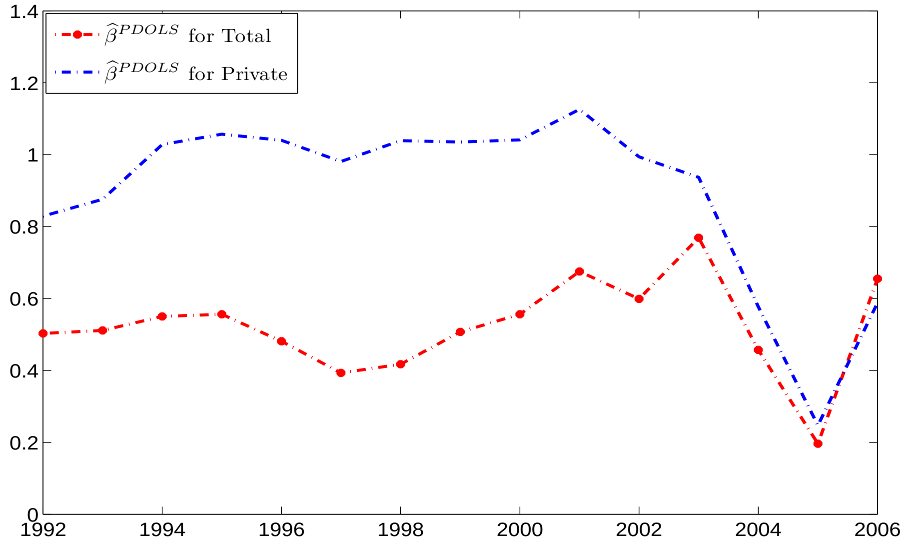
(b) $\widehat{\beta}^{PDOLS}$ for 26 provinces

The window size for the rolling window estimation is 15 years.

Figure 9: Comparison of $\widehat{\beta}^{PDOLS}$ for Total and Private Sector for Developed and Less Developed Regions



(a) $\widehat{\beta}^{PDOLS}$ for Developed Regions



(b) $\widehat{\beta}^{PDOLS}$ for Less Developed Regions

The window size for the rolling window estimation is 15 years.

Figure A1: Sum of Provincial Budget Balances (Billion Yuan)

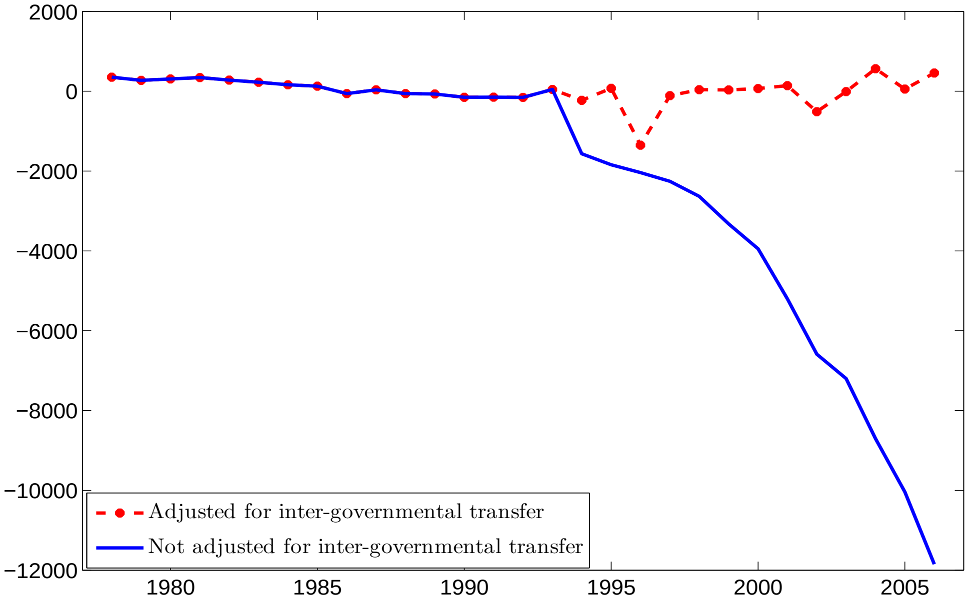


Table 1: Summary of Studies under the Framework of FH (1980)

(a) A Summary of the Studies on the Estimation of the Saving Retention Rates Using Provincial Data of China

Studies	Data	Estimation method	Point estimates of the saving retention rate (standard deviations in parentheses)			
Boyreau-Debray and Wei (2004)	Provincial data of China over 1952-2001	OLS	1952-1977 0.534 (0.062)	1978-2001 0.525 (0.091)	1978-1989 0.300 (0.102)	1990-2001 0.599 (0.084)
Li (2010)	Provincial data of China over 1978-2006	Panel cointegration	Fixed effects 0.6094 (0.0354)	Random effects 0.5761 (0347)	Mean group 0.6009 (0.1255)	MG-SUR 0.6013 (0.1248)

(b) A Summary of the Studies on the Estimation of the Saving Retention Rates Using Panel Data of the OECD Countries

Studies	Country and time coverage	Estimation method	Point estimates of the saving retention rate (standard deviations in parentheses)		
Krol (1996)	21 OECD countries over 1962-1990	OLS (Lux IN)	1962-1990 0.20 (0.03)	1975-1990 0.16 (0.04)	
Jansen (2000)	24 OECD countries over 1960-1994		1962-90	1960-94	1975-94
		OLS (Lux EX)	0.568 (t=12.9)	0.602 (t=19.0)	0.518 (t=12.3)
		OLS (Lux IN)	0.227 (t=7.47)	0.362 (t=13.8)	N.A.
Coiteux and Olivier (2000)	22 OECD countries over 1960-1995	OLS (Lux IN)	0.63(0.04)		
Ho (2002)	20 OECD countries over 1961-1997		Lux IN	Lux EX	
		DOLS	0.4739 (0.0387)	0.4739 (0.0387)	
		FMOLS	0.8426 (0.0345)	0.8367 (0.0355)	

1. "Lux IN" means Luxemburg is included in the regression. "Lux EX" means Luxemburg is excluded from the regression.
2. In Jansen (2000), the t statistics are reported instead of the standard errors.

(c) A Summary of the Studies on the Estimation of the Saving Retention Rates Using Intra-national Data of the OECD Countries

Studies	Country and time coverage	Estimation method	Point estimates of the saving retention rate (standard deviations in parentheses)		
Bayoumi and Rose (1993)	Regional data of UK over 1971-1985	OLS	1971-75 -0.48 (0.16)	1976-1980 0.24 (0.21)	1981-85 0.01 (0.14)
Thomas (1993)	Regional data of UK over 1971-1987	OLS	Total IR and SR -0.5596 (t=-4.2952)	Private IR and SR 0.3299 (t=2.6047)	
	Regional data of Canada over 1961-1989	OLS	-0.1015 (t=-4.2472)	-0.0416 (t=-0.6164)	
Dekle (1996)	Japan prefecture data over 1975-1988	OLS	Total IR and SR -0.36 (t=-4.52)	Private IR and SR 0.13 (t=1.59)	

1. "IR" and "SR" stand for "investment" and "saving" respectively.
2. In Thomas (1993) and Dekle (1996), the t statistics are reported instead of the standard errors.

Table 2: OLS Estimation of the Saving Retention Rate Using Provincial Data of China

Sample period	1978-2006 (whole sample)	1978-1992 (1st subperiod)	1993-2006 (2nd subperiod)
Panel A Dependent variable: Total investment rate			
Constant	0.406 (0.000)	0.370 (0.000)	0.433 (0.000)
Total saving rate	0.005 (0.962)	-0.036 (0.685)	0.059 (0.655)
R-squared	0.000	0.007	0.008
Panel B Dependent variable: Private investment rate			
Constant	0.241 (0.000)	0.138 (0.006)	0.358 (0.000)
Private saving rate	0.386 (0.007)***	0.565 (0.001)***	0.238 (0.065)*
R-squared	0.264	0.394	0.135
Panel C Dependent variable: Government investment rate			
Constant	0.021 (0.002)	0.045 (0.000)	-0.007 (0.307)
Government saving rate	-0.266 (0.031)**	-0.253 (0.001)***	-1.368 (0.407)
R-squared	0.180	0.339	0.029

1. Estimated coefficients are followed by p-values in the parentheses.
2. "*", "**" and "***" indicate siginificance of the slope coefficient at 10%, 5% and 1% level respecitively.

Table 3: Instrumental Variable Estimation of the Saving Retention Rate Using Provincial Data of China

Sample period	1978-2006 (whole sample)	1978-1992 (1st subperiod)	1993-2006 (2nd subperiod)
Panel A Dependent variable: Total investment rate			
Constant	0.342 (0.000)	0.333 (0.000)	0.259 (0.046)
Total saving rate	0.176 (0.152)	0.086 (0.380)	0.454 (0.108)
R-squared	-0.010	-0.074	-0.364
Panel B Dependent variable: Private investment rate			
Constant	0.199 (0.023)	0.138 (0.032)	0.264 (0.026)
Private saving rate	0.500 (0.029)**	0.566 (0.004)***	0.449 (0.091)*
R-squared	0.241	0.394	0.029
Panel C Dependent variable: Total saving rate			
Constant	0.250 (0.000)	0.145 (0.000)	0.370 (0.000)
Per capita GDP	0.0002 (0.000)***	0.0014 (0.000)***	0.0001 (0.026)*
R-squared	0.509	0.571	0.211
Panel D Dependent variable: Private saving rate			
Constant	0.315 (0.000)	0.263 (0.000)	0.375 (0.000)
Per capita GDP	0.0001 (0.013)**	0.0004 (0.035)**	0.0001 (0.035)*
R-squared	0.259	0.232	0.194

1. Estimated coefficients are followed by p-values in the parentheses.
2. "*", "**" and "***" indicate siginificance of the slope coefficient at 10%, 5% and 1% level respecitively.

Table 4: Bootstrap Panel Unit Root Test

	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
$Invsr$	17.0142	62.4478	11.9618	62.4478
	(1.000)	(1.000)	(0.904)	(0.986)
$Invsrp$	21.5615	74.9918	18.3286	73.6406
	(0.998)	(1.000)	(0.821)	(0.998)
$Savr$	28.8557	104.4250	10.2490	33.0329
	(0.985)	(1.000)	(0.961)	(1.000)
$Savrp$	29.1502	19.9236	1.9972	27.0084
	(0.973)	(1.000)	(0.999)	(0.999)

1. $Invsr$: Total innvestment rate. $Savr$:Total saving rate.
2. $Invsrp$: Private innvestment rate. $Savrp$: Private saving rate.
3. Test statistics are followed by p-values in parentheses. "*", "**" and "***" denote significance at 10%, 5% and 1% level respectively.
4. F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). The null hypothesis is that the data series is integrated of order 1.

Table 5: Regressions of Total Investments on Total Savings at Regional Level

(a) Cointegration Bootstrap with Homogeneous Cointegrating Vector

$$y_{it} = \alpha_i + \beta \cdot x_{it} + u_{it}$$

OLS with Homogeneous Cointegrating Vector					
Full sample	$\widehat{\beta}^{OLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
1978-2006	0.577	22.2268	31.8411	22.2268	31.8411
		(0.011)**	(0.000)***	(0.000)***	(0.000)***
1st subperiod	$\widehat{\beta}^{OLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
1978-1992	0.384	12.1641	32.9770	12.1641	32.9770
		(0.335)	(0.000)***	(0.047)**	(0.000)***
2nd subperiod	$\widehat{\beta}^{OLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
1993-2006	0.601	11.9084	21.4509	11.9084	21.4509
		(0.436)	(0.008)***	(0.011)**	(0.003)***

1.”*”,”**” and ”***” denote significance at 10%, 5% and 1% level respectively.
2.Since the OLS standard errors are not valid for conducting inference, we do not report them here.
3.F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). It test the null hypothesis that the series of residuals obtained from estimating the saving and investment cointegrating equation follows a unit root process. A rejection implies the investment and saving series are cointegrated.
4. For the cointegration test (F and K), p-values are in parentheses.
5. Regressions are performed on 9 regions grouped from 26 provinces.

(b) Cointegration Bootstrap with Homogeneous Cointegrating Vector

$$y_{it} = \alpha_i + \beta \cdot x_{it} + u_{it}$$

PDOLS with Homogeneous Cointegrating Vector					
Full sample	$\widehat{\beta}^{PDOLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
0.607	0.607	26.3654	34.4840	26.3654	34.4840
(Param.s.e=0.090)	(NonParam.s.e=0.081)	(0.003)***	(0.010)***	(0.000)***	(0.000)***
1st subperiod	$\widehat{\beta}^{PDOLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
0.448	0.448	19.5209	45.3515	19.5209	45.3515
(Param.s.e=0.341)	(NonParam.s.e=0.136)	(0.015)**	(0.000)***	(0.003)***	(0.000)***
2nd subperiod	$\widehat{\beta}^{PDOLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
0.020	0.020	19.0925	38.0505	19.0925	38.0505
(Param.s.e=1.118)	(NonParam.s.e=0.239)	(0.140)	(0.000)***	(0.073)*	(0.000)***

1. ”*”,”**” and ”***” denote significance at 10%, 5% and 1% level respectively.
2.The homogenous saving-investment parameter is estimated by panel dynamic OLS method in Mark and Sul (2003).
3.Estimated coefficients are followed by standard errors. ”Param.s.e.” and ”NonParam.s.e.” stand for the parametric and nonparametric standard errors respectively.
4.F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). It test the null hypothesis that the series of residuals obtained from estimating the saving and investment cointegrating equation follows a unit root process. A rejection implies the investment and saving series are cointegrated.
5.For the cointegration test (F and K), p-values are in parentheses.
6. Regressions are performed on 9 regions grouped from 26 provinces.
7. Full sample spans from 1978 to 2006. 1st subperiod spans from 1978 to 1992, and 2nd subperiod from 1993 to 2006.

(c) Cointegration Bootstrap with Heterogeneous Cointegrating Vector

$$y_{it} = \alpha_i + \beta \cdot x_{it} + u_{it}$$

DSUR with Heterogeneous Cointegrating Vector (Full sample 1978-2006)

9 regions	$\widehat{\beta}^{DSUR}$	Bootstrap unit root test statistics	
1. Beijing, Tianjin, Hebei	0.771 (0.012)**	F_{OLS}	24.0943 (0.005)***
2. Shanxi, Shandong	0.576 (0.000)***	F_{GLS}	40.2478 (0.000)***
3. Liaoning, Jilin Heilongjiang	0.514 (0.000)***	K_{OLS}	24.0943 (0.000)***
4. Shanghai, Jangsu Zhejiang	1.276 (0.010)***	K_{GLS}	40.2478 (0.000)***
5. Anhui, Henan	0.605 (0.000)***		
6. Hubei, Hunan	1.003 (0.000)***		
7. Guangdong, Hainan, Fujian	0.303 (0.000)***		
8. Guangxi, Guizhou, Yunnan	0.475 (0.000)***		
9. Shaanxi, Gansu, Qinghai,Xinjiang, Inner Mongolia	0.369 (0.000)***		

1. ”*”,”**” and ”***” denote significance at 10%, 5% and 1% level respectively.
2. The heterogenous saving-investment cointegrating parameter is estimated by dynamic seemingly unrelated regression in Mark et al. (2005).
3.Estimated coefficients are followed by standard errors.
4.F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). It test the null hypothesis that the series of residuals obtained from estimating the saving and investment cointegrating equation follows a unit root process. A rejection implies the investment and saving series are cointegrated.
5.For the cointegration test (F and K), p-values are in parentheses.
6. Regressions are performed on 9 regions grouped from 26 provinces.

(d) Cointegration Bootstrap with Heterogeneous Cointegrating Vector

CCR with Heterogeneous Cointegrating Vector				
	9 regions	$\widehat{\beta}^{CCR}$(full sample)	$\widehat{\beta}^{CCR}$(1st sub)	$\widehat{\beta}^{CCR}$(2nd sub)
1.	Beijing, Tianjin, Hebei	1.4425	-2.6688	-0.5573
		(0.239)	(0.070)	(0.292)
2.	Shanxi, Shandong	0.7375	0.8418	0.2634
		(0.000)***	(0.000)***	(0.651)
3.	Liaoning, Jilin Heilongjiang	0.8385	3.2121	6.3199
		(0.042)**	(0.000)***	(0.000)***
4.	Shanghai, Jangsu Zhejiang	0.6527	-1.9511	0.4911
		(0.582)	(0.000)***	(0.666)
5.	Anhui, Henan	0.7276	0.6941	2.0278
		(0.000)***	(0.000)***	(0.000)***
6.	Hubei, Hunan	1.5409	2.1869	0.9140
		(0.000)***	(0.083)*	(0.027)**
7.	Guangdong, Hainan, Fujian	0.3376	0.5879	-0.6355
		(0.000)***	(0.000)***	(0.000)***
8.	Guangxi, Guizhou, Yunnan	0.7408	-0.0978	1.7216
		(0.000)***	(0.431)	(0.007)***
9.	Shaanxi, Gansu, Qinghai,Xinjiang, Inner Mongolia	0.4735	0.2509	2.3221
		(0.000)***	(0.032)**	(0.000)***
	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
Full	28.1683	43.9323	28.1683	43.9323
	(0.010)***	(0.000)***	(0.000)***	(0.000)***
1st	16.6046	26.3088	16.6046	26.3088
	(0.173)	(0.001)***	(0.029)**	(0.002)***
2nd	18.2514	30.6161	18.2514	30.6161
	(0.037)**	(0.000)***	(0.000)***	(0.001)***

1. "*","**" and "***" denote significance at 10%, 5% and 1% level respectively.
2.The heterogenous saving-investment cointegrating parameter is estimated by canonical cointegrating regressions in Park (1992).
3.Estimated coefficients are followed by standard errors.
4.F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). It test the null hypothesis that the series of residuals obtained from estimating the saving and investment cointegrating equation follows a unit root process. A rejection implies the investment and saving series are cointegrated.
5.For the cointegration test (F and K), p-values are in parentheses.
6. Regressions are performed on 9 regions grouped from 26 provinces.

Table 6: Regressions of Private Investments on Private Savings at Regional Level

(a) Cointegration Bootstrap with Homogeneous Cointegrating Vector

$$y_{it} = \alpha_i + \beta \cdot x_{it} + u_{it}$$

OLS with Homogeneous Cointegrating Vector					
Full sample	$\widehat{\beta}^{OLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
1978-2006	0.937	31.9689 (0.009)***	25.1961 (0.027)**	31.9689 (0.001)***	25.1961 (0.001)***
1st subperiod	$\widehat{\beta}^{OLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
1978-1992	0.868	20.1027 (0.178)	26.9690 (0.003)***	20.1027 (0.059)*	26.9690 (0.001)***
2nd subperiod	$\widehat{\beta}^{OLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
1993-2006	0.621	13.1594 (0.323)	14.1091 (0.123)	13.1594 (0.067)*	14.1091 (0.053)*

1.”*”,”**” and ”***” denote significance at 10%, 5% and 1% level respectively.
2.Since the OLS standard errors are not valid for conducting inference, we do not report them here.
3.F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). It test the null hypothesis that the series of residuals obtained from estimating the saving and investment cointegrating equation follows a unit root process. A rejection implies the investment and saving series are cointegrated.
4. For the cointegration test (F and K), p-values are in parentheses.
5. Regressions are performed on 9 regions grouped from 26 provinces.

(b) Cointegration Bootstrap with Homogeneous Cointegrating Vector

$$y_{it} = \alpha_i + \beta \cdot x_{it} + u_{it}$$

PDOLS with Homogeneous Cointegrating Vector					
Full sample	$\widehat{\beta}^{PDOLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
0.968	0.968	34.4658	29.7067	34.4658	29.7067
(Param.s.e=0.118)	(NonParam.s.e=0.095)	(0.013)**	(0.010)***	(0.008)***	(0.000)***
1st subperiod	$\widehat{\beta}^{PDOLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
0.883	0.883	17.2221	19.1632	17.2221	19.1632
(Param.s.e=0.245)	(NonParam.s.e=0.107)	(0.519)	(0.058)*	(0.380)	(0.076)*
2nd subperiod	$\widehat{\beta}^{PDOLS}$	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
0.213	0.213	20.9163	19.7698	20.9163	19.7698
(Param.s.e=1.118)	(NonParam.s.e=0.239)	(0.080)*	(0.013)**	(0.016)**	(0.043)**

1. ”*”,”**” and ”***” denote significance at 10%, 5% and 1% level respectively.
2.The homogenous saving-investment parameter is estimated by panel dynamic OLS method in Mark and Sul (2003).
3.Estimated coefficients are followed by standard errors. ”Param.s.e.” and ”NonParam.s.e.” stand for the parametric and nonparametric standard errors respectively.
4.F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). It test the null hypothesis that the series of residuals obtained from estimating the saving and investment cointegrating equation follows a unit root process. A rejection implies the investment and saving series are cointegrated.
5.For the cointegration test (F and K), p-values are in parentheses.
6. Regressions are performed on 9 regions grouped from 26 provinces.
7. Full sample spans from 1978 to 2006. 1st subperiod spans from 1978 to 1992, and 2nd subperiod from 1993 to 2006.

(c) Cointegration Bootstrap with Heterogeneous Cointegrating Vector

$$y_{it} = \alpha_i + \beta \cdot x_{it} + u_{it}$$

DSUR with Heterogeneous Cointegrating Vector (Full sample 1978-2006)			
9 regions	$\widehat{\beta}^{DSUR}$	Bootstrap unit root test statistics	
1. Beijing, Tianjin, Hebei	1.135 (0.000)***	F_{OLS}	33.7536 (0.018)**
2. Shanxi, Shandong	0.963 (0.000)***	F_{GLS}	36.4424 (0.001)***
3. Liaoning, Jilin Heilongjiang	0.943 (0.000)***	K_{OLS}	33.7536 (0.001)***
4. Shanghai, Jangsu Zhejiang	0.767 (0.000)***	K_{GLS}	36.4424 (0.001)***
5. Anhui, Henan	0.818 (0.000)***		
6. Hubei, Hunan	1.525 (0.000)***		
7. Guangdong, Hainan, Fujian	0.500 (0.000)***		
8. Guangxi, Guizhou, Yunnan	1.447 (0.000)***		
9. Shaanxi, Gansu, Qinghai,Xinjiang, Inner Mongolia	1.073 (0.000)***		

1. ”*”,”**” and ”***” denote significance at 10%, 5% and 1% level respectively.
2. The heterogenous saving-investment cointegrating parameter is estimated by dynamic seemingly unrelated regression in Mark et al. (2005).
3.Estimated coefficients are followed by standard errors.
4.F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). It test the null hypothesis that the series of residuals obtained from estimating the saving and investment cointegrating equation follows a unit root process. A rejection implies the investment and saving series are cointegrated.
5.For the cointegration test (F and K), p-values are in parentheses.
6. Regressions are performed on 9 regions grouped from 26 provinces.

(d) Cointegration Bootstrap with Heterogeneous Cointegrating Vector

CCR with Heterogeneous Cointegrating Vector				
	9 regions	$\widehat{\beta}^{CCR}$(full sample)	$\widehat{\beta}^{CCR}$(1st sub)	$\widehat{\beta}^{CCR}$(2nd sub)
1.	Beijing, Tianjin, Hebei	0.9679 (0.000)***	1.5329 (0.000)***	-0.1607 (0.376)
2.	Shanxi, Shandong	0.8746 (0.000)***	0.8882 (0.000)***	0.2759 (0.669)
3.	Liaoning, Jilin Heilongjiang	1.1235 (0.000)***	0.7440 (0.000)***	3.4018 (0.000)***
4.	Shanghai, Jangsu Zhejiang	0.9468 (0.000)***	1.1305 (0.000)***	-1.2663 (0.335)
5.	Anhui, Henan	0.9059 (0.000)***	0.7273 (0.000)***	2.1120 (0.000)***
6.	Hubei, Hunan	1.8739 (0.000)***	2.4685 (0.000)***	0.4983 (0.381)
7.	Guangdong, Hainan, Fujian	0.5187 (0.000)***	0.6139 (0.000)***	-0.1716 (0.070)*
8.	Guangxi, Guizhou, Yunnan	1.7024 (0.018)**	0.6250 (0.003)***	0.6617 (0.303)
9.	Shaanxi, Gansu, Qinghai,Xinjiang, Inner Mongolia	1.1249 (0.000)***	1.1391 (0.032)**	1.6102 (0.000)***
	F_{OLS}	F_{GLS}	K_{OLS}	K_{GLS}
Full	36.2101 (0.002)***	41.2435 (0.000)***	36.2101 (0.000)***	41.2435 (0.000)***
1st	23.0332 (0.108)	34.2500 (0.002)***	23.0332 (0.048)**	34.2500 (0.001)***
2nd	22.8867 (0.037)**	25.7080 (0.000)***	22.8867 (0.005)***	25.7080 (0.001)***

1. "*","**" and "***" denote significance at 10%, 5% and 1% level respectively.
2.The heterogenous saving-investment cointegrating parameter is estimated by canonical cointegrating regressions in Park (1992).
3.Estimated coefficients are followed by standard errors.
4.F_{OLS}, F_{GLS}, K_{OLS} and K_{GLS} are bootstrap statistics in Chang (2004). It test the null hypothesis that the series of residuals obtained from estimating the saving and investment cointegrating equation follows a unit root process. A rejection implies the investment and saving series are cointegrated.
5.For the cointegration test (F and K), p-values are in parentheses.
6. Regressions are performed on 9 regions grouped from 26 provinces.

Table 7: Comparison between Total and Private Sector $\widehat{\beta}$ from DSUR and CCR

		DSUR		CCR	
	9 regions	Total	Private	Total	Private
1.	Beijing, Tianjin, Hebei	0.771	1.135	1.443	0.968
		(0.012)**	(0.000)***	(0.239)	(0.000)***
4.	Shanghai, Jangsu Zhejiang	1.276	0.767	0.653	0.947
		(0.010)***	(0.000)***	(0.582)	(0.000)***
7.	Guangdong, Hainan, Fujian	0.303	0.500	0.338	0.519
		(0.000)***	(0.000)***	(0.000)***	(0.000)***
2.	Shanxi, Shandong	0.576	0.963	0.738	0.875
		(0.000)***	(0.000)***	(0.000)***	(0.000)***
3.	Liaoning, Jilin Heilongjiang	0.514	0.943	0.839	1.124
		(0.000)***	(0.000)***	(0.000)***	(0.000)***
6.	Hubei, Hunan	1.003	1.525	1.541	1.874
		(0.000)***	(0.000)***	(0.000)***	(0.000)***
5.	Anhui, Henan	0.605	0.818	0.728	0.906
		(0.000)***	(0.000)***	(0.000)***	(0.000)***
8.	Guangxi, Guizhou, Yunnan	0.475	1.447	0.741	1.702
		(0.000)***	(0.000)***	(0.000)***	(0.000)***
9.	Shaanxi, Gansu, Qinghai,Xinjiang, Inner Mongolia	0.369	1.073	0.474	1.125
		(0.000)***	(0.000)***	(0.000)***	(0.000)***

Table A1: Data Availability of Provinces

No.	Province	No missing data over 1978-2006?
1.	Beijing	Y.
2.	Tianjin	Y.
3.	Hebei	Y.
4.	Shanxi	Y.
5.	Inner Mongolia	Y.
6.	Liaoning	Y.
7.	Jilin	Y.
8.	Heilongjiang	Y.
9.	Shanghai	Y.
10.	Jiangsu	Y.
11.	Zhejiang	Y.
12.	Anhui	Y.
13.	Fujian	Y.
14.	Jiangxi	N.
15.	Shandong	Y.
16.	Henan	Y.
17.	Hubei	Y.
18.	Hunan	Y.
19.	Guangdong	Y.
20.	Guangxi	Y.
21.	Hainan	Y.
22.	Chongqing	N.
23.	Sichuan	N.
24.	Guizhou	Y.
25.	Yunnan	Y.
26.	Tibet	N.
27.	Shaanxi	Y.
28.	Gansu	Y.
29.	Qinghai	Y.
30.	Ningxia	N.
31.	Xinjiang	Y.

Table A2: Grouping of 9 Regions

No.	Province
1.	Beijing, Tianjin, Hebei
2.	Shanxi, Shandong
3.	Liaoning, Jilin, Heilongjiang
4.	Shanghai, Jiangsu, Zhejiang
5.	Anhui, Henan
6.	Hubei, Hunan
7.	Guangdong, Hainan, Fujian
8.	Guangxi, Guizhou, Yunnan
9.	Shaanxi, Gansu, Qinghai, Xinjiang, Inner Mongolia