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Accounting for China's Growth

Loren Brandt
Xiaodong Zhu

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of Labor

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Loren Brandt
University of Toronto
and IZA

Xiaodong Zhu
University of Toronto

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

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China has achieved impressive growth over the last three decades. However, there has been debate over the sources of the growth, and the role of the intensive versus extensive margin. Growth accounting exercises at the aggregate level (Rawski and Perkins, 2008; Bosworth and Collins, 2008) suggest an equal role for both. For the non-agricultural sector, there have been doubts about the contribution of TFP improvements to growth. For the period between 1978 and 1998, Young (2003) stresses the role of labor deepening, including the reallocation from agriculture, while more recent analysis points to the role of rising rates of investment. Because labor reallocation across sectors, TFP growth at the sector level and investment are all inter-related, simple growth decompositions that are often used in the literature are not appropriate for quantifying their contributions to growth. In this paper, we develop a three-sector dynamic model to quantify the sources of China's growth. The sectors include agriculture, and within non-agriculture, the state and non-state components. We find only a modest role for labor reallocation from agriculture and capital deepening, and identify rising TFP in the non-state non-agricultural sector as the key driver of growth. We also find significant misallocation of capital: The less efficient state sector continues to absorb more than half of all fixed investment. If capital had been allocated efficiently, China could have achieved the same growth performance without any increase in the rate of aggregate investment. This has important implications for China as it tries to re-balance its growth. Finally, in light of important concerns over data, we examine the robustness of our key results to alternative data sets.

JEL Classification: E2, O4

Keywords: China, investment, growth, productivity, capital market distortions

Corresponding author:

Loren Brandt
Department of Economics
University of Toronto
150 St. George Street
Toronto, Ontario M5S lAl
Canada
E-mail: brandt@chass.utoronto.ca

1 Introduction

China has achieved impressive growth over the last three decades of reform. However there has been continued debate over the sources of the growth, and the role of the intensive versus extensive margin. Most aggregate growth accounting exercises for China find a nearly equal role for the two (Bosworth and Collins (2007); Rawski and Perkins (2008)). But for the non-agricultural sector, there have been doubts about the contribution of improvements in total factor productivity (TFP) to growth. In an influential article, Young (2003) suggests that for the first two decades (1978-1998) TFP growth in China's non-agricultural sector was modest, and that labor deepening, including the transfer of labor out of agriculture, was the key force behind the extraordinary improvements in per capita living standards. For the period since the early 1990s, high and rising saving and investment rates have shifted attention to the contribution of capital deepening in China's growth. In fact, a number of recent papers[1] argue that China has become excessively dependent on investment for growth.

The reallocation of labor from agriculture could have contributed to aggregate growth in China if there were differences on the margins in the returns to labor between the agricultural and non-agricultural sectors. At the end of the Maoist era, about 70 percent of the labor force was in agriculture. Moreover, a variety of institutional restrictions tied these individuals to the land and severely limited their choice of economic activity, thereby resulting in lower returns to labor in agriculture than outside the sector. Over the last three decades, the restrictions have been relaxed significantly and the share of the labor force in agriculture has declined by more than 40 percent. (See Figure 1.)

Increasing capital intensity by raising the rate of investment could also have been a source of aggregate growth. At the start of the reforms, China's capital to output ratio was 1.62, far below

[1] See, e.g., Blanchard and Giavazzi (2005); Kuijs and Wang (2005); Prasad and Rajan (2006); Aziz (2007); Lardy (2007) and Prasad (2009).

the average in the OECD countries. From 1978 to 2007, aggregate investment as a percentage of GDP in China increased from 21 percent to 40 percent. (See Figure 2.)

So, in principle, the reallocation of labor from agriculture and the increases in the rate of investment could have been sources of China's growth. But how important are they quantitatively? Could China have achieved its remarkable growth performance without significant TFP improvements in the non-agricultural sector? In this paper we develop a unified framework that allows us to quantitatively address these questions. The key to our analysis is distinguishing between the state and non-state components within the non-agricultural sector.[2]

In the late 1970s, much of employment and GDP outside of agriculture was in the state sector. With economic transition, there has been a substantial reallocation of labor within the non-agricultural sector from the state to the non-state sector. Between 1978 and 2007, the state sector's share of total non-agricultural employment declined from 52 percent to only 13 percent. (See Figure 1.) As a result of soft budget constraints and other preferential policies favoring the state sector, TFP growth in the state sector has consistently lagged that in the more dynamic non-state sector by a wide margin (Jefferson and Rawski, 1994). Gains to this labor reallocation would be concealed in analysis looking at the non-agricultural sector only in the aggregate.

The reallocation of capital between the two sectors has occurred much more slowly. Even as late as 2007, more than half of all new capital formation was still going to the state sector despite the fact that its contribution to GDP had fallen below thirty percent. This has two important implications. First, the rate of return to capital likely differs significantly between the two sectors, and capital is seriously misallocated. And second, capital accumulation in the state and non-state sectors must be considered separately when trying to assess the overall contribution of rising investment to China's growth.

The objective of this paper is to quantify the contributions of the rising investment rate and productivity growth within each sector as well as the labor reallocation across sectors to aggregate TFP and labor productivity growth. The labor reallocations include those from the agriculture to

[2] In a previous study, we found that distinguishing the state and non-state sectors is also crucial to the understanding of aggregate fluctuations and inflation in China. See Brandt and Zhu (2000).

non-agriculture, and within non-agriculture, from state to non-state. Because the reallocations of labor across sectors are endogenous and generally depend on sector-level TFP growth and frictions in the labor market, their contributions to aggregate TFP and labor productivity growth cannot be quantified without taking into account the impact of these factors.

We construct a three-sector model that explicitly accounts for the interactions between these factors and the labor reallocations. The sectors include agriculture and within the non-agricultural sector, the state and non-state components. We take the sector level TFPs, between-sector wage wedges and the aggregate investment rates as exogenous[3] and let the model determine the allocation of capital and labor across sectors. We calibrate our benchmark model so that the model's predictions are consistent with the structural transformation and growth in China over the last three decades. We then quantify the contribution of each prospective source of growth by eliminating its influence from the benchmark model and comparing the resulting outcome with that from the benchmark model.[4]

1.1 Main Results

The importance of TFP growth in the non-state sector

Disaggregating the non-agricultural sector into its state and non-state components helps us to identify TFP growth in the non-state non-agricultural sector as the most important source of China's growth. This role is obscured in more aggregate analysis that combines the state and non-state sectors. Between 1978 and 2007, while TFP in the state sector grew at an annual rate of 1.52 percent per annum, the non-state sector's TFP grew at a rate of 4.56 percent per annum. This rapid TFP growth in the non-state sector helped to offset the drag of the inefficient state sector and was instrumental in absorbing labor transferred out of agriculture. Employment in the non-state

[3] We treat the aggregate investment rates as exogenous in the model for two reasons. First, the aggregate investment rate in China has been rising steadily over the last three decades. Such behavior is inconsistent with the predictions of most standard growth models. While it is important to explain this puzzling behavior, we leave it for future research. Second, we want to quantify the role of the rising investment rate in China's growth. It would be hard to do so if the investment rate is endogenously determined in the model.

[4] This model based accounting approach is similar to the one used by Greenwood, Hercowitz and Krusell (1997) in their accounting for the contribution of investment-specific technological change to long-run growth in the US.

non-agricultural sector grew by more than 420 million between 1978 and 2007. Without the TFP growth in the non-state sector, the growth rate of labor productivity in the non-agricultural sector would have been reduced by 4.65 percent per annum, and the growth rate of GDP per worker in China would have been reduced by 3.79 percent per annum.

As large as these contributions are, they could have been even larger if not for the capital market distortions that prevented the non-state firms from taking full advantage of their high productivities.

The cost of capital market distortions and the unimportance of a rising investment rate

Our estimates show that since the early 1990s, the returns to capital in the non-state sector have remained above 50 percent, implying a capital-labor ratio in the non-state sector that is too low relative to its TFP levels. Although the state sector's share of employment has declined sharply in recent years, its share of fixed investments has declined only slowly. Even as late as 2007, the state's share of non-agricultural fixed investment, which represents more than 95 percent of total fixed investment, was 53 percent while its employment share was 13 percent. This bias has helped to sustain a large and widening gap in the capital-labor ratio and the returns to capital between the state and the non-state sectors.[5] To quantify the impact of the misallocation of capital on growth, we use our model to do a counter-factual simulation in which capital is allowed to flow freely between the two sectors so that the returns to capital are equalized. In this case, the annual growth rate of GDP per worker between 1978 and 2007 would have increased by 1.58 percentage points.

The misallocation of capital has also made China's government overly dependent on the increase in capital intensity in promoting growth. Between 1978 and 2007, the aggregate investment rate increased from 21 percent to 40 percent of GDP. Without this increase, aggregate labor productivity growth rate would have been reduced by 1.37 percentage points. However, if capital had been allowed to flow freely between the state and non-state sectors, the aggregate labor productivity growth rate would have been increased by 0.06 percent. So, absent capital market distortions,

[5] Using firm level data, Dollar and Wei (1997) also found a significant gap in returns to capital between the firms in the state and the non–state sectors.

China could have achieved the same growth performance without any increase in the aggregate investment rate.

Contributions of the structural transformations

Somewhat surprisingly, we find only a modest role for the reallocation of labor from agriculture: Without the reallocation, aggregate labor productivity growth rate would have been reduced by 0.97 percent per annum. The reason for the modest contribution is the capital constraint faced by the non-state non-agricultural sector, into which most of the labor leaving agriculture have gone. Due to a lack of investment, the capital-labor ratio in the non-state non-agricultural sector has grown very slowly, thereby limiting the gains from the labor reallocation from agriculture.

In contrast, we find a more important contribution of the reallocation from state to non-state associated with economic transition: If the state sector's share of non-agricultural employment had stayed at its 1978 level, aggregate labor productivity growth rate would have been reduced by 1.61 percent per annum. A main reason the government disproportionately allocated capital to the state sector was to maintain the high wages for the workers in that sectors. Without the reduction in the state sector's share of non-agricultural employment, even more capital would have been allocated to the inefficient sector, and aggregate productivity growth significantly reduced.

1.2 Robustness of our results

Concerns about the quality of the official data continue to persist. Our quantitative analysis uses a number of revised data series to address these concerns.[6] However, our key quantitative results are similar even if we use the official data. In our analysis of the returns to capital in the state and non-state sectors, we also examine the implications of treating infrastructure investment by the state separately from the rest of state sector investment. We allow the returns to this investment to be captured by both the state and non-state sectors. Although this lowers the relative return to capital in the non-state sector, a significant gap remains in returns between the two sectors and our quantitative analysis continues to identify the misallocation of capital as a serious problem.

[6] In an appendix, we reconcile our numbers with those used in the literature and, in particular, with those of Young (2003) for the period between 1978 and 1998.

1.3 Related Literatures

Our paper is part of a growth accounting literature that tries to identify the sources of China's growth since 1978. (See Ren, 1993; Wang and Yao, 2001; Young, 2003; Zheng, Bigsten and Hu, 2006; Bosworth and Collins, 2008; Perkins and Rawski, 2008.) However, our paper is different from earlier studies in that we do growth accounting at the sector level and use a model to account for the contributions of sector TFP and resource reallocation across sectors to growth.

Our paper's emphasis on better resource allocation across sectors as a source of aggregate TFP growth is related to a recent literature that attributes low aggregate TFP in developing countries to misallocation at the micro-level. (See Caselli and Coleman, 2002; Gollin, Parente and Rogerson, 2004; Banerjee and Duflo, 2005; Restuccia, Yang and Zhu, 2007; Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Gancia and Zillibotti, 2009; and Durate and Restuccia, 2010.)

In recent years there has been a debate in the literature and in policy circles about whether China's growth strategy is sustainable. This debate generally focuses on China's high saving and high investment rates. Many have argued that they are too high to be sustainable and China needs to rebalance its growth strategy from promoting investment to promoting consumption. (See the references in footnote 1.) Our paper contributes to this debate by showing that China could potentially reduce the investment rate without lowering growth through better allocation of existing capital in the economy. In other words, reducing distortions in the capital markets could help China to maintain its high growth performance and restore the imbalance between consumption and investment at the same time.

There are two recent papers that are closely related to ours. Dekle and Vandenbroucke (2006) also use a dynamic three-sector model to study China's growth. However, they do not explicitly consider the factor market distortions, which we emphasize here. Song, Storesletten and Zilibotti (2008) focus their study on the non-agricultural sector and use a dynamic two-sector model to study the impact of financial market distortions on China's investment allocation, saving and growth. Their objective is to explain the high growth and high saving phenomena in China rather than quantifying the sources of China's growth.

The rest of the paper is organized as follows. In section 2, we briefly examine a number of key

data series, saving more detailed discussion for the appendix. Section 3 discusses the results of the standard growth accounting, followed by an examination of the behavior of sector-level productivity. We describe our benchmark model and discuss the driving forces of structural transformations in Section 4. A key feature of the model is the link it draws between distortions in the labor market and capital allocation. In section 5, we use this model to examine the contributions of China's structural transformations to TFP growth, and then situate this in the context of a growth accounting in which changes in aggregate labor productivity come from either capital accumulation, TFP growth within each sector, or inter-sector reallocation from low to high TFP sectors. In light of important concerns over data issues in the literature, in the appendix we demonstrate that our findings are robust to the use of alternative data series for key variables.

2 Data

We do growth accounting at the aggregate level, for the non-agricultural sector, and within the non-agricultural sector, for the state and non-state components separately. This requires data on nominal GDP, prices, employment and the capital stock. Ongoing debate over problems in "official" Chinese data raises a variety of issues. We limit our discussion here to a few key issues relating to GDP and fixed investment deflators, employment, estimates of value-added in the state and non-state sectors, as well as investment in the state and non-state sectors. We carry out the growth accounting using a number of revised series, but also report results based on the official data.

2.1 GDP Deflators

In China's national income and product accounts, the aggregate economy is divided into three sectors, primary, secondary (manufacturing plus construction, mining and utilities) and tertiary (services). We will treat the primary sector as the agricultural sector and the sum of secondary and tertiary sectors as the non-agricultural sector.

Much of the debate in the literature has been over sector-level GDP deflators needed to convert nominal GDP into real GDP. China's implicit GDP deflators have been criticized by Ren (1995),

Young (2003) and Maddison (2007) for underestimating inflation, and thus contributing to an overestimate of real GDP growth. For the secondary sector, Holz (2006) provides a defence of their internal consistency by comparing the changes in the implicit GDP deflator with the prices of final goods and that of raw materials and intermediates.

Following Ren (1995), Young (2003) proposes a set of alternatives: For the primary sector, the farm and sideline products purchasing index, which rose 7.9% per annum between 1978 and 1998 compared to 8.5% by the implicit deflator; for the secondary sector, the ex-factory industrial price index, which increased 6.1% annually compared to 4.4% by the implicit deflator; and for the tertiary or services sector, the consumer service price index, which rose 10.7% per annum compared to 7.1% by the implicit deflator. It is important to note that all of these *alternative* deflators are final goods deflators, as opposed to value-added deflators.

We carry out our analysis using the alternatives proposed by Ren and Young, with one modification. We construct an alternative deflator for services that reflects the rising role of business services, and differences in the behavior of the prices of business and consumer services. Young's alternative is based solely on the price of consumer services. Our new service price index implies a rate of inflation in between the implicit deflator and Young's alternative.

2.2 Fixed Investment Deflators

The National Bureau of Statistics in China (NBS) begins to report a fixed investment deflator only in 1991. For the period between 1978 and 1995, a deflator for fixed capital formation can be backed out of NBS-reported data on the nominal and real value of fixed capital formation. This implicit deflator, which shows an annual increase in the price of investment of 7.0 percent, has been criticized for likely underestimating the rate of inflation in capital formation.

Following the suggestion of Young (2003), Brandt and Rawski (2008) construct an alternative deflator for fixed investment spanning the longer period between 1952 and 2007 that is based on: 1) separate deflators for equipment and structures; and 2) estimates of the percentage of total fixed investment spending in structures and equipment. Comparing this alternative with the *official* deflators, two things are noteworthy. First, the NBS fixed investment deflator beginning in 1991

and our alternative deflator behave very similarly. Second, the implicit deflator for gross fixed capital formation shows much less inflation than does our alternative. For the period between 1978 and 1995, the implicit index rises 7.0 percent per annum, compared to 10.2 annually by the alternative. The most likely source of the difference is the failure of the implicit deflator to reflect the rapidly rising costs of building and installation, and their influence on the costs of fixed investment.

2.3 Employment

NBS provides estimates of total employment and a breakdown by sector: primary, secondary and tertiary. Between 1978 and 2007, the NBS measure of employment increased from 401.5 million to 769.9 million. The NBS data also show a decline in the percentage of the labor force in the primary sector from 70.5 percent in 1978 to 50 percent in 2000, and then to 40.8 percent in 2007.

There are two difficulties with the official data. The first is a major discontinuity in the employment data beginning in 1990. This "break" reflects a major upward adjustment to the NBS employment series based on new information obtained from China's population censuses of 1990 and 2000. These adjustments did not extend to years before 1990, leading to a big jump in the NBS employment measure during 1989/1990.

A second issue concerns the possibility that NBS data underestimate the rate of decline in the primary sector labor force (Rawski and Mead, 1998, Chen, 1992). Critics point to several potential sources of this bias: the exclusion of employment in private and cooperative enterprises owned by households prior to 1984 (Wong, 1988, p. 14); incomplete tabulation of self-employment and part-time work outside agriculture by individuals who derived the bulk of their incomes from farming; and erroneous inclusion of out-migrants in the farm labor force.

Following Holz (2006), we use information from the 1982 Census to adjust the pre-1990 data in a way analogous to the adjustments made for 1990 and after. This results in an increase in the level of employment in 1978, and a reduction in the rate of employment growth over the entire period. We also construct an alternative estimate of primary sector employment by utilizing detailed labor supply data for rural households disaggregated by activity collected by the Research Centre for

Rural Economy as part of their annual rural household survey. These alternative estimates imply a more rapid transfer of labor out of agriculture, especially in the early years of the introduction of the household responsibility system (HRS) and rural reform. In absolute terms, employment outside agriculture grew from 144 million in 1978 to 568 million in 2007. Moreover, by 2007, our alternative estimates suggest that the percentage of the labor force in the primary sector had fallen to 26.2 percent compared to 40.8 percent in the official data.

2.4 Labor Productivity in the State and Non-state Non-agricultural Sectors

We will carry out growth accounting for the non-agricultural sector for the state and non-state components, separately. NBS reports data on employment and capital formation disaggregated by sector and ownership. They also decompose gross output and value-added in industry into the state and non-state components, however they do not provide a similar breakdown for the remainder of the secondary sector (construction plus public utilities) or for the tertiary sector. We utilize wage data for the state and non-state sectors to estimate such a division for the entire non-agricultural economy. To do this, we assume that wages are proportional to average value products, and that labor shares in the state and non-state sectors are the same. Information on wages in the state and non-state sector, the latter including urban collective, foreign-owned, private and township and village enterprises, suggest that wages outside the state sector were between 60-70 percent of state sector wages between 1978 and 1995, rose to nearly 85 percent by the late 1990s, and then fell sharply to 66 percent by 2007.[7]

[7] These data conceal a potentially important complication: they include only cash compensation and neglect the value of subsidies and in-kind wages enjoyed primarily by workers in the state sector, the largest component of which was probably housing. Rawski (1982), Bannister (2004), and Benjamin et al (2008) offer estimates of the magnitude of these benefits for various years. There is a consensus in the literature that the relative importance of such non-cash benefits has declined markedly over time, with estimates suggesting that they have fallen from rough equality with cash wages in the late 1970s, to half of cash wages by the early 1990s, to perhaps a quarter of cash wages today. These figures imply that total compensation in the non-state sector increased relative to compensation in the state sector twice as much between 1978 and 1998 as did cash wages. We examined the robustness of our results to revised estimates of relative labor productivity based on this alternative wage series and found that the main results in the paper remain unchanged.

2.5 Fixed Investment in the State and Non-state Non-agricultural Sectors

The NBS provides estimates of aggregate gross fixed capital formation and gross fixed investment for years after 1978. The key difference between the two is that fixed investment data include expenditure on land. These series are nearly indistinguishable throughout much of the period, but after 2002 fixed investment increases more rapidly because of the growing importance of expenditure on land. We need to obtain a breakdown between primary and non-primary, and in the non-primary sector, state and non-state. We utilize the more detailed data on fixed investment expenditure, but scale total investment expenditure to be consistent with the NBS estimates of gross fixed capital formation.

Investment in the primary sector is made up of investment from three sources: state, collective and households. The Fixed Investment Yearbooks provide estimates of investment in the primary sector by both state-owned and collective units for the years 1981-2007. They also provide estimates of total rural household investment, but do not break it down between primary and non-primary. Assuming that investment is proportional to net income, we use additional information on the percentage of total net business income from agriculture to obtain an estimate of household fixed investment in agriculture. Our estimate of total primary investment is then the sum of our estimate for rural households, plus the state and collective fixed investment.

Investment in the non-primary sector is calculated as total fixed investment less our investment in the primary sector. We utilize the information on total state sector investment and state-sector investment in the primary sector to obtain non-primary investment by the state sector. Beginning in 1993, the NBS begins to report separately fixed investment in shareholding companies, which were typically medium-to-large SOEs that had been restructured, but in which the state still exercises significant influence[8]. Our estimate of fixed investment in the state sector includes that by state-owned firms, plus shareholding companies. We also adjust for the privatization of state sector firms after 1998.

[8] On the basis of the 2004 Industrial Census, for example, there were 17,427 shareholding companies out of a total of 1.37 million industrial firms. These firms however represented between 11 and 12 percent of total output and fixed assets.

3 Simple Growth Accounting by Sectors

Following the standard growth accounting practice, we assume Cobb-Douglas production technologies in all three sectors (agriculture, non-state non-agriculture and state sectors):

$$Y_{at} = A_{at}K_{at}^{1-\alpha}L_{at}^{\alpha}, \quad (1)$$

$$Y_{st} = A_{st}K_{st}^{1-\alpha}L_{st}^{\alpha}, \quad (2)$$

$$Y_{nst} = A_{nst}K_{nst}^{1-\alpha}L_{nst}^{\alpha}, \quad (3)$$

Here, Y_{it} is GDP, L_{it} employment, and K_{it} capital stock in sector i ($i = a$, agriculture, s, state and ns non-state non-agriculture), respectively. α is the factor share of labor, which is assumed to be the same in all three sectors.

On the basis of the national income accounts for China and the national input-output tables constructed by the NBS, the labor share in non-agriculture has remained roughly 0.5. These accounts put the labor share for the entire economy at 0.58-0.60, which implies a share for agriculture of nearly 0.7. Moreover, the falling contribution of agriculture in GDP since 1978 means that the share of labor in agriculture has been rising over time. The high and rising share of labor in agriculture is inconsistent with estimates made on the basis of household data, which suggest a labor share in the vicinity of 0.50. For all three sectors, then, we assume that the labor share is 0.5 throughout the period of our study.

The capital stock in agriculture consists of land only. We assume that the land endowment in agriculture is fixed over time and normalize it to one. As a result, our estimate of TFP growth in agriculture may partially reflect changes in either the land endowment or land quality. Also note that when we calculate TFPs we do not control for the levels of human capital. Thus, the TFP differences over time and across sectors may also reflect differences in human capital.

Using the revised data series described above, we carry out the standard growth accounting exercise for the entire economy, the non-primary sector, and within the non-primary sector, the state and non-state sectors separately. In each case, we do the analysis for the full period, and then split the period into three decades: 1978-1988, 1988-1998 and 1998-2007. We report the results of

this simple growth accounting in Table 1. In the appendix, we compare these results with those using "official" price deflators and employment and the results from the literature.

Table 1 here

Our benchmark data imply a rate of growth in the aggregate real output per worker of 7.6 percent per annum. Over the entire 29-year period, the contributions to growth of capital deepening and TFP are fairly evenly divided, 3.7 percent versus 3.9, or 49 and 51 percent of total growth, respectively. Splitting the data into sub-periods reveals an increase in the rate of growth of output per work in the last decade resulting from both more rapid capital accumulation and faster TFP growth.

In the non-agricultural sector, output per worker grows less rapidly over the entire period than we observe in the aggregate, a product of both lower TFP growth and less rapid capital accumulation per worker. Between 1978 and 2007, output per worker in the non-agricultural sector grows 2.2 percent and TFP 3.2 percent. Note however the increase in the rate of growth over time and the growing contribution of capital deepening. Early in the reform, rapid growth in the non-agricultural labor force contributed to a decline in the capital-labor ratio in the non-agriculture sector. All of the growth in output per worker was coming from TFP growth. In contrast, capital deepening became more important in the non-agricultural sector for the last two decades.

The aggregate estimates conceal stark differences between the non-state and state sectors. Over the entire period, TFP growth in the non-state sector was three times that in the state sector. This was offset by much slower growth in capital per worker so that output per work in the two sectors grew at fairly similar rates. Only in the last decade, through massive reorganization and layoffs, did the state sector's TFP growth became comparable to that in the non-state sector.

Figure 3 plots the TFP levels for the three sectors.[9] There has been significant growth of TFP in agriculture and the non-state non-agricultural sector, which increased at annual rates of 6.20

[9]The TFP level in agriculture is not comparable to the TFP levels in the two non-agricultural sectors because of differences in the production technologies. In Figure 3, we normalize the initial levels of the agricultural and non-agricultural sectors' TFP to one. The TFP levels within the non-agricultural sector, namely, those of the state and the non-state sector, however, are directly comparable.

and 4.56 percent, respectively. By comparison, TFP growth in the state sector has been relatively sluggish, increasing only at the rate of 1.52 percent per annum. In terms of levels, in 1978 TFP in the non-state non-agriculture sector was nearly the same as that in the state sector. Due to the more rapid growth in the non-state sector, TFP levels diverge over time, with the gap peaking in 2000 at 125 percent.

Figure 3 here

4 A Three Sector Model of Structural Transformation and Growth

Given the large differences in TFP across the three sectors, reallocations of resources across sectors are potentially important sources for the growth in the aggregate productivity. However, these reallocations are also likely to be a function of the TFP differences across sectors as well as labor market frictions. To fully account for the contribution of sector TFPs and the reallocation across sectors, a model of sectoral reallocation is needed. Also, as is well known, using the simple growth accounting to gauge the importance of capital accumulation to growth is problematic because its contribution depends on the TFP growth. (Without TFP growth, the rapid increase in the capital to labor ratio would have resulted in a declining contribution of capital deepening due to diminishing returns.) To better assess the contribution of a rising investment rate to growth, we need to use a model that takes into account the impact of TFP growth on the contribution of capital deepening.

In this paper, we consider a dynamic model with three sectors: agriculture, non-state non-agriculture and state. There are two goods in the economy, agricultural and non-agricultural. The agricultural good is produced in the agriculture sector and the non-agricultural good is produced by both the non-state non-agriculture and state sectors. The production technologies were given in equation (1)-(3). The capital stock in the agricultural sector (land) is assume to be a constant Z.

Preferences: In each period, the representative household consumes an agricultural good and a non-agricultural good. Preferences are summarized by the following utility function:

$$\sum_{t=0}^{\infty} \beta^t \left[a \ln(c_{at} - \overline{c}) + (1-a) \ln(c_{nt}) \right], \quad 0 < a < 1, \quad 0 < \beta < 1.$$

Here, c_{at} and c_{nt} are the amounts of agricultural and non-agricultural goods the household consumes in period t, respectively, $\overline{c} > 0$ is the subsistence consumption of the agricultural good. The representative household's consumption allocation problem is

$$\max_{c_{at}, c_{nt}} a \ln(c_{at} - \overline{c}) + (1-a) \ln(c_{nt})$$

subject to

$$p_{at} c_{at} + p_{nt} c_{nt} = (1 - s_t) y_t^m$$

where s_t is the investment rate, y_t^m is the nominal income, p_{it} is the price of good i, $i = a, n$. The optimal consumption allocation is given by the following equations:

$$c_{at} = (1-a)\overline{c} + a \frac{(1-s_t) y_t^m}{p_{at}}, \tag{4}$$

$$c_{nt} = (1-a) \frac{(1-s_t) y_t^m - p_{at} \overline{c}}{p_{nt}}. \tag{5}$$

Exogenous investment rate and investment efficiency:

$$\begin{aligned} K_{t+1} &= (1-\delta) K_t + I_t / \pi_t, \\ I_t &= s_t (p_{at} Y_{at} + Y_{nt}). \end{aligned}$$

Here s_t is the investment rate, and π_t is a variable that is inversely related to the efficiency of converting the non-agriculture good into the capital good. Both are taken as exogenous.

Frictions in the Labor Market:

We consider two kinds of labor market frictions. First, the level of employment and wage in the state sector are set by the government rather than determined by the market. Over the years, the Chinese government has kept the average wage in the state sector at levels that are higher

than those in the non-state sector. Second, there are many institutional and policy constraints that restrict movement of labor from agriculture. Although difficult to measure directly, they generally have the effect of depressing the returns to labor in agriculture relative to those in non-agriculture. Thus, the wedge in returns to labor between agriculture and non-agriculture can be used as an implicit measure of the barriers to labor reallocation between the two sectors. We denote this wedge by θ_t.

Let ξ_t be the wage premium in the state sector and μ_t be the wedge in wages between the agricultural sector and the non-state non-agricultural sector. Then, we have

$$w_{at} = (1-\mu_t)w_{nst}, \tag{6}$$

$$w_{st} = (1+\xi_t)w_{nst}. \tag{7}$$

Here, w_{it} is a wage in sector i in period t. Let $\varphi_{st} = L_{st}/L_{nt}$ be the state sector's share of non-agricultural labor force, which we assume is an exogenous variable that is set by the government. The wage wedge between the agricultural and non-agricultural sectors can then be expressed as

$$\theta_t = \frac{\mu_t + \xi_t\varphi_{st}}{1+\xi_t\varphi_{st}}, \tag{8}$$

which is increasing in μ_t, ξ_t and φ_{st}.

We do not have direct data on the average returns to labor in the agricultural and non-agricultural sectors. However, we do have data on the average value product of labor (or nominal output per worker) for the two sectors. Under the assumption that labor shares of income are the same in the two sectors, the gap in the average value product of labor equals the gap in average returns to labor and therefore can be used as a measure of θ_t.

Figure 4 plots this measure of labor market barriers. Between 1978 and 1984, the gap in average returns to labor between agriculture and non-agriculture declined sharply, from 83 percent to 52 percent. Subsequently, the gap widened, and in 2007 was equal to 65 percent. Figure 4 also plots the three components of the average wage gap: μ_t, the gap in wages between the agriculture and the non-state non-agriculture sector; ξ_t, the gap in wages between the non-state and the state sector or

the state sector's wage premium; and φ_{st} the size of the state sector measured by the share of the state sector's share of non-agricultural employment. While the behavior of the first component is very similar to the overall gap, the second component fluctuates and the third component declines steadily over time.

Figure 4 here

4.1 Share of Labor Force in Agriculture

Using the market clearing condition for the agricultural good and the facts that wages equal marginal value products of labor in each sector, we can derive the employment share of labor in agriculture[10]:

$$l_{at} = \frac{(1-a)(1-\theta_t)}{1-\theta_t+a(1-s_t)\theta_t}\frac{\overline{c}}{A_{at}\left(Z/L_t\right)^{1-\alpha}}l_{at}^{1-\alpha} + \frac{a(1-s_t)}{1-\theta_t+a(1-s_t)\theta_t}. \tag{9}$$

Equation (9) will be the basis for calibration and predicting agriculture's share of total employment. It identifies three potential sources for reallocation of labor from agriculture: (1) increases in agricultural productivity that relax a subsistence food consumption constraint; (2) a reduction in barriers to labor mobility between sectors; and (3) increases in the investment rate.

4.2 Capital Allocation in the Non-Agricultural Sector

The barriers to labor mobility not only affect the reallocation of labor across sectors, they also influence the allocation of capital across sectors and therefore growth in non-agriculture and the whole economy. From the labor market condition (7) we have

$$\alpha A_{st}L_{st}^{\alpha-1}K_{st}^{1-\alpha} = (1+\xi_t)\alpha A_{nst}L_{nst}^{\alpha-1}K_{nst}^{1-\alpha},$$

which implies that

[10] The derivation is available from the authors upon request.

$$K_{st} = \frac{\varphi_{st}}{1-\varphi_{st}} \left((1+\xi_t) \frac{A_{nst}}{A_{st}} \right)^{\frac{1}{1-\alpha}} K_{nst}.$$

From the market clearing condition $K_t = K_{st} + K_{nst}$ and the labor market clearing condition, then, we have

$$k_{nst} = \frac{1}{\left[1 - \varphi_{st} + \varphi_{st} \left((1+\xi_t) \frac{A_{nst}}{A_{st}} \right)^{\frac{1}{1-\alpha}} \right]} k_t / l_{nt}, \tag{10}$$

$$k_{st} = \frac{\left((1+\xi_t) \frac{A_{nst}}{A_{st}} \right)^{\frac{1}{1-\alpha}}}{\left[1 - \varphi_{st} + \varphi_{st} \left((1+\xi_t) \frac{A_{nst}}{A_{st}} \right)^{\frac{1}{1-\alpha}} \right]} k_t / l_{nt}. \tag{11}$$

From (10) and (11) we can see the resulting relationship between the capital-labor ratios in the two sectors

$$\frac{k_{st}}{k_{nst}} = \left((1+\xi_t) \frac{A_{nst}}{A_{st}} \right)^{\frac{1}{1-\alpha}}.$$

In contrast, if capital is allowed to allocate freely across the two sectors so that the marginal products of capital are equalized, we would have the following relationship:

$$\frac{k_{st}}{k_{nst}} = \left(\frac{A_{nst}}{A_{st}} \right)^{-\frac{1}{\alpha}}.$$

That is, the share of capital that is allocated to the state sector would be decreasing rather than increasing in the productivity gap between the two sectors, A_{nst}/A_{st}.

When $A_{nst} > A_{st}$, more resources should be allocated to the non-state sector. However, maintaining a large share of employment with a wage premium in the state sector implies that more capital needs to be allocated to the state sector rather than the non-state sector. So, the share of capital that is allocated to the state sector is increasing in ξ_t, φ_{st} and the productivity gap between the state and the non-state sector, A_{nst}/A_{st}. In other words, distortions in the labor market are supported by distortions in capital allocation. In the quantitative analysis below, we will show that such distortions have a significant impact on growth.

4.3 TFP in the Non-agricultural Sector and the Aggregate

From (10) and (11), we have

$$y_{nt} = y_{st}\varphi_{st} + y_{nst}(1-\varphi_{st}) = A_{nt}k_t^{1-\alpha}l_{nt}^{\alpha-1}. \tag{12}$$

Here

$$A_{nt} = \frac{(1+\varphi_{st}\xi_t)}{\left[(1-\varphi_{st})A_{nst}^{-\frac{1}{1-\alpha}} + \varphi_{st}(1+\xi_t)^{\frac{1}{1-\alpha}}A_{st}^{-\frac{1}{1-\alpha}}\right]^{1-\alpha}},$$

is the TFP of the non-agricultural sector. Note that when $\xi_t = 0$, the TFP in the non-agricultural sector becomes

$$A_{nt} = \left[(1-\varphi_{st})\,A_{nst}^{-\frac{1}{1-\alpha}} + \varphi_{st}A_{nst}^{-\frac{1}{1-\alpha}}\right]^{-(1-\alpha)},$$

which is a weighted geometric average of the two sector's TFPs, with the weights being the employment shares of the two sector. Since the TFP in the state sector has been lower than that in the non-state sector, the larger the share of the state sector's employment, the lower the TFP in the non-agricultural sector. Therefore, a potential source of TFP growth in the non-agricultural sector is the reduction in the state sector's share of employment. For $\xi_t > 0$, we can rewrite the TFP of the non-agricultural sector as follows:

$$A_{nt} = \frac{1+\varphi_{st}\xi_t}{\left[1-\varphi_{st}+\varphi_{st}(1+\xi_t)^{\frac{1}{1-\alpha}}\right]^{1-\alpha}}\left[\omega_{nst}A_{nst}^{-\frac{1}{1-\alpha}} + \omega_{st}A_{st}^{-\frac{1}{1-\alpha}}\right]^{-(1-\alpha)} \tag{13}$$

where

$$\begin{aligned}
\omega_{nst} &= \frac{1-\varphi_{st}}{1-\varphi_{st}+\varphi_{st}(1+\xi_t)^{\frac{1}{1-\alpha}}} < 1-\varphi_{st}, \\
\omega_{st} &= \frac{\varphi_{st}(1+\xi_t)^{\frac{1}{1-\alpha}}}{1-\varphi_{st}+\varphi_{st}(1+\xi_t)^{\frac{1}{1-\alpha}}} > \varphi_{st}.
\end{aligned}$$

Note that, by Jensen's inequality,

$$\left[1-\varphi_{st}+\varphi_{st}(1+\xi_t)^{\frac{1}{1-\alpha}}\right]^{1-\alpha} > 1-\varphi_{st}+\varphi_{st}(1+\xi_t) = 1+\varphi_{st}\xi_t,$$

and therefore

$$\frac{1+\varphi_{st}\xi_t}{\left[1-\varphi_{st}+\varphi_{st}(1+\xi_t)^{\frac{1}{1-\alpha}}\right]^{1-\alpha}} < 1. \tag{14}$$

We can see from equation (13) and inequality (14) the impact of the wage premium ξ_t on the TFP in the non-agriculture sector. First, TFP in the non-agricultural sector will still be proportional to a weighted average of the TFPs in the two sectors, but with a higher weight now on the state sector. In addition, the wage premium introduces a further distortion in resource allocation across the two sectors such that the TFP in the non-agricultural sector is smaller than the weighted average of the TFPs in the two sectors. Thus, an added potential source of the TFP growth in the non-agricultural sector is the reduction in the state sector's wage premium. In summary, the state sector's wage premium ξ_t and the employment share φ_{st} both have negative impacts on non-agricultural TFP if the TFP in the non-state sector is higher than that in the state sector.

As for the aggregate TFP, we have

$$y_t = p_a^* y_{at} l_{at} + y_{nt}(1-l_{at}) = p_a^* A_{at} z_t^{1-\alpha} l_{at}^{\alpha} + A_{nt} k_t^{1-\alpha}(1-l_{at})^{\alpha}.$$

Here $z_t = Z/L_t$ is land per capita, A_{nt} is the TFP in the non-agricultural sector, which is given by equation (13), and p_a^* is the relative price of agricultural output in the base year. Following the standard growth accounting exercises, the growth of output per worker in the aggregate is decomposed into two parts: growth in physical capital per worker k_t, and the growth in aggregate TFP. That is $y_t = A_t k_t^{1-\alpha}$. Thus, the expression for the measured aggregate TFP in our model is given by the following:

$$A_t = p_a^* A_{at} \left(z_t/k_t\right)^{1-\alpha} l_{at}^{\alpha} + A_{nt}(1-l_{at})^{\alpha}, \tag{15}$$

where the TFP in the non-agricultural sector is given by equation (13). Note how various "sectoral"

factors contribute to the measured aggregate TFP. First, TFP growth in any of the three sectors, agriculture, non-state non-agriculture and state sector, contributes positively to the aggregate TFP growth. Second, if there is a positive TFP gap between the non-agricultural and agricultural sectors, the reallocation of labor away from agriculture also leads to aggregate TFP growth. Third, reduction in the state sector's share of employment and wage premium also contribute positively to the aggregate TFP growth through two channels: increasing the TFP in the non-agricultural sector and facilitating faster reallocation of labor away from agriculture.

4.4 Calibration of the Model

As we discussed in the section on TFP, the labor share has been approximately 50 percent in both the aggregate and the non-agriculture sector in China. So we set α to 0.5. We use equation (9) to calibrate the values of the other two parameters, a and $\overline{c}$. We normalize the value of Z to one. Given the values of A_{at} we calculated in section 3 and the values of θ_t and s_t, which are taken directly from the data, we choose the values of a and $\overline{c}$ so that in the beginning and ending years of the period, 1978 and 2007, agriculture's share of employment implied by equation (9) matches that in the data. The calibrated values for a and $\overline{c}$ are 0.147 and 0.475, respectively. Figure 5 plots the employment shares of agriculture implied by the calibrated model and their counterparts in the data, and Table 2 compares the labor productivity and TFP growth rates predicted by the model to their counterparts in the data.

Figure 5 and Table 2 here

4.5 Driving Forces of Reallocation of Labor from Agriculture

Our model identifies three potential sources for the reallocation of labor from agriculture: (1) increases in agricultural productivity that relax a subsistence food consumption constraint; (2) a reduction in barriers to labor mobility between sectors; and (3) increases in the aggregate investment rate. The potential relevance of each of these three sources in the Chinese context is discussed in detail by Brandt, Hsieh and Zhu (2008). To evaluate the quantitative importance of these three factors. we use our calibrated model to conduct a series of counter-factual exercises, each of which

removes one of the factors driving labor reallocation. Table 3 summarizes the results of these calculations.[11]

Table 3 here

The TFP growth in agriculture is clearly the most important factor. For the other two forces, the reduction in barriers is important in the first decade of the reform during which many restrictions on non-farming activities in the rural areas were removed, while the increase in the investment rate played only a marginal role for the entire period.

5 Model Based Growth Accounting

We now turn to the quantification of growth contributions of various factors, including

1. The increases in the investment rate;
2. TFP growth within each of the three sectors;
3. Inter-sectoral reallocation of labor and capital from low TFP sectors to high TFP sectors.

We estimate the contribution of each prospective source of growth by eliminating its influence from the benchmark model and then comparing the resulting outcome with that from the benchmark model. For example, to investigate how much TFP growth in the non-state sector contributed to overall growth, we conduct a counter-factual experiment that imposes a constant TFP in the non-state sector throughout 1978-2007 and let the model determine the paths and rates of growth of the aggregate TFP and aggregate labor productivity. We then take the differences between these hypothetical growth rates and the growth rates from the benchmark model as our estimates of the contribution of the TFP growth in the non-state sector to overall TFP and labor productivity

[11] Note that because the different factors contribute to labor reallocation in a non-linear fashion, their contributions are not additive. That is, the combined contribution to the labor reallocation may be higher or lower than the sum of the contributions by individual factors, depending on their interactions.

growth. Table 4 provides the results from these counter-factual exercises for the entire 29-year period and Table 5 reports the results for the three sub-periods.[12] We discuss the results reported in the tables below.

Table 4 and 5 here

5.1 Contributions of Sector TFP growth

5.1.1 TFP growth in agriculture

In agriculture, where land is essentially fixed and the quantity of capital remains modest, the impact of TFP growth on labor productivity in agriculture is enormous: Without it, labor productivity in agriculture would have actually declined at an annual rate of -0.74 percent, compared to the 7.02 percent annual growth in the benchmark model and in the data. As we discussed in the last section, TFP growth in farming is also an important driving force for the reallocation of labor out of agriculture. Because of the higher productivity in the non-agricultural sector, the reallocation also contributed indirectly to the growth of the aggregate TFP. The combined contribution of these two effects is a 1.5 percent increase in the growth rates of both the aggregate TFP and aggregate labour productivity.

Given the remarkable 6.2 percent growth rate of the agricultural TFP, it's contribution to aggregate growth—including the direct effect through labor productivity growth within agriculture and indirect effect through reallocation of labor–is relatively modest. Assuming no TFP growth in agriculture, aggregate labor productivity would have still grown at a robust rate of 5.76. An important reason for this modest contribution is that agriculture's share of GDP was already below 30 percent in 1978. By 2007, it fell to less than half of this. As a result, growth in that sector exercised only weak influence on the path of the economy-wide labor productivity.

[12] Again, the contributions of individual factors are not necessarily additive because they may influence the aggregate growth in a non-linear fashion.

5.1.2 TFP growth in the non-state sector

Employment in the non-state sector grew by more than 420 million, while its share of total employment jumped from 14.8 percent to 64.4 percent between 1978 and 2007. Despite this rapid increase, labor productivity grew at an impressive 5.37 percent annual rate. Because of the non-state sector's limited access to capital, labor productivity and TFP, which shows annual growth of 4.56 percent during 1978-2007, are closely linked. If there had been no TFP growth in the non-state sector, the rapid increase in employment would drive labor productivity growth rates in the non-state sector and the non-agriculture sector to 1.14 percent and 0.35 percent, respectively. Without the TFP growth in the non-state sector, there would have been virtually no TFP growth in the non-agriculture sector (0.09 percent) and a much lower TFP growth rate in the aggregate (1.68 percent). Overall, the aggregate labor productivity growth rate would have been 3.46 percent instead of 7.16 percent, a more than 50% reduction. In addition, without the TFP growth in the non-state sector, less capital would have been accumulated in the economy. As a result, the state sector, which relies heavily on capital accumulation for growth, would see its labor productivity growth rate reduced from 5.48 percent to 0.83 percent, a reduction of 4.65 percentage points.

5.1.3 TFP growth in the state sector

Consistent with extensive empirical work on the experience in industry (Jefferson and Rawski, 1999; Groves et. al. 1994), we find only modest growth of TFP in the state sector, especially through the late 1990s. Although it is significantly lower than that in the non-state sector, this growth in TFP is moderately important. If TFP in the state sector had not grown, the drag of the state sector on overall growth would have been even larger as state enterprises would have absorbed an even larger portion of China's capital formation in order to maintain its employment and wage premiums. Overall, stagnation of state-sector TFP would have reduced the non-agricultural TFP growth rate to 2.15 percent and the aggregate TFP growth rate to 3.04 percent. The labor productivity in the non-agriculture sector and the aggregate would have been 3.68 percent and 6.08 percent, respectively.

5.2 Contributions of Labor Reallocations

5.2.1 Reallocation of labor from agriculture to non-agriculture

As we have seen, three factors influenced the reallocation of labor from agriculture: TFP growth in agriculture, a reduction in labor market barriers, and increases in the investment rate. In addition to promoting labor reallocation, each of these factors also has a direct effect on growth. To isolate the pure impact of labor reallocation from agriculture to non-agriculture, we conduct a counter-factual exercise in which we simply force the share of employment in agriculture to remain at the 1978 level. In this case, none of the growth would have been due to the reallocation between agriculture and non-agriculture.

In this counter-factual exercise, the growth rate of agricultural labor productivity falls to 6.28 percent compared to 7.25 percent, leaving agriculture to absorb more labor under conditions of sharply diminishing returns (i.e. adding more workers to the farm sector depresses labor productivity). The absence of labor inflows from the farm sector would actually increase the growth rate of labor productivity in the non-agricultural sector from 5.00 percent to 6.59 percent. There is a third effect related to the elimination of labor reallocation: economy-wide average labor productivity is now lower because a larger percentage of employment is allocated to the sector with lower productivity.

Taking all these three effects into account, eliminating the transfer of labor across the two sectors would reduce the annual growth rate of aggregate labor productivity from 7.25 percent to 6.28 percent, a modest reduction of 0.97 percentage points per year. So, this experiment with our dynamic model shows that the reallocation of labor from agriculture to non-agriculture had three impacts on growth: higher labor productivity growth in agriculture, lower labor productivity growth in non-agriculture, and more efficient labor allocation across sectors. Overall, they translate into a very modest increase of 0.97 percentage points in the growth rate of aggregate labor productivity. The impact on the aggregate TFP growth is slightly larger, a 1.04 percentage point reduction, from 3.95 percent to 2.91 percent. Most of the gains from the reallocation came during the first decade of reform.

Other authors have used a simple decomposition to quantify the contribution of the labor reallocation from agriculture and generally find a much larger role than what our model implies[13]. In the appendix we compare our model-based accounting to the simple decomposition and explain why the results obtained from the simple decomposition are likely to be biased.

5.2.2 Reallocation of Labor from State to Non-state Sector

To quantify the contribution of the second structural transformation, i.e. the reallocation of labor from state to non-state sector, we do a counter-factual simulation that is similar to the one we described above. Instead of keeping agriculture's employment share constant, we let the state sector's share of non-agricultural employment remain at its 1978 level. Under this scenario, growth of aggregate labor productivity falls to 5.64 percent a year, or 1.59 percentage points lower than the 7.25 percent growth rate observed in the data. The contribution of this reallocation is smaller in the first sub-period than the latter two sub-periods. The contribution to overall growth of reallocation of labor from state to non-state is 1.09 percentage points between 1978 and 1988, but 1.50 percentage points between 1988 and 1998, and 2.31 percentage points between 1998 and 2007. This is not surprising given that most of the reallocation of labor from the state to the non-state sector occurred in the last two sub-periods.

5.3 Contribution of the Increases in the Investment Rate

As a result of the reallocation of labor from agriculture to non-agriculture and general increases in total employment, output in the non-agricultural sector grew rapidly. Although the investment rate has generally moved upward, capital accumulation did not catch up with the rapid employment growth in the non-agricultural sector in the first 10 years or so. Before 1991, the capital-labor ratio in the non-agricultural sector actually remained below its 1978 level, as non-agricultural employment grew faster than the corresponding capital stock. The last two decades, however, the

[13] See, for example, OECD (2005), pg. 32, which performs similar calculations in the context of three-sector model for period 1983-2003. They find that a fifth or so of the overall growth was due to sectoral reallocations of labor, and suggest the contribution could have been even larger in light of differences in the marginal (as opposed to average) products of labor. See also Bosworth and Collins (2008).

rate of investment increased dramatically, which lead to a tripling in the capital-labor ratio in the non-agricultural sector.

To quantify the impact of the increase in the rate of investment, we conduct a counter-factual experiment in which investment is assumed to remain at 21 percent of GDP throughout the 29-year period. The reduction in the investment rate would have no effect on the TFP in the non-agricultural sector and a slightly positive effect on the TFP in the aggregate. The aggregate labor productivity growth rate, however, would have been reduced to 5.88 percent, a 1.37 percentage point reduction. Due to the diminishing returns to capital, however, the importance of capital accumulation declines over time. In the period between 1998 and 2007, if the investment rate had remained at its 1998 level, 33 percent of GDP, the aggregate labor productivity growth rate would have been reduced by only 0.78 percentage point.

5.4 Potential Gains from Eliminating Capital Market Distortions

While the reallocation of labor from the state to non-state sector has contributed significantly to the overall growth in China, the gains could have been even larger if not for the distortions in the capital market. Despite the significant reduction in the state sector's share of employment and the substantial gains to the economy from the reallocation, the state sector continues to be a drag on the overall growth in the economy. Figure 6 plots the returns to capital in the state and the non-state sector and the capital-labor ratios for the two sectors, respectively. Note the enormous gap in the returns to capital between the two sectors that persists through 2007. Yet, the capital-labor ratio in the state sector has increased much faster than that in the non-state sector. This rise in the capital to labor ratio is a result of the government's policy of continuing to support the state sector in spite of the widening gap in TFP levels between the state and the non-state sector. While the investment rate in China is high, a significant portion of the investment is in the less efficient state sector where the return to capital is close to zero. Even as late as 2007, more than 50 percent of fixed investment was going to the state sector, broadly defined. At the same time, too little investment has gone to the non-state sector where the returns to capital have hovered around 55 percent.

Figure 6 here

To quantify the potential gains from more efficient capital allocation, we conduct a counterfactual exercise in which the capital is allowed to flow freely between the state and the non-state sectors so that the two sectors' returns to capital are equalized. In this case, the annual growth rates of the aggregate TFP and labor productivity would have increased by 0.82 percent and 1.58 percent, respectively, for the entire 29-year period.

The misallocation of capital has also made the economy's growth more dependent on the increase in capital intensity. Between 1978 and 2007, the aggregate investment rate increased from 21 percent to around 40 percent of GDP. As we discussed earlier, without the increase in the investment rate, aggregate labor productivity growth rate would have been reduced by 1.37 percentage points. If capital had been allowed to flow freely between the state and the non-state sectors, however, the growth rate would have increased by 0.06 percentage points. In other words, absent capital market distortions, China could have achieved the same growth performance without any increase in the aggregate investment rate.

As can be seen from Figure 6, the gap in returns to capital between the state and the non-state sectors has been widening over time, suggesting an increase in capital market distortions in recent years. This is in contrast to the distortions in the labor market, which have declined over time. Reflecting the increasing capital market distortions in the recent decade, the growth effect of capital accumulation diminishes and the potential gains from eliminating the distortions are even larger in the last decade. If there had been no increase in the investment rate between 1998 to 2007, aggregate labor productivity growth rate would have only been reduced by 0.78 percentage points per annum during this period. However, if we maintain the aggregate investment rate at the 1998 level but allow capital to be allocated efficiently between the state and the non-state sectors, the aggregate TFP and labor productivity growth would have *increased* by 2.63 percent and 3.64 percent per annum, respectively. (See Table 5.)

5.5 Robustness

5.5.1 Simulation Results from the Official Data

So far we have focused our discussions of the model-based accounting using the benchmark data set. Most of the results do not change much when we conduct the exercises using the official data. Most important, it remains true that the TFP growth in the non-state sector and the reallocation of labor from the state to the non-state are the two largest contributors to aggregate TFP and labor productivity growth, and that there are potentially substantial gains from eliminating capital market distortions. Table 6 presents the main results using both our revised data and the official data.

5.5.2 Incorporating Infrastructure Capital

Some may argue that the gap in returns to capital between the state and the non-state sectors are overestimated because some of the investments in the state sector are for infrastructure. It is possible that these infrastructure investments have helped to increase the output in the non-state sector and the total returns to these investments have not been fully captured by the output in the state sector. To deal with this issue, in the appendix we consider a modification of our benchmark model that incorporates infrastructure capital into our analysis.

Figure 7 shows the returns to capital and the capital-labor ratios in the state and the non-state sectors after we adjust for infrastructure capital. Even after we exclude infrastructure capital from the capital in the state sector, the capital-labor ratio in the sector is still significantly higher than that in the non-state sector and a large gap in returns to capital remains between the two sectors.

We also carried out counter-factual simulations based on the model with infrastructure capital. The results are summarized in Table 7. While this model does not match the data as well as the benchmark model, its implications for the sources of growth are the same as those of the benchmark model. In particular, it still suggests that TFP growth in the non-state sector has been the most important source of the growth and the potential gain from eliminating capital market distortions is large.

6 Conclusion

There has been continued debate over the sources of China's remarkable growth over the last three decades. Some have argued that the reallocation of labor from agriculture and the rising investment rate rather than improvements in TFP are the key sources of the growth. In this paper, we construct a dynamic three-sector model that allows us to quantitatively assess the contributions of various factors to aggregate TFP and labor productivity growth in China. The key to our analysis is distinguishing between the state and non-state components within the non-agricultural sector.

We find that the contributions of the reallocation of labor from agriculture and the rising investment rate are modest. The most important sources of growth are the rapid growth of TFP in the non-state non-agriculture sector and the reallocation of labor and other resources out of the state sector and into the non-state sector. Our analysis helps to corroborate the view that rapidly rising productivity growth within the non-agriculture sector has been a key driver of China's economic success, and suggests the need in future analysis to get inside the black box and identify the sources of this growth.

While institutional constraints on resource mobility have weakened significantly, our analysis also highlights the continued cost of the state sector. Even as late as 2007, more than half of all resources for investment went to the state sector. Analysis at the aggregate level misses this stark contrast in behavior between the state and non-state sectors, and the role of the dynamism in the non-state sector in absorbing more than 420 million workers. Significant gains exist from further reallocation of resources from the state sector, especially the re-direction of investment from the state to non-state sector. Perhaps this should be the focus of China's growth rebalancing strategy rather than a shift from investment to consumption as emphasized by many. In fact, our analysis shows that redirecting investment from the state to non-state sector has the potential of helping China to restore the balance between investment and consumption while maintaining the remarkable growth performance it experienced in the last three decades.

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Figure 1. Labor Reallocations in China: 1978-2007

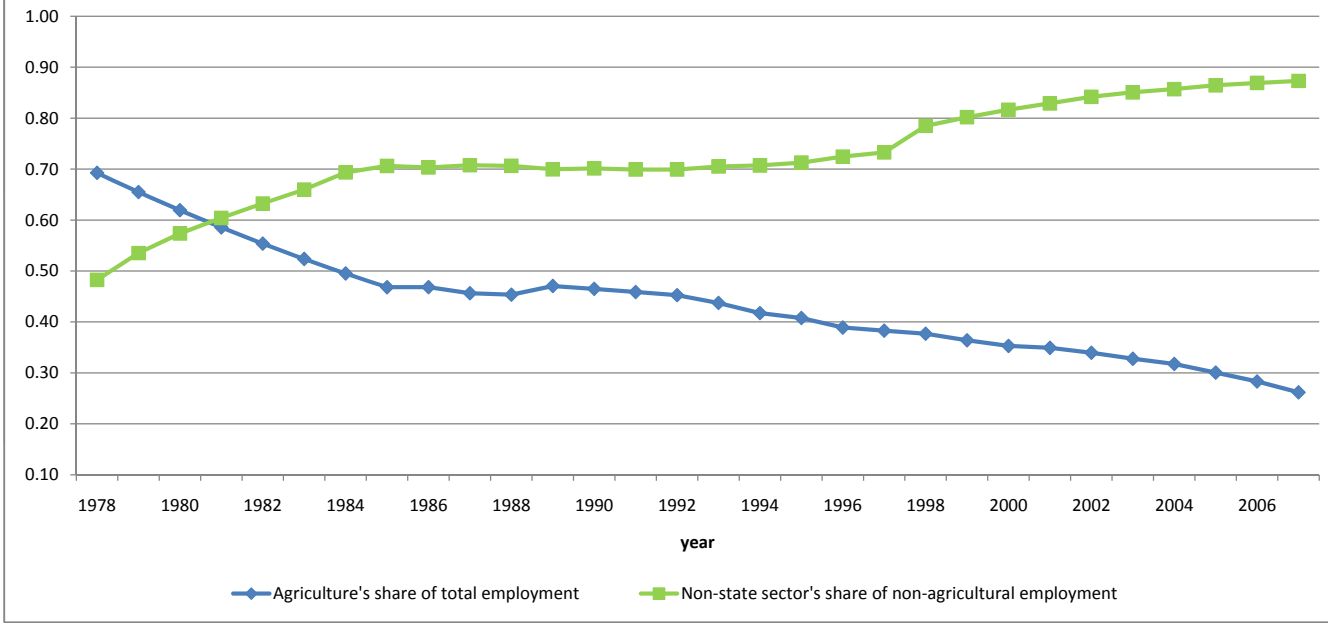


Figure 2. Capital Formation in China: 1978-2007

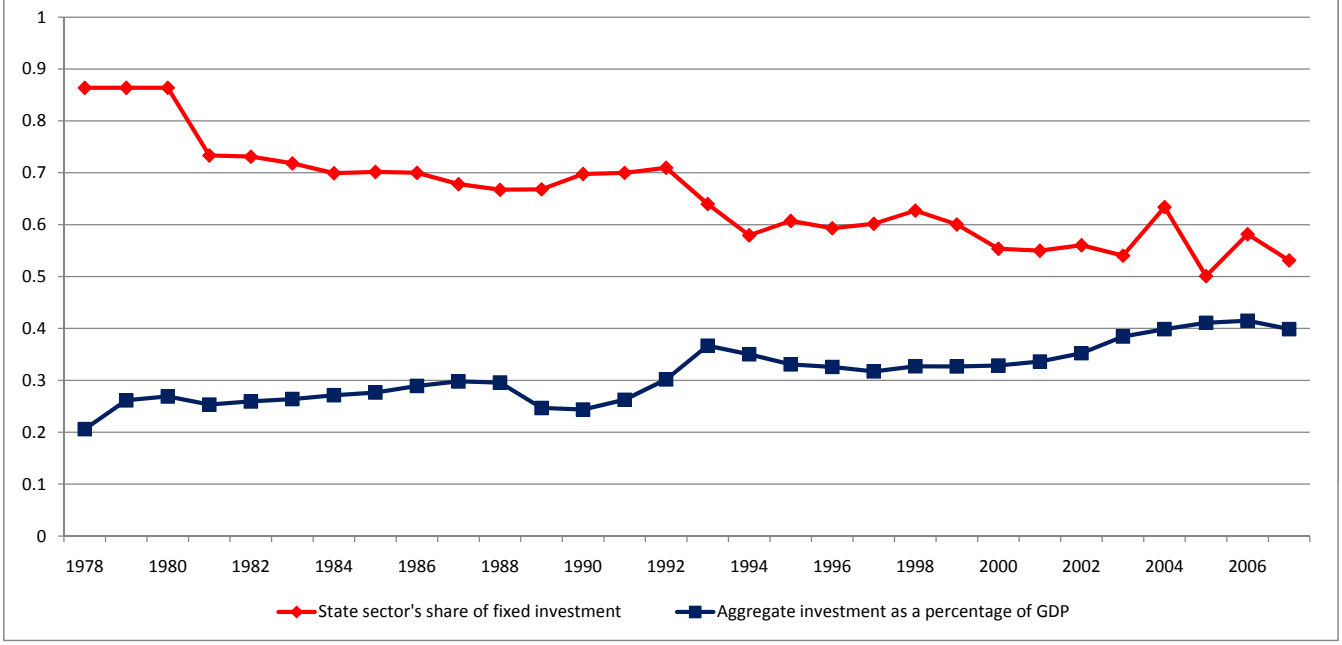


Figure 3. Total Factor Productivity by Sector

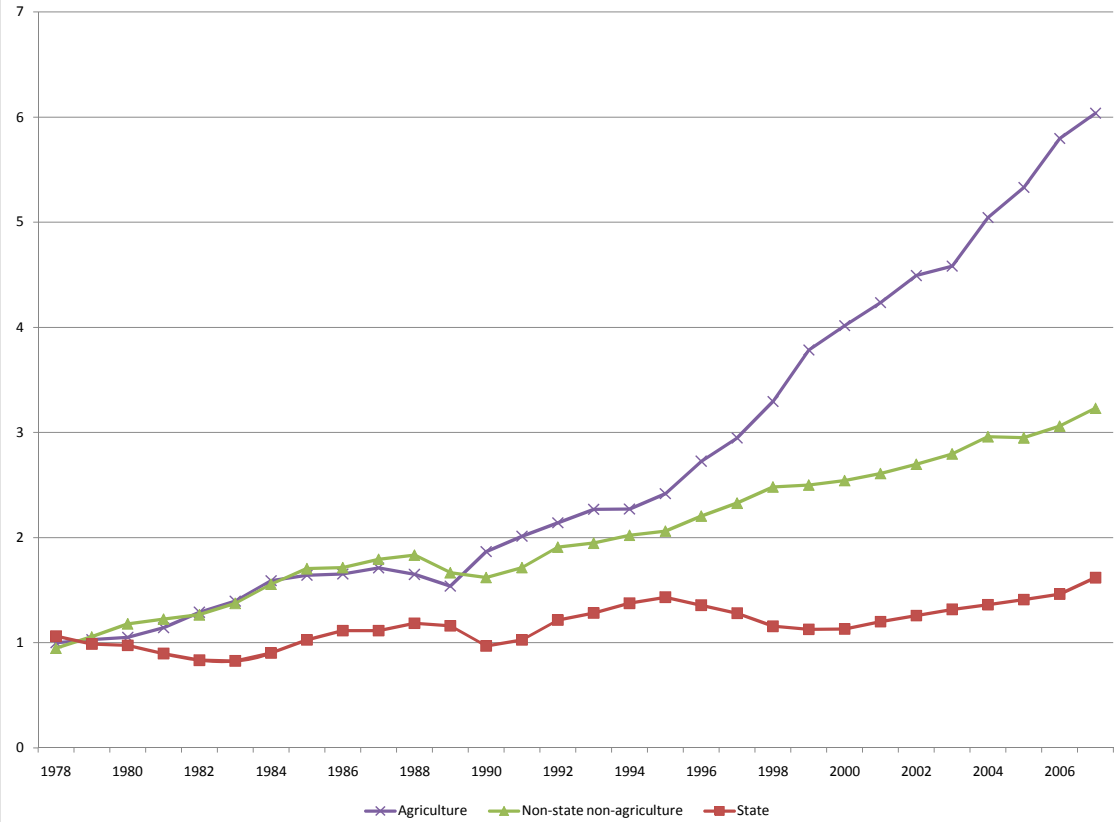
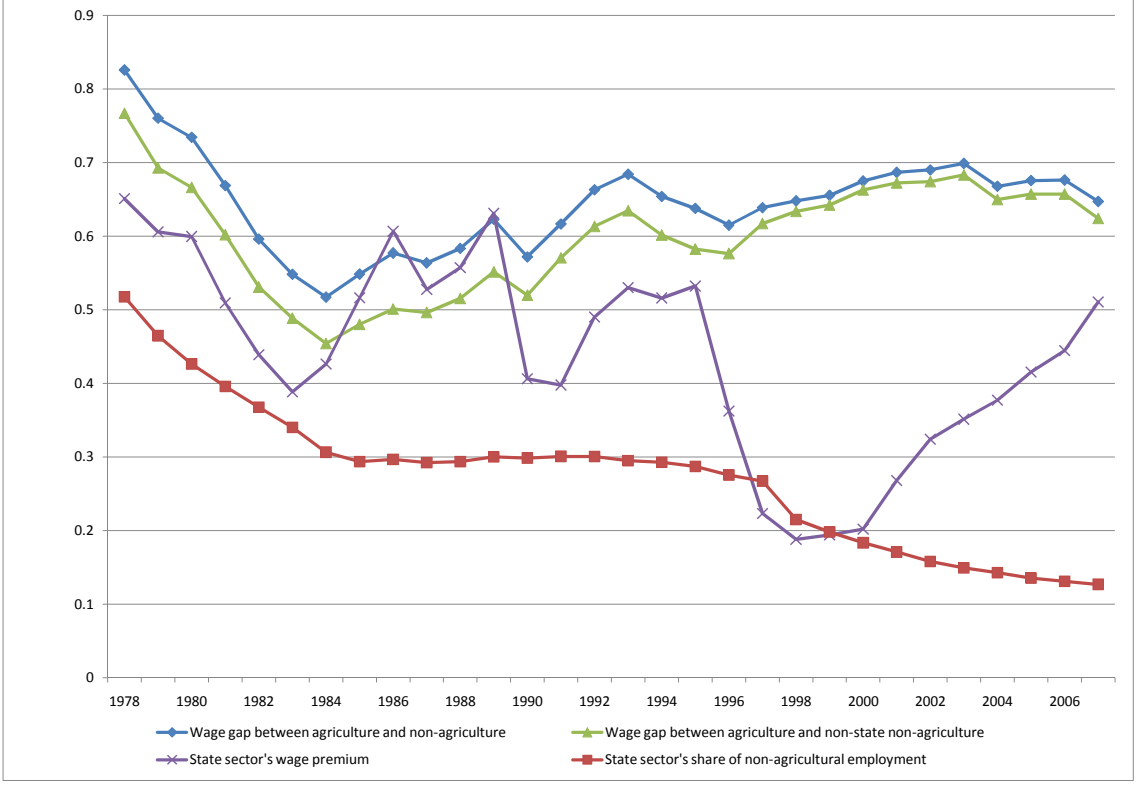


Figure 4. Labor Market Barriers



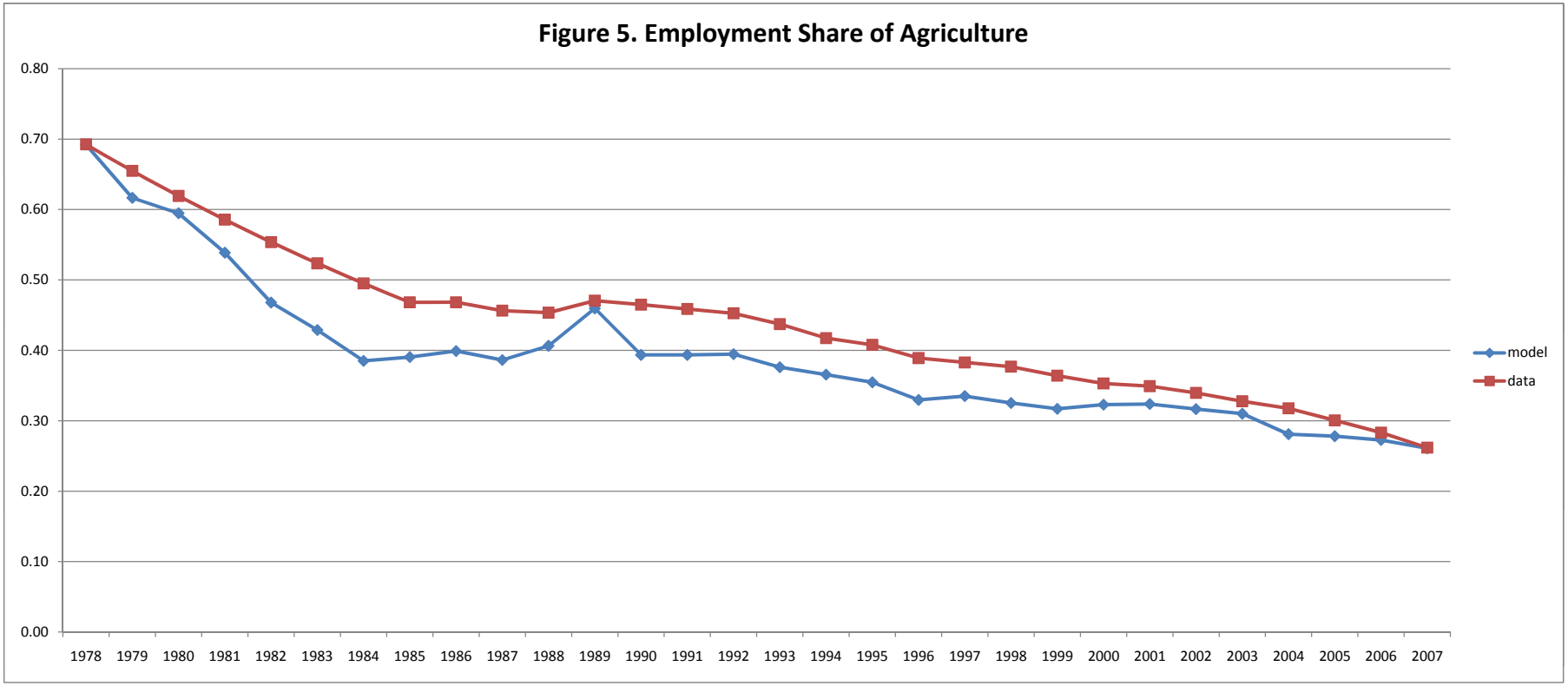


Figure 5. Employment Share of Agriculture
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
model
data

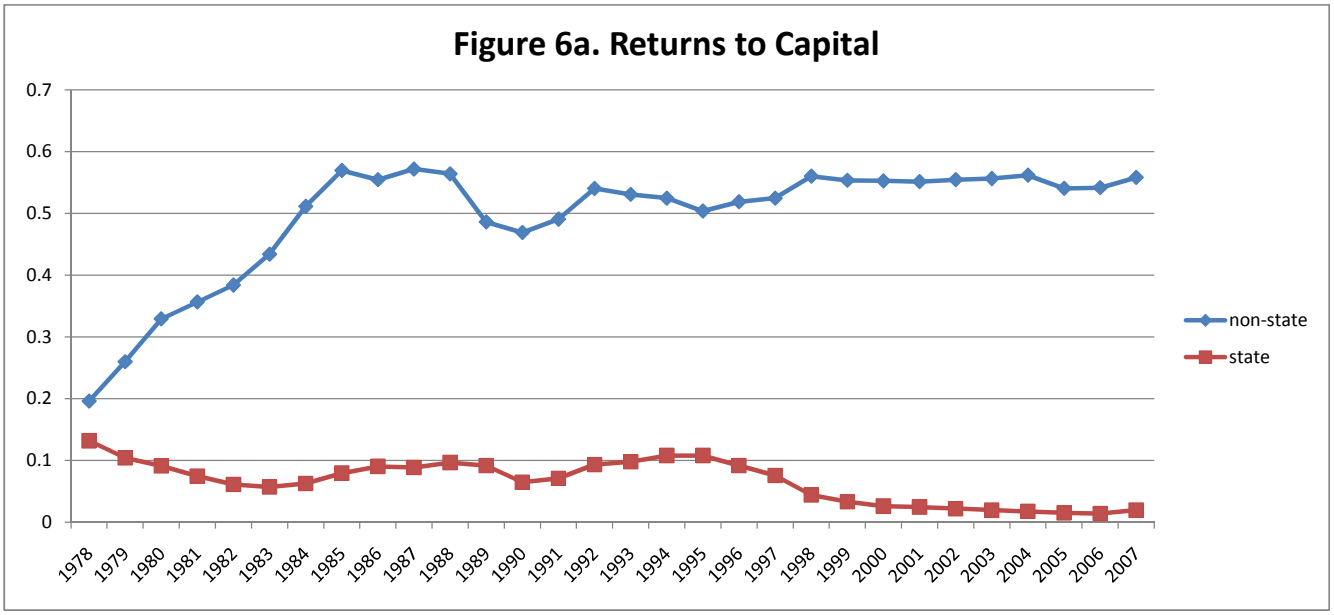


Figure 6a. Returns to Capital
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
non-state
state

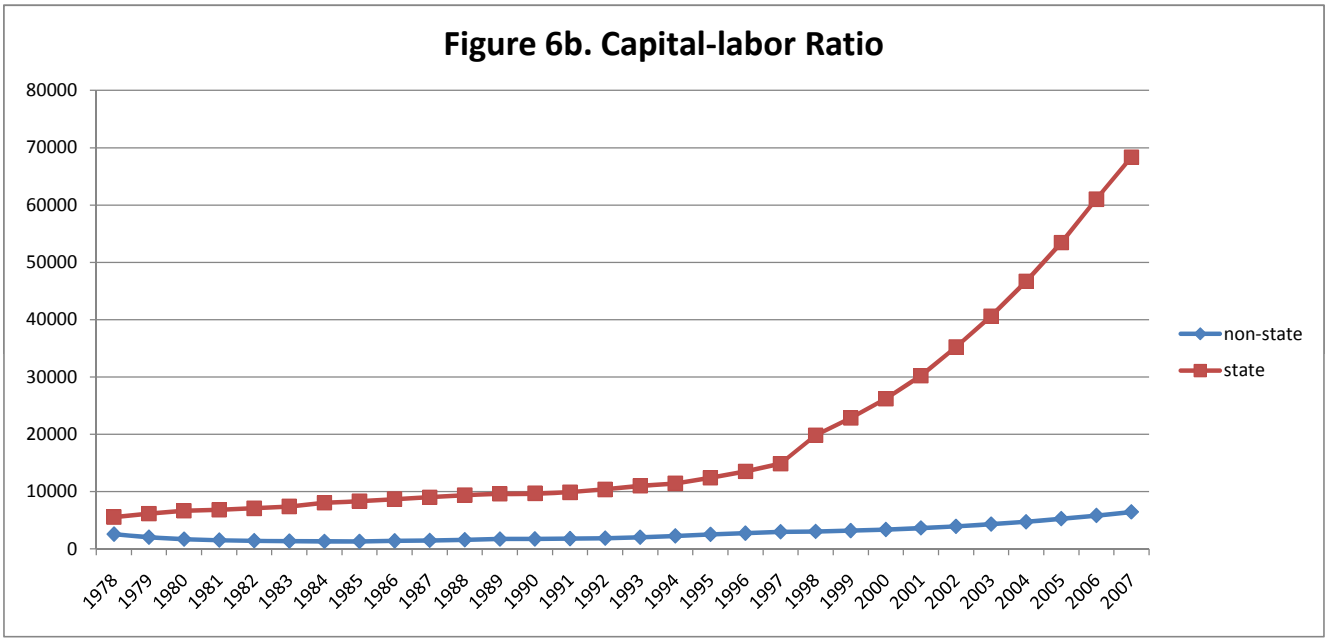


Figure 6b. Capital-labor Ratio
80000
70000
60000
50000
40000
30000
20000
10000
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
non-state
state

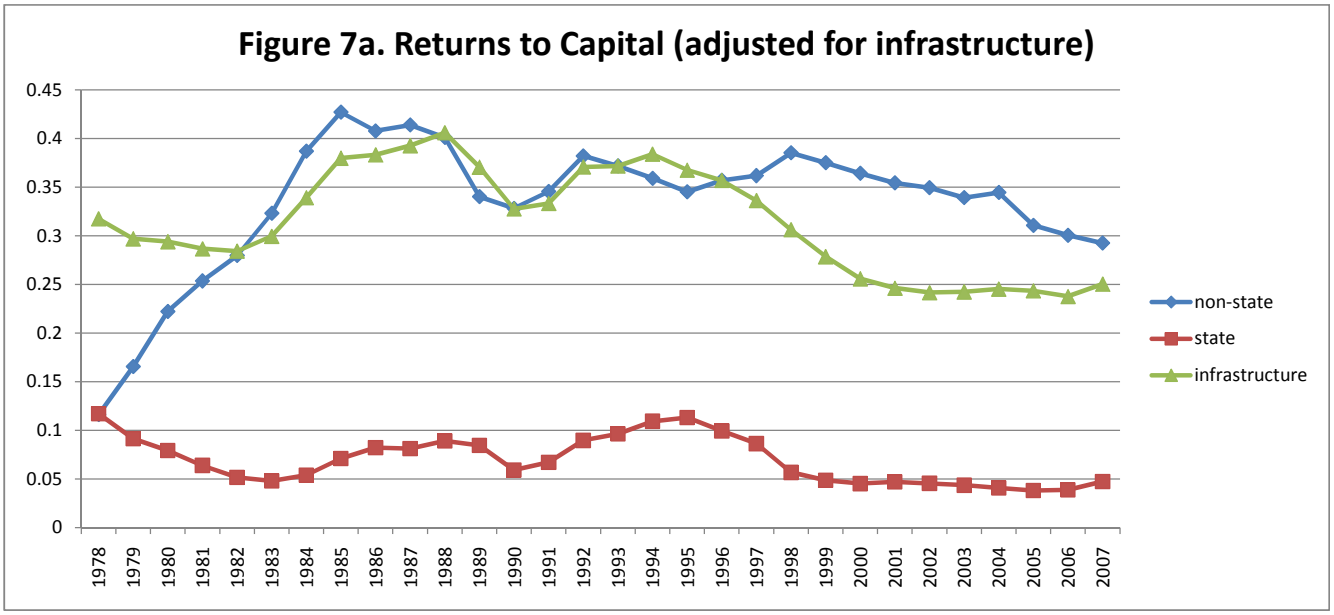


Figure 7a. Returns to Capital (adjusted for infrastructure)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
non-state
state
infrastructure

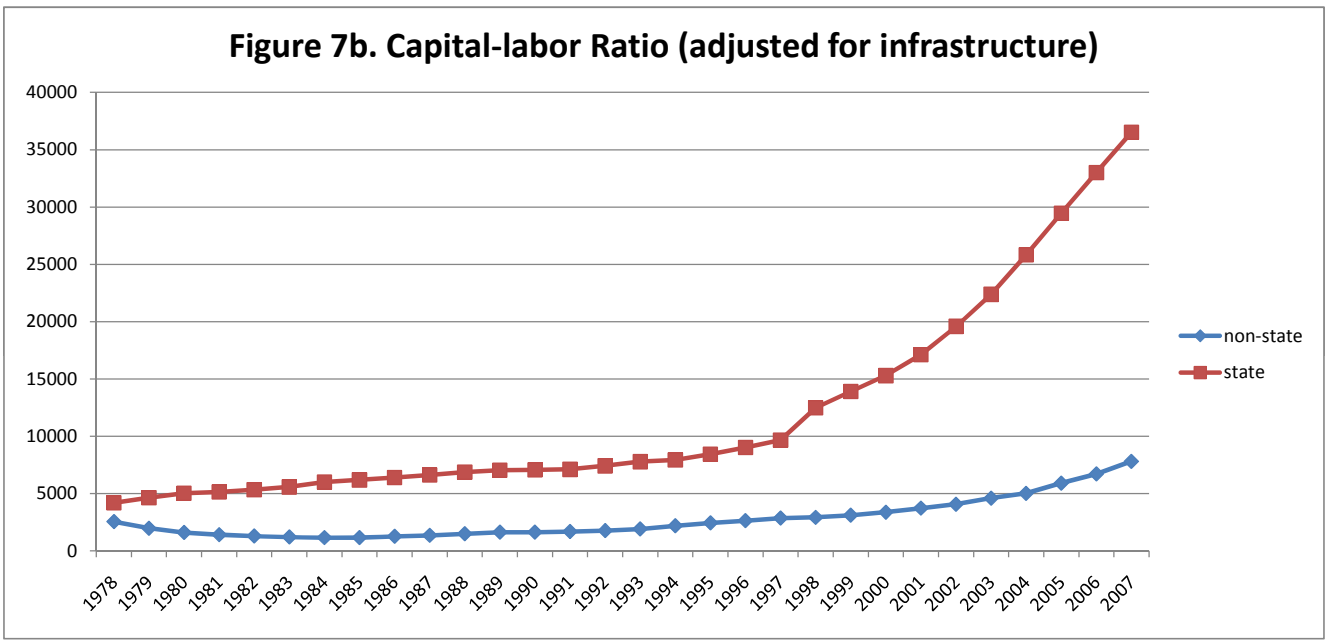


Figure 7b. Capital-labor Ratio (adjusted for infrastructure)
40000
35000
30000
25000
20000
15000
10000
5000
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
non-state
state

Table 1. Simple Growth Accounting: aggregate and by sector

Aggregate	1978-2007	1978-1988	1988-1998	1998-2007
Output per worker	7.58	6.77	6.40	9.79
capital per worker	3.66	2.58	3.35	5.21
TFP	3.92	4.19	3.05	4.58
Non-agricultural	1978-2007	1978-1988	1988-1998	1998-2007
Output per worker	5.37	2.52	5.28	8.65
capital per worker	2.15	-0.30	2.69	4.27
TFP	3.22	2.81	2.59	4.38
Non-State	1978-2007	1978-1988	1988-1998	1998-2007
Output per worker	6.16	3.91	6.40	8.39
capital per worker	1.60	-2.39	3.23	4.21
TFP	4.56	6.30	3.17	4.18
State	1978-2007	1978-1988	1988-1998	1998-2007
Output per worker	5.85	3.32	3.69	11.06
capital per worker	4.33	2.62	3.74	6.88
TFP	1.52	0.70	-0.05	4.19

The calculations here use the alternative deflators for both GDP and the capital stock, and the revised data on total employment and the share in agriculture.

Table 2. Comparison of Model's Predictions to Data (1978-2007)

	Change in agriculture's share of employment	Labor Productivity Growth					TFP Growth	
		ya	yns	ys	yn	y	An	A
Data	**-0.43**	**7.02**	**6.16**	**5.85**	**5.37**	**7.58**	**3.22**	**3.92**
Model	**-0.43**	**7.02**	**5.79**	**5.48**	**5.00**	**7.25**	**3.22**	**3.95**

ya	labor productivity in agriculture
yns	labor productivity in the non-state non-agricultural sector
ys	labor productivity in the state sector
yns	labor productivity in the non-agricultural sector
y	aggregate labor productivity
An	TFP in the non-agricultural sector
A	TFP in the aggregate

Table 3. Driving Forces of the Reallocation of Labor from Agriculture

Reduction in agriculture's share of employment due to:	**1978-2007**	**1978-1988**	**1988-1998**	**1998-2007**
TFP growth in agriculture	**39**	**19**	**13**	**6**
Reduction in barriers	**14**	**17**	**-2**	**-1**
Increase in investment rate	**6**	**3**	**1**	**2**

Table 4. Model-based growth accounting: Results from counter-factual simulations for the period 1978-2007

	Change in agriculture's	Labor Productivity Growth					TFP growth	
	employment share	agriculture	NSOEs	SOEs	non-agriculture	aggregate	non-agriculture	aggregate
Benchmark Model	**-0.43**	**7.02**	**5.79**	**5.48**	**5.00**	**7.25**	**3.22**	**3.95**
Counterfactuals:								
No TFP growth in agriculture	**-0.04**	**-0.74**	**7.08**	**6.78**	**6.30**	**5.76**	**3.22**	**2.45**
No reduction in barriers	**-0.29**	**6.27**	**2.98**	**2.98**	**2.98**	**5.04**	**2.02**	**2.94**
No reduction in ag-nonstate wage gap	**-0.34**	**6.50**	**5.76**	**5.45**	**4.97**	**6.86**	**3.22**	**3.84**
No reduction in state emplyment share	**-0.40**	**6.83**	**3.46**	**3.16**	**3.27**	**5.64**	**2.11**	**3.04**
No reduction in state wage premium	**-0.43**	**7.01**	**5.35**	**5.35**	**4.63**	**6.90**	**3.09**	**3.85**
No TFP growth in non-state sector	**-0.43**	**7.02**	**1.14**	**0.83**	**0.35**	**3.46**	**0.09**	**1.68**
No TFP growth in state sector	**-0.43**	**7.02**	**4.46**	**4.16**	**3.68**	**6.08**	**2.15**	**3.04**
No reallocation btw ag and non-ag	**0.00**	**5.34**	**7.38**	**7.07**	**6.59**	**6.28**	**3.22**	**2.91**
No capital market distortion	**-0.43**	**7.02**	**7.50**	**1.43**	**6.71**	**8.83**	**4.17**	**4.77**
No increase in investment rate	**-0.37**	**6.67**	**4.46**	**4.15**	**3.68**	**5.88**	**3.22**	**4.06**
and no capital market distortion	**-0.37**	**6.67**	**6.11**	**0.04**	**5.33**	**7.31**	**4.17**	**4.79**

Table 5. Model-based growth accounting: Results from counter-factual simulations for the three sub-periods

1978-1988	Change in agriculture's	Labor Productivity Growth					TFP growth	
	employment share	agriculture	NSOEs	SOEs	non-agriculture	aggregate	non-agriculture	aggregate
Benchmark Model	**-0.29**	**6.24**	**2.98**	**2.40**	**1.59**	**6.59**	**2.81**	**4.53**
Counterfactuals:								
No TFP growth in agriculture	**-0.10**	**-0.67**	**5.02**	**4.43**	**3.63**	**4.60**	**2.81**	**2.42**
No reduction in barriers	**-0.12**	**4.54**	**1.02**	**1.02**	**1.02**	**3.88**	**1.83**	**3.03**
No reduction in ag-nonstate wage gap	**-0.15**	**4.79**	**3.57**	**2.98**	**2.18**	**5.20**	**2.81**	**3.86**
No reduction in state emplyment share	**-0.27**	**6.03**	**0.90**	**0.32**	**0.53**	**5.50**	**1.97**	**3.80**
No reduction in state wage premium	**-0.28**	**6.20**	**2.43**	**2.43**	**1.27**	**6.27**	**2.62**	**4.37**
No TFP growth in non-state sector	**-0.29**	**6.24**	**-0.38**	**-0.97**	**-1.77**	**3.85**	**0.07**	**2.41**
No TFP growth in state sector	**-0.29**	**6.24**	**2.96**	**2.38**	**1.57**	**6.58**	**2.30**	**4.02**
No reallocation btw ag and non-ag	**0.00**	**3.58**	**6.62**	**6.03**	**5.23**	**4.79**	**2.81**	**2.37**
No capital market distortion	**-0.29**	**6.24**	**7.55**	**-3.64**	**4.41**	**9.02**	**4.73**	**6.06**
No increase in investment rate since 1978	**-0.26**	**5.92**	**2.00**	**1.42**	**0.61**	**5.45**	**2.81**	**4.60**
and no capital market distortion	**-0.26**	**5.92**	**6.44**	**-4.75**	**3.31**	**7.71**	**4.73**	**6.08**

1988-1998	Change in agriculture's	Labor Productivity Growth					TFP growth	
	employment share	agriculture	NSOEs	SOEs	non-agriculture	aggregate	non-agriculture	aggregate
Benchmark Model	**-0.08**	**7.40**	**6.17**	**3.46**	**5.05**	**6.16**	**2.59**	**3.05**
Counterfactuals:								
No TFP growth in agriculture	**0.05**	**-1.02**	**7.49**	**4.79**	**6.37**	**4.50**	**2.59**	**1.34**
No reduction in barriers	**-0.10**	**7.24**	**1.50**	**1.50**	**1.50**	**4.05**	**0.25**	**1.75**
No reduction in ag-nonstate wage gap	**-0.13**	**7.62**	**5.36**	**2.65**	**4.24**	**6.35**	**2.59**	**3.47**
No reduction in state emplyment share	**-0.09**	**7.46**	**4.73**	**2.03**	**3.13**	**4.66**	**1.12**	**1.93**
No reduction in state wage premium	**-0.07**	**7.19**	**4.15**	**4.15**	**3.71**	**4.90**	**1.34**	**1.99**
No TFP growth in non-state sector	**-0.08**	**7.40**	**2.00**	**-0.71**	**0.88**	**2.87**	**-0.19**	**1.16**
No TFP growth in state sector	**-0.08**	**7.40**	**5.52**	**2.82**	**4.40**	**5.61**	**2.67**	**3.23**
No reallocation btw ag and non-ag	**0.00**	**6.28**	**6.88**	**4.17**	**5.76**	**5.89**	**2.59**	**2.72**
No capital market distortion	**-0.08**	**7.40**	**6.10**	**-0.34**	**6.15**	**7.18**	**3.20**	**3.58**
No increase in investment rate since 1988	**-0.07**	**7.25**	**6.00**	**3.29**	**4.88**	**5.91**	**2.59**	**3.04**
and no capital market distortion	**-0.07**	**7.25**	**11.75**	**-8.05**	**8.38**	**8.95**	**5.20**	**5.20**

1998-2007	Change in agriculture's	Labor Productivity Growth					TFP growth	
	employment share	agriculture	NSOEs	SOEs	non-agriculture	aggregate	non-agriculture	aggregate
Benchmark Model	**-0.06**	**7.48**	**8.48**	**11.15**	**8.74**	**9.18**	**4.38**	**4.32**
Counterfactuals:								
No TFP growth in agriculture	**0.00**	**-0.52**	**8.93**	**11.60**	**9.18**	**8.46**	**4.38**	**3.73**
No reduction in barriers	**-0.07**	**7.11**	**6.81**	**6.81**	**6.81**	**7.44**	**4.19**	**4.14**
No reduction in ag-nonstate wage gap	**-0.06**	**7.16**	**8.63**	**11.30**	**8.88**	**9.29**	**4.38**	**4.22**
No reduction in state emplyment share	**-0.04**	**7.02**	**4.90**	**7.57**	**6.47**	**6.87**	**3.36**	**3.41**
No reduction in state wage premium	**-0.08**	**7.70**	**9.94**	**9.94**	**9.36**	**9.80**	**5.54**	**5.35**
No TFP growth in non-state sector	**-0.06**	**7.48**	**1.87**	**4.54**	**2.13**	**3.67**	**0.42**	**1.46**
No TFP growth in state sector	**-0.06**	**7.48**	**4.95**	**7.62**	**5.21**	**6.05**	**1.41**	**1.74**
No reallocation btw ag and non-ag	**0.00**	**6.25**	**8.78**	**11.45**	**9.04**	**8.38**	**4.38**	**3.72**
No capital market distortion	**-0.06**	**7.48**	**9.01**	**9.03**	**9.90**	**10.44**	**4.62**	**4.65**
No increase in investment rate since 1998	**-0.04**	**7.01**	**7.91**	**10.58**	**8.17**	**8.40**	**4.38**	**4.29**
and no capital market distortion	**-0.04**	**7.01**	**14.53**	**-4.45**	**12.92**	**12.72**	**7.53**	**6.99**

Table 6. Counterfactual simulations using alternative data sets

	Change in Agirculture's Employment Share				Aggregate Labor Productivity Growth Rate			
Benchmark Data	1978-2007	1978-1988	1988-1998	1998-2007	1978-2007	1978-1988	1988-1998	1998-2007
Calibrated Model	**-0.43**	**-0.29**	**-0.08**	**-0.06**	**7.25**	**6.59**	**6.16**	**9.18**
Counter-Factuals								
No TFP growth in agriculture	**-0.04**	**-0.10**	**0.05**	**0.00**	**5.76**	**4.60**	**4.50**	**8.46**
No Reduction in Barriers	**-0.29**	**-0.12**	**-0.10**	**-0.07**	**5.04**	**3.88**	**4.05**	**7.44**
No Reduction in ag-nonstate wage gap	**-0.34**	**-0.15**	**-0.13**	**-0.06**	**6.86**	**5.20**	**6.35**	**9.29**
No Reduction in state employment share	**-0.40**	**-0.27**	**-0.09**	**-0.04**	**5.64**	**5.50**	**4.66**	**6.87**
No Reduction in state wage premium	**-0.43**	**-0.28**	**-0.07**	**-0.08**	**6.90**	**6.27**	**4.90**	**9.80**
No TFP growth in non-state sector	**-0.43**	**-0.29**	**-0.08**	**-0.06**	**3.46**	**3.85**	**2.87**	**3.67**
No TFP growth in state sector	**-0.43**	**-0.29**	**-0.08**	**-0.06**	**6.08**	**6.58**	**5.61**	**6.05**
No reallocation of labor btw ag and non-ag	**0.00**	**0.00**	**0.00**	**0.00**	**6.28**	**4.79**	**5.89**	**8.38**
No capital market distortion	**-0.43**	**-0.29**	**-0.08**	**-0.06**	**8.83**	**9.02**	**7.18**	**10.44**
No increase in investment rate since 1978	**-0.37**	**-0.26**	**-0.07**	**-0.04**	**5.88**	**5.45**	**5.00**	**7.35**
and no capital market distortion	**-0.37**	**-0.26**	**-0.07**	**-0.04**	**7.31**	**7.71**	**5.92**	**8.43**
No increase in investment rate since 1988	**-0.40**	**-0.29**	**-0.07**	**-0.04**	**6.80**	**6.59**	**5.91**	**8.01**
and no capital market distortion	**-0.40**	**-0.29**	**-0.07**	**-0.04**	**8.27**	**6.59**	**8.95**	**9.38**
No increase in investment rate since 1998	**-0.41**	**-0.29**	**-0.08**	**-0.04**	**7.00**	**6.59**	**6.16**	**8.40**
and no capital market distortion	**-0.41**	**-0.29**	**-0.08**	**-0.04**	**8.34**	**6.59**	**6.16**	**12.72**
Official Data	1978-2007	1978-1988	1988-1998	1998-2007	1978-2004	1978-1991	1991-2004	1998-2007
Calibrated Model	**-0.30**	**-0.21**	**-0.05**	**-0.04**	**7.14**	**6.96**	**6.55**	**8.01**
Counter-Factuals								
No TFP growth in agriculture	**0.12**	**0.00**	**0.09**	**0.03**	**4.71**	**4.09**	**4.05**	**6.16**
No Reduction in Barriers	**-0.28**	**-0.14**	**-0.07**	**-0.08**	**5.52**	**5.92**	**4.02**	**6.74**
No Reduction in ag-nonstate wage gap	**-0.33**	**-0.16**	**-0.10**	**-0.07**	**7.26**	**6.37**	**6.91**	**8.65**
No Reduction in state employment share	**-0.26**	**-0.19**	**-0.05**	**-0.01**	**5.67**	**6.74**	**4.58**	**5.68**
No Reduction in state wage premium	**-0.30**	**-0.20**	**-0.04**	**-0.06**	**6.81**	**6.74**	**5.28**	**8.58**
No TFP growth in non-state sector	**-0.30**	**-0.21**	**-0.05**	**-0.04**	**2.74**	**4.27**	**1.24**	**2.70**
No TFP growth in state sector	**-0.30**	**-0.21**	**-0.05**	**-0.04**	**5.83**	**5.89**	**5.78**	**5.83**
No reallocation of labor btw ag and non-ag	**0.00**	**0.00**	**0.00**	**0.00**	**5.93**	**5.09**	**5.75**	**7.06**
No capital market distortion	**-0.30**	**-0.21**	**-0.05**	**-0.04**	**8.43**	**7.48**	**8.33**	**9.59**
No increase in investment rate since 1978	**-0.23**	**-0.18**	**-0.04**	**-0.01**	**5.57**	**5.67**	**5.10**	**5.99**
and no capital market distortion	**-0.23**	**-0.18**	**-0.04**	**-0.01**	**6.75**	**6.15**	**6.77**	**7.38**
No increase in investment rate since 1988	**-0.26**	**-0.21**	**-0.04**	**-0.02**	**6.61**	**6.96**	**6.24**	**6.63**
and no capital market distortion	**-0.26**	**-0.21**	**-0.04**	**-0.02**	**7.84**	**6.96**	**8.46**	**8.12**
No increase in investment rate since 1998	**-0.27**	**-0.21**	**-0.05**	**-0.02**	**6.85**	**6.96**	**6.55**	**7.05**
and no capital market distortion	**-0.27**	**-0.21**	**-0.05**	**-0.02**	**8.00**	**6.96**	**6.55**	**10.76**

Table 7. Counterfactual simulations using the model with infrastructure

	Change in Agirculture's Employment Share				Aggregate Labor Productivity Growth Rate			
Benchmark Data	1978-2007	1978-1988	1988-1998	1998-2007	1978-2007	1978-1988	1988-1998	1998-2007
Calibrated Model	**-0.43**	**-0.29**	**-0.08**	**-0.06**	**6.88**	**6.60**	**5.73**	**8.46**
Counter-Factuals								
No TFP growth in agriculture	**-0.04**	**-0.10**	**0.05**	**0.00**	**5.34**	**4.59**	**3.98**	**7.68**
No Reduction in Barriers	**-0.29**	**-0.12**	**-0.10**	**-0.07**	**5.28**	**4.30**	**4.06**	**7.71**
No Reduction in ag-nonstate wage gap	**-0.34**	**-0.15**	**-0.13**	**-0.06**	**6.52**	**5.24**	**5.94**	**8.58**
No Reduction in state employment share	**-0.40**	**-0.27**	**-0.09**	**-0.04**	**5.87**	**5.93**	**4.67**	**7.15**
No Reduction in state wage premium	**-0.43**	**-0.28**	**-0.07**	**-0.08**	**6.53**	**6.28**	**4.49**	**9.08**
No TFP growth in non-state sector	**-0.43**	**-0.29**	**-0.08**	**-0.06**	**3.24**	**3.97**	**2.40**	**3.36**
No TFP growth in state sector	**-0.43**	**-0.29**	**-0.08**	**-0.06**	**5.55**	**6.61**	**5.12**	**4.85**
No reallocation of labor btw ag and non-ag	**0.00**	**0.00**	**0.00**	**0.00**	**6.02**	**4.93**	**5.56**	**7.75**
No capital market distortion	**-0.43**	**-0.29**	**-0.08**	**-0.06**	**7.87**	**8.02**	**6.33**	**9.40**
No increase in investment rate since 1978	**-0.37**	**-0.26**	**-0.07**	**-0.04**	**5.57**	**5.42**	**4.64**	**6.79**
and no capital market distortion	**-0.37**	**-0.26**	**-0.07**	**-0.04**	**6.45**	**6.74**	**5.17**	**7.56**
No increase in investment rate since 1988	**-0.40**	**-0.29**	**-0.07**	**-0.04**	**6.46**	**6.60**	**5.49**	**7.37**
and no capital market distortion	**-0.40**	**-0.29**	**-0.07**	**-0.04**	**7.36**	**6.60**	**7.26**	**8.33**
No increase in investment rate since 1998	**-0.41**	**-0.29**	**-0.08**	**-0.04**	**6.65**	**6.60**	**5.73**	**7.74**
and no capital market distortion	**-0.41**	**-0.29**	**-0.08**	**-0.04**	**7.48**	**6.60**	**5.73**	**10.42**

Appendix

Simple Growth Accounting Using Official Data

Table A1 reports simple growth accounting results using official deflators and employment series. The use of official data only modestly modifies the basic picture. Rates of growth in output per worker at the aggregate level are very similar between the benchmark and the official data, with the effect of slightly lower rates of inflation in the official data offset by more rapid employment growth. Using the official deflator for capital accumulation however makes capital deepening more important and the contribution of TFP growth lower as a result of the more rapid growth in the capital stock. A fairly similar picture using the benchmark and official data also emerges with respect to the non-agricultural sector. Gains in TFP growth in the state sector between the last two periods are also much smaller using the official data, largely because of the more rapid rates of capital accumulation.[14]

Table A1 here

Comparison with the Literature

In Table A2, we compare our results from the standard aggregate growth accounting with a number of prominent ones in the literatures constructed for similar periods. The differences are marginal.

Table A2 here

For the slightly shorter period between 1978 and 1998, however, our estimate of TFP in the non-primary sector is higher than that reported by Young (2003), which is often cited as an important

[14] Productivity in the state and non-state sectors based on an alternative relative wage series that includes in-kind compensation leaves the growth accounting for the entire non-primary sectors unchanged. It also does not influence the growth in capital per worker in either the state or non-state sector. The change does influence however the rate of growth in labor productivity and our estimate of TFP in the two sectors, especially in the period up through 1998. For the full period, the revision implies significantly higher growth in output per worker and TFP in the non-state sectors, and very small increases in the state sector. The reason for the latter is that larger differences in output per worker between the state and the non-state at the beginning implies that the reallocation of labor away from the state will lower the growth rate of the non-agriculture sector, which must be compensated by higher growth rates within the two sectors.

benchmark in the assessment of Chinese data. Table A3 compares our estimates with those Young provides to identify the underlying reasons for the differences. We focus on four key components: nominal GDP estimates, deflators, employment, and the capital stock.

Table A3 here

First, our estimates of nominal GDP growth are slightly higher than Young's (15.74 versus 15.37) reflecting the effect of the 2006 NBS revision to GDP estimates. Most of the revision occurred in the tertiary sector. These revised estimates were not available to Young. Second, as discussed in the text, we construct an alternative deflator for the tertiary sector to reflect the growing role of businesses services, and the differences in the rate of inflation in business services compared to consumer services. Our alternative deflator for the tertiary sector shows 2.5 percent less inflation per year. These two revisions lead to an upward revision in the rate of real GDP growth in the non-primary sector from 8.1 to 9.5 percent annum, of which 0.4 percentage points is due to the upward revision of nominal GDP estimates, and 1.0 percentage points is due to the use of alternative deflator for the tertiary sector. All else equal, they also result in an upward revision of TFP of 1.4 percentage points.

The upward revision in the rate of growth in real output in the non-primary sector is partially offset by our revisions to the employment data, and differences in the employment series used. Young extends an older employment series to cover the period between 1990 and 1998 rather than combine the pre-1990 un-revised labor series with the revised series for the post-1998 period. We combined the revised series after 1990, with our own revision to the pre-1990 data. We also construct our own estimate of the share of the labor force in the primary sector, which results in a more rapid exodus of labor out of agriculture, and more rapid growth of employment in the non-primary sector. Young's employment estimate shows growth of 4.5 percent annum between 1978 and 1998, compared to 5.6 per annum growth in our estimates. This reduces the gap in the two estimates of output per worker: 3.6 by Young, versus our estimate of 3.93.

Finally, there are small differences in the estimates of the rate of capital accumulation that reflect differences in construction, and fixed investment deflators. First, Young uses estimates of

the breakdown in capital formation between the primary and non-primary sectors at the provincial level to construct national-level estimates of the nominal capital stock in the non-primary sector. A careful examination of these data makes them suspect in numerous provinces, and we selected to construct estimates on the basis of national-level fixed investment data disaggregated by sector and ownership. Second, there may be differences in the starting values used for the capital stock in 1978, which could also affect the rate of growth. In nominal terms, Young's capital stock grows at 16.6 percent per annum compared to our estimate of 17.0. Third, there are small differences in the deflators. We have tried to use identical methods, but modest differences emerge on the order of 0.6 percent per year. One potential source of the difference is the data on building costs for structures: Young uses building costs for the state sector, while we use costs for both the state and non-state. Young's estimate of the capital stock grows at 7.7 percent per annum, compared to our estimate of 6.6 percent.

To summarize, our estimate of GDP per worker grows at an annual rate of 3.93 percent compared to Young's 3.6 percent. Ignoring the role of human capital, and assuming a share of capital of 0.50, our estimates imply a rate of growth of TFP in the non-primary sector of 3.4 percent per annum compared to Young's estimate of 2.0 percent. Adjustments for human capital will lower this by between 0.5 and 1.0 percent per year.

Comparison of the model-based accounting with a simple decomposition.

Other authors have used a simple decomposition to quantify the contribution of the labor reallocation. The decomposition begins by noting that aggregate labor productivity can be expressed as the weighted average of productivities in the two sectors: $y_t = y_{at} l_{at} + y_{nt}(1 - l_{at})$. The aggregate labor productivity growth, then, can be expressed as follows:

$$d \ln y_t = \frac{y_{at} l_{at}}{y_t} d \ln y_{at} + \frac{y_{nt}(1 - l_{at})}{Y_t} d \ln y_{nt} - \frac{y_{nt} - y_{at}}{y_t} dl_{at}.$$

That is, the aggregate labor productivity growth can be decomposed into three sources: labor productivity growth in both sectors and labor reallocation. Without labor movement between the two sectors (i.e. $dl_{at} = 0$), the growth rate of aggregate labor productivity simply equals the

weighted average of the growth rates of labor productivities in the two sectors, with the weights being the GDP shares of the two sectors, respectively. Any extra growth beyond this average, then, is attributed to the labor reallocation.

These simple decompositions tell us that reallocation across sectors is positively associated with growth, but the estimated magnitude of the reallocation effect resulting from this analysis is likely to be biased. There are two primary reasons for believing that this is the case.[15] First, the reallocation of labor may be a result of the growth in TFP in the two sectors. If that is the case, the decomposition may overestimate the role of the reallocation and underestimate the role of labor productivity growth within sectors.[16] And second, labor productivity growth within each of the two sectors will depend on labor reallocation. Because of diminishing returns, all else equal, the gap in productivities between the two sectors will narrow as labor is reallocated from agriculture to non-agriculture. Simple decompositions ignore all these potentially important considerations surrounding inter-sectoral productivity and labor flows.[17] They provide no more than an upper bound for the actual contribution of labor reallocation out of agriculture to overall growth during China's reform period.

Table A4 here

Table A4 reports the estimated contribution of the labor reallocation to labor productivity growth using this popular approach as well as the estimated contribution obtained from the counter-factual simulations based on our dynamic three-sector model. Our estimate is significantly less than

[15] There is also a third potential bias. The decompositions implicitly assume that the "gaps" in average and marginal productivities of labor between sectors are the same. The returns to reallocation depend on differences in marginal productivity however the decompositions are based on information on averages. If the underlying production technology is Cobb-Douglas and labor shares in the two sectors are the same, the ratio of average and marginal productivity between sectors will be the same, but this does not hold true for other functional forms. It is an empirical matter as to how sensitive the returns to reallocation are to alternative assumptions about the underlying technology. Based on sensitivity analysis we carried out, this is not an important consideration here.

[16] This bias generally exists in standard growth accounting in which the contribution of capital accumulation is overestimated, and that of TFP is underestimated.

[17] The problems of using these simple decomposition methods are also revealed in trying to estimate the returns to reallocation of labor between the state and non-state non-agricultural sector. At the beginning of reform, average labor productivity in the state sector was actually higher than that in the non-state. This would imply negative returns to the reallocation. However, differences in TFP between the two sectors offset this.

the estimate from the "naive" simple decomposition. For the period between 1978 to 2007, the contribution of the reallocation is only 13 percent compared to the 23 percent estimate using the simple decomposition method. The difference is even larger for the first sub-period, when nearly half of the reallocation occurred. Our model-based accounting suggests that the contribution of labor reallocation to overall labor productivity growth is only 1.80 percentage points, while the simple decomposition implies a contribution that is almost two times as large, 3.36 percentage points. These differences point to the shortcomings of the simple decomposition method.

The Model with infrastructure capital investment by the state sector

We break down capital in the state sector into infrastructure and non-infrastructure capital and denote them by K_{pt} and K_{st}, respectively. We modify the production functions for both the state and the non-state sectors to include infrastructure capital as an input.

$$Y_{st} = A_{st} K_{pt}^{\gamma_1} K_{st}^{\gamma_2} L_{st}^{\alpha}, \tag{16}$$

$$Y_{nst} = A_{nst} K_{pt}^{\gamma_1} K_{nst}^{\gamma_2} L_{nst}^{\alpha}. \tag{17}$$

Following Aschauer (1989) and Hulten (1996), we assume that the production functions are constant returns to scale with respect to all inputs. That is, $\gamma_1 + \gamma_2 + \alpha = 1$. Given these assumptions and the parameter choices, we can then calculate the returns to infrastructure capital and to capital in the state and non-state sectors as follows:

$$\begin{aligned} r_{pt} &= \gamma_1 \frac{Y_{st} + Y_{nst}}{K_{pt}} = \gamma_1 \frac{Y_{nt}}{K_{pt}}, \\ r_{st} &= \gamma_2 \frac{Y_{st}}{K_{st}}, \\ r_{nst} &= \gamma_2 \frac{Y_{nst}}{K_{nst}}. \end{aligned}$$

To empirically calculate these returns, we need to estimate the infrastructure capital in the data. To do so we break the investment by the state into infrastructure and non-infrastructure investments. We then use the investment data to generate the infrastructure and non-infrastructure capital stock, respectively. China's fixed investment yearbooks provide annual data on the compo-

sition of state-sector fixed investment. We use a broad definition of infrastructure, and include state investment in transportation; electricity, gas and water; water management; health, and education. Of these categories, transportation and power are the most important, and represent more than eighty percent of total state infrastructure investment. Over time, the share of state investment going to infrastructures steadily rises from 25 percent at the start of the reforms to as high as 49.6 percent in 2006. Since our definition of state sector investment also includes shareholding companies (which are not included in the definition above of state fixed investment), we then apply our estimates of the share of state investment going to infrastructure to total investment by the state (state owned plus shareholding companies) to obtain our estimate of total state infrastructure investment. Finally, the non-infrastructure capital stock in the state sector is simply the total capital stock in the state sector minus the infrastructure capital stock.

We continue to set α to 0.5. For the output elasticities of infrastructure and non-infrastructure capital, we calibrate their values by assuming that the returns to infrastructure capital and the returns to private capital in the non-state sector are equalized on average[18]:

$$\gamma_1 \overline{\frac{Y_n}{K_p}} = \gamma_2 \overline{\frac{Y_{ns}}{K_{ns}}}.$$

We can calculate the average output to capital ratios $\overline{\frac{Y_n}{K_p}}$ and $\overline{\frac{Y_{ns}}{K_{ns}}}$ from the data. The equation above and the fact that $\gamma_1 + \gamma_2 + \alpha = 1$ then allow us to pin down the value of γ_1 and γ_2, which turn out to be 0.15 and 0.35, respectively.

References

[1] Aschauer, David. 1989. "Is Public Expenditure Productive?" Journal of Monetary Economics 23, 177-200.

[18] Given the inefficiency of infrastructure investment in the state sector, this assumption is likely to overestimate the returns to public intrastructure capital and therefore its output elasticity γ_1. Alternatively, we could have assumed that the returns to infrastructure capital and the returns to non-infrastructure capital in the state sector are equalized on average. This would imply a much smaller γ_1. Our main growth accounting results, however, are robust to these alternative values of γ_1.

[2] Hulten, Charles. 1996. "Infrastructure Capital and Economic Growth: How Well You Use It May Be More Important than How Much You Have." NBER Working Paper 5847.

Table A1. Simple Growth Accounting Using Official Data

Aggregate	1978-2007	1978-1988	1988-1998	1998-2007
Output per worker	7.46	6.73	7.09	8.68
capital per worker	4.28	3.54	3.97	5.46
TFP	3.17	3.19	3.12	3.22
Non-agricultural	1978-2007	1978-1988	1988-1998	1998-2007
Output per worker	5.97	4.75	5.89	7.40
capital per worker	3.08	1.93	2.92	4.55
TFP	2.88	2.82	2.97	2.86
Non-State	1978-2007	1978-1988	1988-1998	1998-2007
Output per worker	6.88	5.94	7.64	7.09
capital per worker	2.14	-0.15	2.53	4.25
TFP	4.74	6.09	5.11	2.84
State	1978-2007	1978-1988	1988-1998	1998-2007
Output per worker	6.58	5.35	4.95	9.74
capital per worker	5.21	3.64	5.03	7.17
TFP	1.36	1.71	-0.08	2.57

Table A2: Comparison of Growth Accounting Exercises in the Literature

		Annual Growth Rate				Contribution to Y/L			Contribution to Y/L in Percent	
	Period	GDP	L	Human Capital Adjusted Labor	Y/L	K	Education	TFP	TFP	TFP and Education
Bosworth and Collins (2008)	1978-2004	9.3	2.0		7.3	3.2	0.3	3.6	49.3	53.4
	1978-1993	8.9	2.5		6.4	2.4	0.4	3.5	54.7	60.9
	1993-2004	9.7	1.2		8.5	4.2	0.3	3.9	45.9	49.4
Perkins and Rawski (2008)	1978-2005	9.5	1.9	2.7	7.6	4.7	0.4	3.4	45.2	50.6
Zheng, Bigsten and Hu (2006)	1978-1993	9.9	2.5		7.4	3.1		4.3	58.6	
	1993-2004	9.9	1.1		8.9	5.6		3.3	36.9	
Brandt and Zhu (2009)	1978-2007	9.3	1.7		7.6	3.6		3.9	51.3	
	1978-1993	8.3	2.4		6.0	2.5		3.5	58.3	
	1993-2004	9.6	1.1		8.5	4.6		3.9	45.9	

Note: In Brandt and Zhu, TFP is TFP plus human capital.

Table A3. Comparison with Alwyn Young (2003)

	Young (2003)	BZ(2009)	Explanation for difference
Nominal GDP	15.4	15.7	Revision by NBS in 2006
Nonagr GDP	16.0	16.4	Revision by NBS in 2006
GDP deflators			
Primary	7.9	7.9	Identical
Secondary	6.1	6.1	Identical
Tertiary	10.7	8.2	We constructed new deflator that captures costs of business services. Young uses consumer service deflator
Capital stock deflator	8.9	9.5	Use nearly identical method, however we use unit building costs for all structures, while Young uses for state sector only
Real GDP	7.4	8.7	27 percent of difference due to revised nominal GDP numbers; 73 percent due to revised tertiary sector deflator
Real nonagr	8.1	9.5	
Labor	2.2	2.1	Differences in employment series used
Agr	0.8	-0.2	Differences in emploment series used and our use of alternative estimate for share of labor in primary sector
Nonagr	4.5	5.6	Same as above
Real GDP per worker	5.2	6.6	
Agr			
Nonagr	3.6	3.9	
Labor shares nonagr			
1978	0.3		
1998	0.5	0.5	
Capital stock			
Nominal	16.6	17.0	Due to differences in construction. Young bases estimates of composition on provincial GFCF data while we construct estimates using sector estimates for state, collective and housing sector for fixed investment; may also be differences in starting values
Real	7.7	6.6	55 percent due to differences in deflator, and 45 percent due to differences in estimate of nominal capital stock
TFP excluding human capital	2.0	3.4	

Table A4. Contribution to Growth of the Reallocation of Labor from Agriculture

	1978-2007	1978-1988	1988-1998	1998-2007
Based on simple decomposition:				
growth rate	1.74	3.36	0.80	1.20
percentage	0.23	0.50	0.12	0.12
Based on the model:				
growth rate	0.97	1.80	0.27	0.80
percentage	0.13	0.27	0.04	0.08