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GROWTH IN CHINA 1978-2008: FACTOR ACCUMULATION, FACTOR REALLOCATION, AND IMPROVEMENTS IN PRODUCTIVITY

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BACKGROUND PAPER FOR "CHINA BIG IDEAS" REPORT

INTRODUCTION

China's economic success over the past three decades can be decomposed into three broad contributions to growth: accumulation of labor and capital, growth induced by structural transformation (i.e., the reallocation of labor and capital across sectors and ownership units), and growth in total factor productivity. Understanding the evolution of these three growth determinants is important for understanding China's future growth potential. For example, in the neoclassical growth model, rapid growth through factor accumulation eventually slows with the onset of diminishing returns. And growth achieved through the reallocation of factors of production from less efficient to more efficient uses will also eventually peter out as marginal products of factors are equated across units.

In this paper we perform a growth accounting exercise for China which allows us to separate these three broad contributions to growth. The main novelty of our exercise lies in our efforts to understand the role of reallocation of both capital and labor across major sectors (agriculture, industry, and services), and across ownership forms (state, collective, and other).

This paper contributes to a long-standing literature on understanding the sources of Chinese growth. This literature began in earnest in the 1990s with contributions by Borensztein and Ostry (1996), Chow (1993), and Hu and Khan (1997), among others. Motivated by the huge shift of labor out of agriculture since economic reforms began in China in the late 1970s, some of these studies focused on the contribution of labor reallocation to growth. In particular, Woo (1998) and Young (2003) account for labor reallocation effects out of agriculture, and produce low estimates of TFP growth; Woo finds TFP growth of 1.1% over 1979-1993, while Young finds TFP growth of 1.4% over 1978-1998. Brandt, et al. (2008) account for labor reallocation out of agriculture as well as out of state firms within the non-agricultural sector; they find that the latter reallocation has been particularly important for China's recent growth. Cao, et al. (2009) also study TFP growth and account for reallocation effects over the period 1982-2000.

This paper updates and significantly expands the methodology used in World Bank (1997), which also isolates the contribution of labor reallocation to growth. Our analysis adds to existing studies by looking at capital reallocation in addition to labor reallocation across both economic sectors (primary, industry, and tertiary) as well as ownership types within industry and services (state-owned, collective, and other). This emphasis on capital reallocation is important in light of continuing distortions in financial markets in China that many observers have argued are responsible for substantial misallocation of financial resources across different types of firms. While this issue is of strong current policy relevance, our evidence here is also more tentative, given the difficulties in piecing together credible estimates of sectorally-disaggregated capital stocks by ownership using available published Chinese statistics. Our emphasis on misallocation of capital is shared with Hsieh and Klenow (2008) and Dollar and Wei (2007).

We find a TFP growth of 2.1 percent over the entire period 1978-2008; in recent years, however, TFP growth has declined sharply, from 2.9 percent over 1979-1995, to 1.0 percent over 1996-2008. Reallocation of capital and labor to more efficient uses has also contributed importantly to growth, each accounting for 0.8 percentage points of growth per year on average. Notably, the contribution of capital reallocation to growth has increased in recent years, averaging just 0.4 percentage points of growth during the first half of the sample, but 1.3 percentage points of growth subsequently. Regarding the scope for future growth through factor reallocation, our findings suggest that sectoral differences in marginal products of both capital and labor remain substantial across broad sectors, indicating nontrivial scope for continued future growth through factor reallocation.

The following section lays out our data and assumptions, Section II presents our methodology, Section III discusses our results, and Section IV presents a sensitivity analysis. A detailed description of data sources and construction is provided in a separate data appendix.

I. DATA AND ASSUMPTIONS

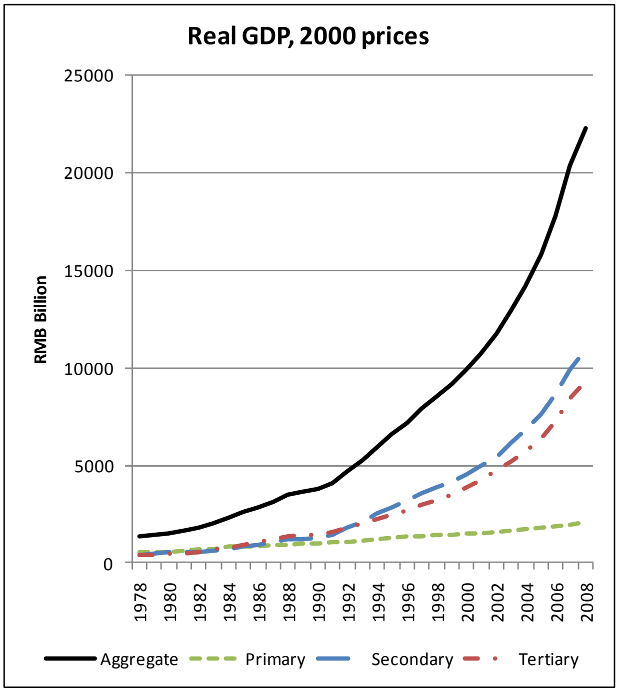
Our interest in this paper is in the contribution of reallocation of capital and labor across sectors to China's rapid growth performance. We calculate the contributions to growth across three sectors of the economy (primary, secondary, tertiary), as well as across ownership units (state, collective, and other) within the secondary and tertiary sectors. Given data limitations and the large share of individual employment in the primary sector, we do not disaggregate primary sector data by ownership type. For the analysis, we require aggregate and sector-level data on GDP, employment, and capital stocks by ownership, as well as estimates for the capital income share, for the same level of disaggregation. A brief discussion of the construction of these data sets and necessary assumptions follows, with a more complete description provided in a data appendix.

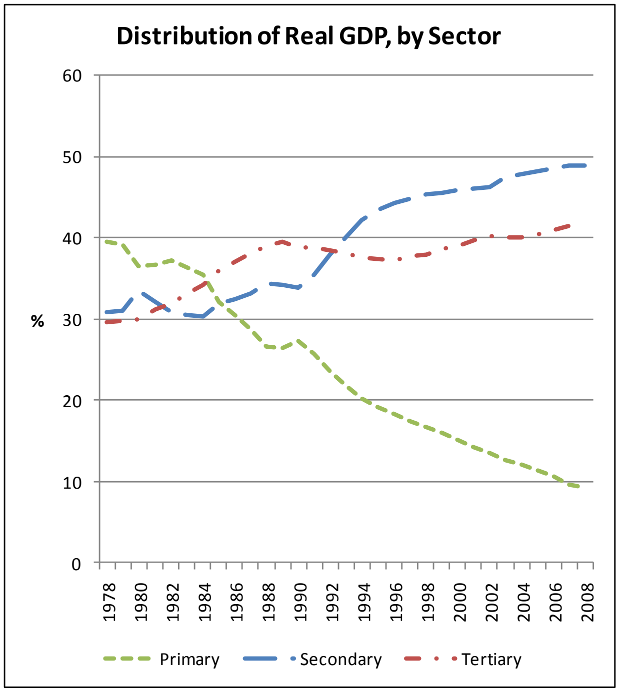
A few potential concerns are worth noting at the outset. First, Chinese data often ignores small enterprises and self-employed individuals, which tends to bias downwards estimates for collective and "other" output, investment, and employment (most state firms will be larger than the minimum reporting requirements). We do our best to scale up estimates appropriately, but there is no wholly satisfying fix for this problem.

Additionally, the evolving enterprise classification system makes identification of state ownership as much an art as a hard science. We attempt to include all state-owned and state-controlled units (SOUs) in our "state" sector, which includes joint ownership firms where the state maintains a controlling interest. However, as reclassifications occurred over our three-decade time horizon, it is likely that some data are for smaller subsets, e.g., directly-controlled state-owned enterprises (SOEs). Similarly, given frequent reclassifications of enterprise types and data availability (particularly during the 1980s and 1990s), we generally calculate "other" enterprises as a residual, which prevents us from differentiating between foreign, private, self-employed, and other firm types. Disaggregation of "other" firms to include foreign and private firms would be a valuable future contribution, but one that is difficult to implement given the limitations of available data.

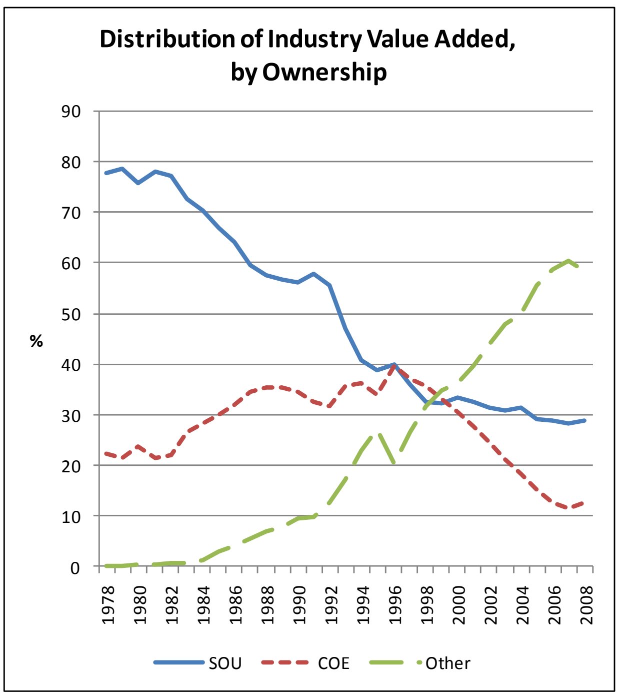
GDP and Value Added

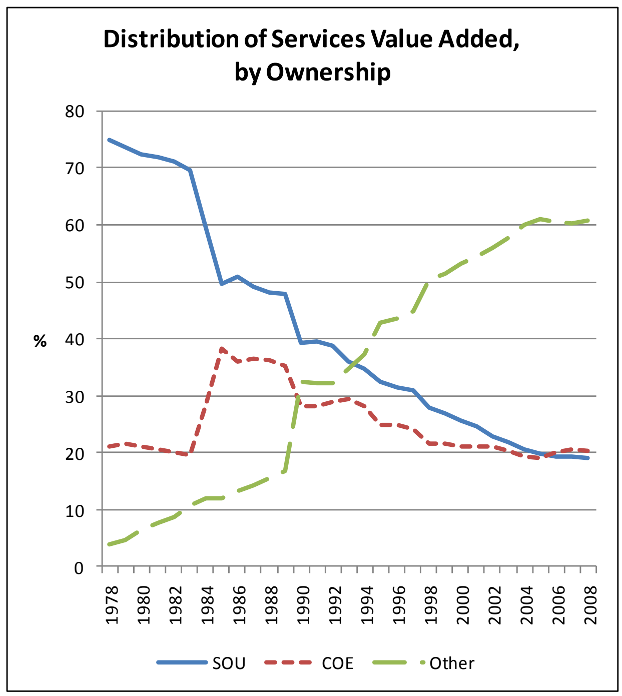
Significant debate exists over whether China's official deflators overestimate growth; however, with no consensus on a superior deflator we opt to use official statistics. In the sensitivity analysis, we experiment with an alternate deflator. Primary, secondary, and tertiary GDP is calculated at 2000 prices, with aggregate GDP calculated as the sum across sectors. The charts below show the evolution of GDP by sector. As expected, there is a precipitous decline in value added in the primary sector. Surprisingly, after rapid growth in the 1980s, the services sector share has remained relatively flat for the past two decades, while industry has grown rapidly.





Official data on industrial value added (IVA) by ownership begins in 1981. For 1978-1980, we generate data based on gross output value of industry (GOVI) data. IVA statistics after 1998 only include industries "above designated size" (defined as annual income of at least 5 million yuan). While this includes almost all SOEs, it excludes small private enterprises and small collective units. To generate a consistent series and include all enterprises, we calculate adjusted IVA based on recalculations of GOVI for 2000-2008, assuming that the growth rate in output for small collective firms is equivalent to the growth rate of TVE industrial employment and that the growth rate of the small "other" enterprise sector is equivalent to the growth rate of private and individual employment.[1] We assume that the IVA/GOVI ratios from the official data hold for the adjusted set. To arrive at total IVA, we add in construction value added (CVA),[2] estimated based on official data for aggregate CVA and ownership shares of gross output value of construction. To disaggregate service sector value added, ownership shares are calculated assuming value added shares equivalent to employment shares across state, collective, and other categories; in other words, we assume value added per worker is the same across ownership categories). This is a strong assumption, but one with no viable alternative.





[1] We assume that SOE output is equal to the "above designated size" estimate This assumption is motivated by the equal values of these two accounting methods in 1998 and 1999 (data for these two years is presented using both accounting methods), as well as the assumption that by the late 1990s, following the *zhuada fangxiao* ("grasp the big, release the small") strategy, most, if not all, SOEs under 5 million yuan had been restructured. In the sensitivity analysis, we re-run the results using the official un-adjusted data.

[2] Construction data is unreliable; while we estimate values to our best ability, we also find it helpful to report results excluding the construction sector from IVA calculations.

As seen in the charts above, state ownership shares have declined dramatically over the last 30 years in both industry and services, falling from nearly 80% of value added to 30% and 20%, respectively.[3] In the 1980s, the collective sector took up much of this growth with the rapid development of TVEs; over the 1990s and 2000s, however, industrial and service sector growth has been led by foreign and private firms.

Employment[4]

For total employment and employment across sectors (agriculture, industry, and services), we begin with official NBS data and then scale up pre-1990 data to reflect census revisions (which result in a discontinuous 100 million employee jump between 1989 and 1990), distributing across sectors based on official sector employment shares. There is an additional potential problem concerning the overestimation of agricultural employment as a result of undocumented off-farm migration as well as non-farm rural self-employment. As the official statistics account for some migration, we accept the official numbers, experimenting with out-migration estimates in our sensitivity analysis. As the charts below show, revised data are essential to make sense of the discontinuity in official statistics in 1990. Both industrial and service sector employment have risen rapidly to take up off-farm migration. Even excluding adjustments for off-farm migration, the agriculture employment share fell from 70% in 1978 to below 40% in 2008.

To disaggregate employment across ownership categories, we use statistics on "total staff and workers," SOU employment, collectively-owned enterprise (COE) employment, town and village enterprise (TVE) employment, and private and individual employment across sectors. The services share by ownership type is calculated as a residual.[5] As seen in the charts below, employment in SOUs has declined precipitously in both industry and services, from over 50% of employment in industry to less than 6%, and from 75% of services employment to less than 20%. These declines in state employment shares are far more dramatic than the corresponding output shares in the previous graphs, implying sharp increases in output per worker in the state sector.

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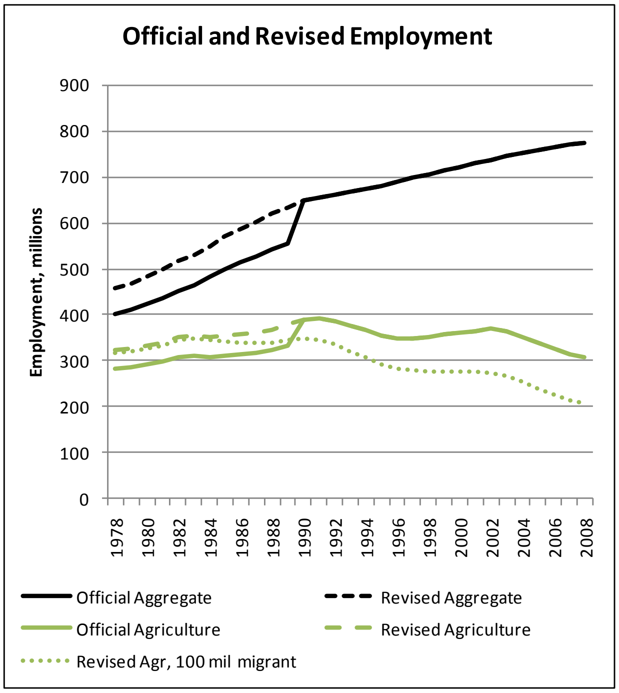
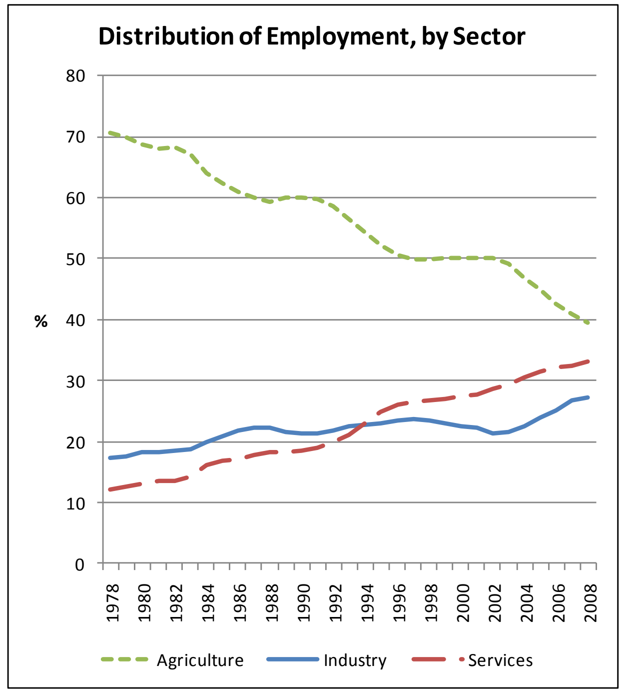
[3] The sharp decline in SOU services value added and the corresponding increase in COE services value added in 1983-1984 comes from official data on SOU, TVE, and urban COE employment by sector, which show total employment for SOUs dropping slightly from 1983-1984 while TVE employment grows by 60% and urban COE employment grows by almost 20%. Although the discontinuity implies new reporting guidelines, we for now continue to use official data.

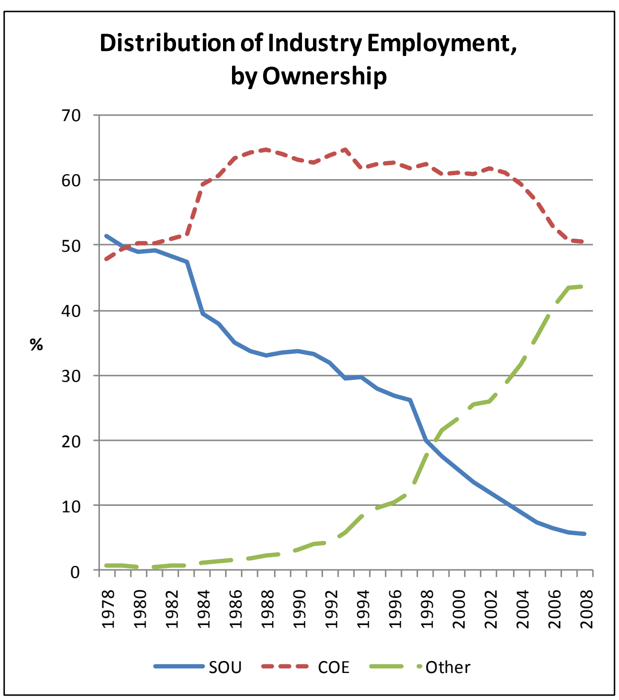
[4] Note that we focus on employment, while other studies (e.g., Perkins and Rawski, 2008) focus on working-age population; this is essential for disaggregating employment across sectors. We also do not adjust employment for human capital gains, which would lower our TFP estimates.

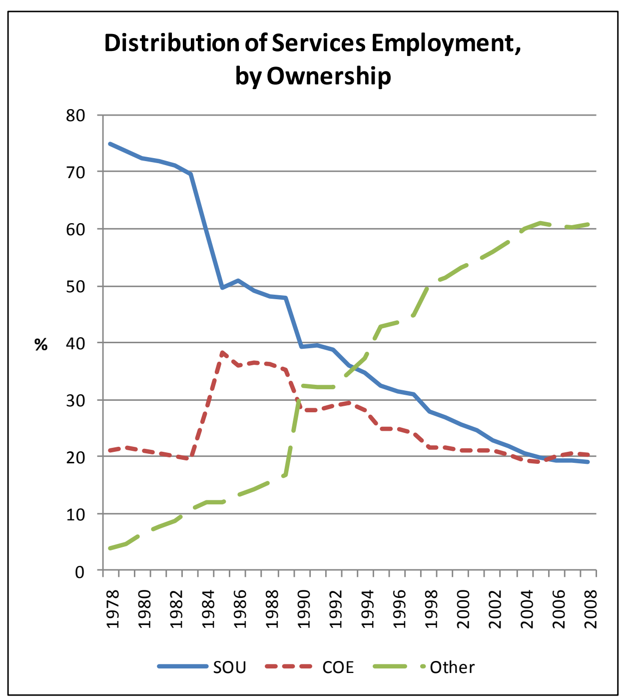
[5] For 1978-1997, we use shares calculated across industrial ownership types, scaled to the official aggregate (the industrial sub-sectors frequently sum to greater than the aggregate, possibly reflecting dual and part-time employment); for 1998-2008, we calculate industrial "other" ownership employment as the residual of total, SOU, and COE employment. See the appendix for more information on data construction.

In contrast, however, collective sector employment has remained relatively constant in industry, with the decline over the past decade still leaving COEs with over 50% of industrial employment. Most COE employment remains in rural areas; as of 2008, rural TVEs accounted for half of industrial employment. In services, the growth of non-SOE, non-COE employment has been particularly rapid, now accounting for over 50% of employment.



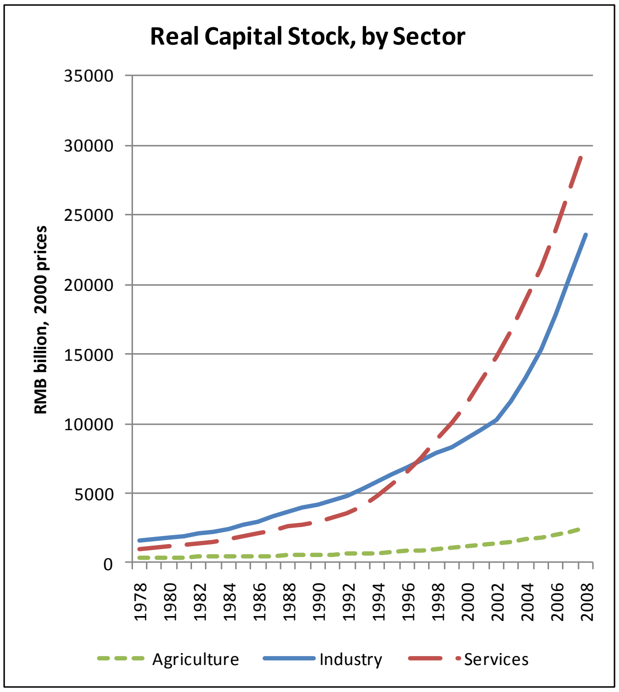


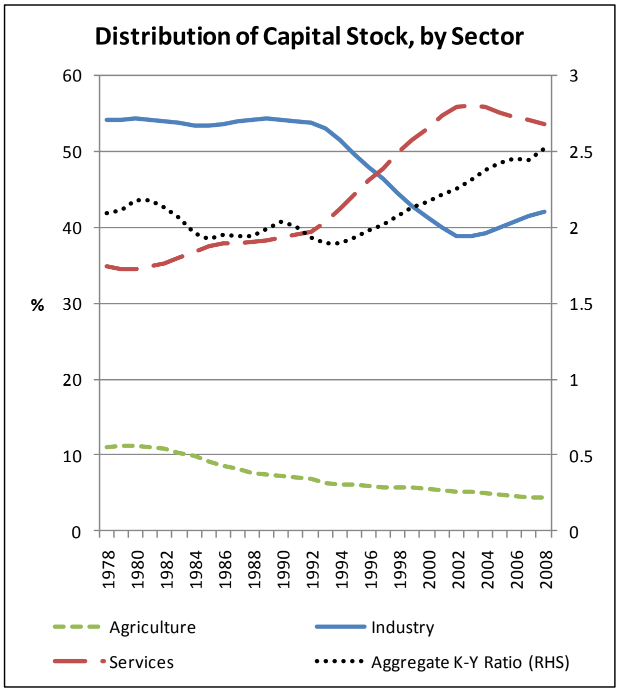




Fixed Capital Stock

We apply a perpetual inventory method to obtain estimates for the total capital stock, assuming annual depreciation of 7% and an initial capital stock in 1952 of twice 1952 real GDP.[6] For annual investment, we use gross fixed capital formation (GFCF) rather than fixed asset investment, as this series more accurately reflects total investment levels across large- and small-scale projects, excluding land sales.[7] We use the official FAI deflator for 1991-2008 and the implicit GFCF deflator reported in Hsueh & Li (1999) for 1952-1990 to convert nominal GFCF into 1990 prices.



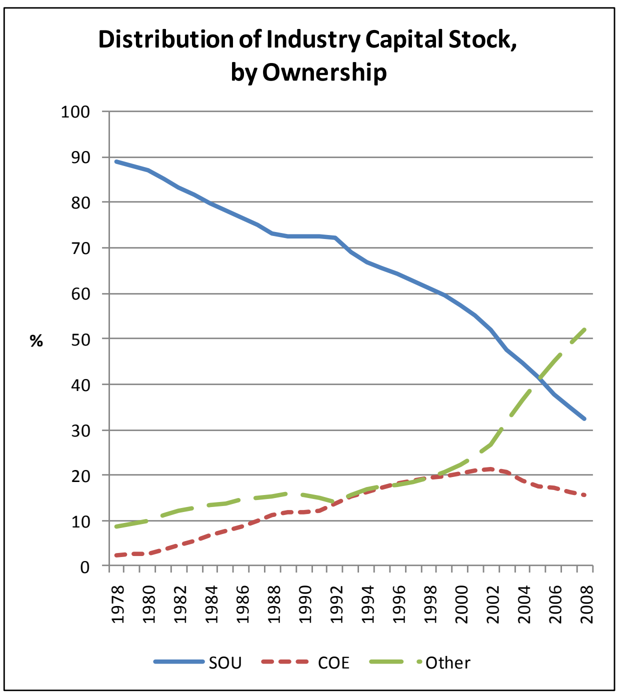


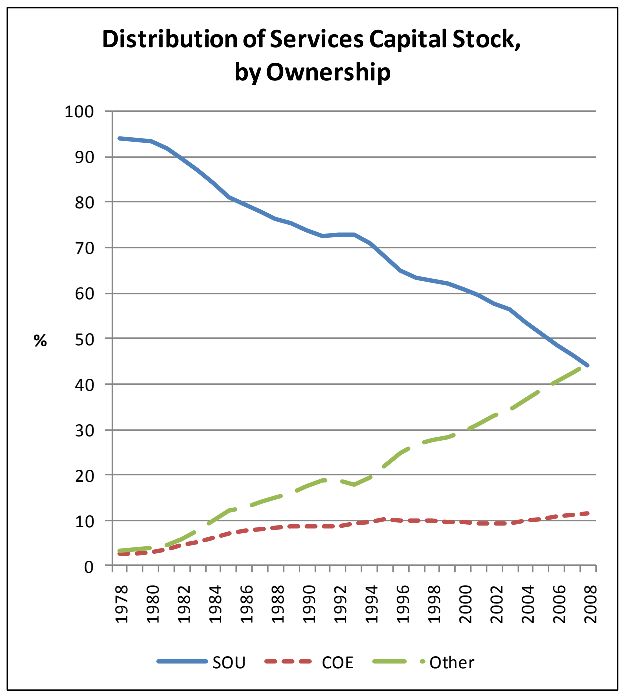
Our calculations for capital stock by sector and ownership go beyond existing studies; although the exercise is unavoidably imprecise, it nevertheless adds significant value to the current China growth accounting by allowing us to analyze the effects of capital reallocation in addition to labor reallocation. This issue is particularly relevant given concerns about the ability of the Chinese financial system to allocate financial capital to high-return activities. To calculate capital stock by sector and ownership type, we assume depreciation of 7% and initial capital stock in 1978 based on the five year average (1978-1982) sector shares of GFCF, and then apply

[6] Admittedly, this may be a high estimate for the initial capital stock; however, the initial stock in 1952 is largely irrelevant by our base year for analysis (1978) given high investment levels over the intervening period.
[7] NBS counts the value of purchased land and expenditure on used machinery as part of FAI, and also excludes survey data for small investments (only investments over 500,000 yuan are included after 1997). See Bai (2008)

a perpetual inventory method for each series using disaggregated values of real GFCF (assuming the same investment deflators across sectors/ownership as for the aggregate). Disaggregated nominal GFCF data comes from Hsueh and Li (1999) and provincial statistical yearbooks, as well as converted FAI data from Fixed Asset Investment Yearbooks. For the initial capital stock by sector and ownership in 1978, we apply disaggregated GFCF investment shares to the aggregate capital stock. In the sensitivity analysis, we also experiment by assuming zero capital stock in non-state ownership types in 1977, implying COE and other initial capital stocks equal to 1978 GFCF.

As the charts above show, the largest increase in capital has been in the services sector, while shares of the capital stock in industry and agriculture have declined. Given the industrial investment-driven nature of China's pre-reform economy, this trend makes sense. While China's capital-output ratio fell slightly during the first 15 years of reform, the last 15 years have seen a steady rise as investment has increasingly outpaced GDP growth. By ownership, the rapid increase of non-state, non-collective capital since 2000 stands out, as shown in the charts below.

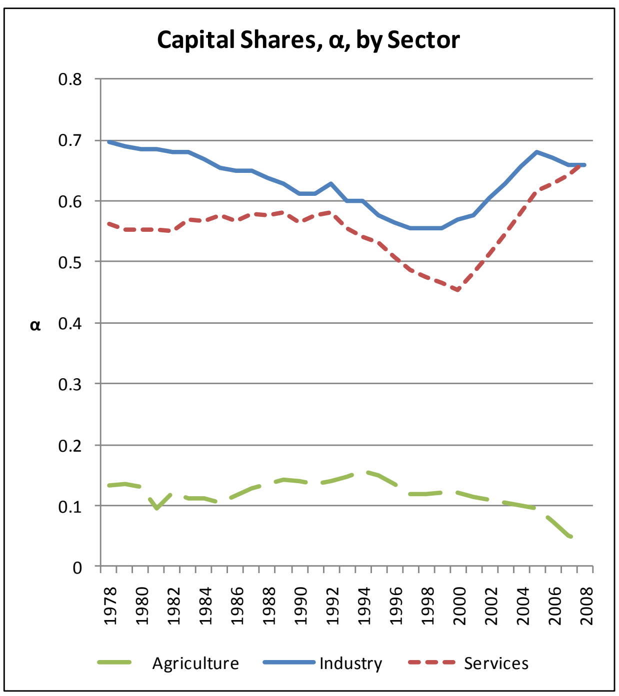


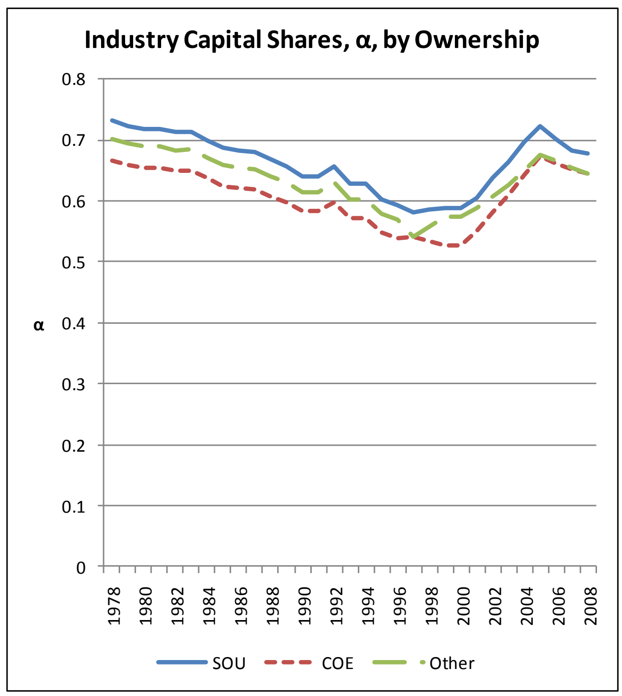


Capital share

The last key ingredient in our growth accounting exercise is an estimate of the output elasticities of capital and labor. Like most growth accounting papers, we impose the assumption of constant returns to scale at the level of sectoral production functions, so that the capital output elasticity is one minus the labor output elasticity Most studies for China in addition assume a constant and arbitrarily imposed capital share over time and across sectors (typically a value ranging from 0.4 to 0.6). Another common approach is to assume competitive factor markets, so that the labor output elasticity can be approximated by the share of labor compensation in value added.[8] This assumption is likely not literally true in the case of China, but we nevertheless adopt it as a benchmark and then explore the sensitivity of our findings to alternative estimates of the labor and capital output elasticities.

We rely on Hsueh and Li (1999) for provincial-level sectoral value added and compensation for 1978-1995 and input-output table figures for 1997, 2000, 2005, and 2007. Intervening years are estimated as noted in the data appendix. For the ownership breakdown of the labor share, we apply I-O table industry sub-sector capital share estimates to data on sub-sector industrial value added by ownership. No ownership value-added breakdown exists in the service sector, so we assume that all ownership types have the same capital and labor shares as the service sector aggregate. This approach only provides a broad-stroke estimate, but we believe that it better captures reality than does the assumption of constant capital shares. The charts below demonstrate the declining capital share in agriculture and the rising capital shares in industry and services over the past decade.





[8] This calculation assumes that factors are paid their marginal products, which in turn assumes a competitive labor market, but China (1) doesn't have a competitive market, (2) likely has a labor surplus (or did over until recently), and (3) relies on a +150 million informal migrant labor market. All of these will tend to drive down labor share calculations.

II. METHODOLOGY

Following World Bank (1996) we begin by assuming a constant-returns production function at the level of each sector, with aggregate output as the sum of the value of output across sectors and ownership forms:

$$Y = \sum_i \sum_j \mathrm{Y_{ij}} = \sum_i \sum_j \mathrm{A_{ij}} \mathrm{F_{ij}}(\mathrm{K_{ij}}, \mathrm{L_{ij}})$$

Here Y is aggregate value added and $\mathrm{Y_{ij}}$ is value added in sector i and ownership form j. In the data, i indexes agriculture, industry, and services, while j indexes state, collective, and other ownership. As noted in the previous section, we do not have information that permits a breakdown of output or inputs across ownership forms in agriculture. For this reason, in the empirical implementation that follows we set $\mathrm{Y_{11}} = \mathrm{Y_{12}} = 0$, i.e. we assume that all of output in agriculture is produced in the non-state, non-collective sector.

We assume that value added in each sector-ownership combination is produced using a constant returns production function $\mathrm{F_{ij}}(.)$ using capital and labor ($\mathrm{K_{ij}}$ and $\mathrm{L_{ij}}$), and $\mathrm{A_{ij}}$ is a measure of Hicks-neutral technological progress. Time subscripts are suppressed for notational convenience: typically however we will be working with annual data.

Aggregate GDP growth can be written as a share-weighted sum of growth in each sector:

$$g_Y = \sum_i \sum_j \mathrm{s_{ij}} \left(g_{A_{ij}} + \alpha_{ij} g_{K_{ij}} + (1 - \alpha_{ij}) g_{L_{ij}} \right)$$

where $\mathrm{s_{ij}}$ is the constant-price share of sector-ownership combination ij in total GDP, and α_{ij} is the output elasticity of capital in sector-ownership combination ij. A useful decomposition of output growth is as follows:

$$\begin{aligned} g_Y &= \alpha g_K + (1 - \alpha) g_L \\ &+ \sum_i \mathrm{s_i} \alpha_i (g_{K_i} - g_K) + \sum_i \mathrm{s_i} (1 - \alpha_i)(g_{L_i} - g_L) \\ &+ \sum_i \sum_j \mathrm{s_{ij}} \alpha_{ij} \left(g_{K_{ij}} - g_{K_i} \right) + \sum_i \sum_j \mathrm{s_{ij}} (1 - \alpha_{ij}) \left(g_{L_{ij}} - g_{L_i} \right) \\ &+ \sum_i \sum_j \mathrm{s_{ij}} g_{A_{ij}} \end{aligned}$$

where g_K and g_L are the growth rates of the aggregate stocks of capital and labor; g_{K_i} and g_{L_i} are the growth rates of capital and labor in sector i; $\mathrm{s_i}$ is the share of GDP in sector i; and $\alpha_i = \sum_j \mathrm{s_{ij}} \alpha_{ij} / \mathrm{s_i}$ and $\alpha = \sum_i \mathrm{s_i} \alpha_i$ are the weighted averages of the output elasticity by sector, and for the economy as a whole.

The two terms in the first line can be interpreted as the contributions of aggregate capital and labor accumulation to output growth. A standard aggregate growth accounting exercise would identify aggregate TFP growth as the difference between total output growth and this aggregate share-weighted average of capital and labor growth.

Such an exercise however would not be capable of distinguishing between productivity growth at the disaggregated level, and the contribution of factor reallocation across sectors, to overall growth. These are captured by the remaining three lines. The second line captures the contribution of factor reallocation across economic sectors, while the third line captures the reallocation of factors across ownership forms within sectors. The final line is a share-weighted average of TFP growth across sectors and ownership forms. We will refer to this latter sum as aggregate TFP growth, in order to distinguish it from the separate contributions of capital and labor reallocation in the middle two lines.

The capital and labor reallocation terms can usefully be re-written in terms of the size of the sector and its relative marginal product. For example, for the contribution intersectoral capital and labor reallocation to growth can be written as:

$$\sum_i \mathrm{s_i}\alpha_\mathrm{i}\left(g_{K_i} - g_K\right) = \alpha \sum_i \frac{\mathrm{K_i}}{\mathrm{K}}\frac{\mathrm{MPK_i}}{\mathrm{MPK}}\left(g_{K_i} - g_K\right)$$

$$\sum_i \mathrm{s_i}(1-\alpha_\mathrm{i})\left(g_{L_i} - g_L\right) = (1-\alpha) \sum_i \frac{\mathrm{L_i}}{\mathrm{L}}\frac{\mathrm{MPL_i}}{\mathrm{MPL}}\left(g_{L_i} - g_L\right)$$

where K and L are the economy-wide aggregates of capital and labor, $\mathrm{MPK_i} = \alpha_\mathrm{i}\mathrm{Y_i}/\mathrm{K_i}$ and $\mathrm{MPL_i} = (1-\alpha_\mathrm{i})\mathrm{Y_i}/\mathrm{L_i}$ denote the sectoral marginal products of capital and labor, and MPK and MPL are the corresponding aggregate marginal products.

These expressions have a very natural intuitive interpretation. If, for example, capital is being shifted into sector i so that the growth rate of capital in sector i is faster than average, i.e. $g_{K_i} - g_K > 0$, then this will contribute to growth to the extent that the marginal product of capital in sector i is greater than average, and also the larger is the share of the aggregate capital stock in sector i.

III. Results and Discussion

Using the model and data described above, we estimate that aggregate TFP growth contributed 1.5 percentage points to annual GDP growth (which averaged 9.8%) over 1979-2008, while labor reallocation contributed 0.8 percentage points annually over this period and capital reallocation contributed 1.4 percentage points. Factor accumulation contributed the remaining 6.1 percentage points of growth. This TFP estimate falls towards the low end of most estimates for China; it is above those of Young (2003) and Woo (1998), who estimate TFP growth of 1.4% and 1.1% respectively, but significantly less than that of Perkins and Rawski (2008), who estimate TFP growth of 3.8% over 1978-2005, and Hu and Khan (1997), who estimate TFP growth of 3.9% during 1979-1994; these high estimates do not account for factor reallocation. TFP growth of 1.5%, while at the low end of estimates for China, is nevertheless quite respectable in international comparisons. For example, Bosworth and Collins (2003) find TFP growth over 1960-2000 of 0.9% (world), 1.0% (industrial countries), and 1.0% (East Asia less China).

While the numbers for the aggregate period show healthy growth from TFP and reallocation, growth in more recent years has been predominantly led by factor accumulation and capital reallocation. From 1979-1995, TFP growth contributed 1.9 percentage points, with labor and capital reallocation contributing 0.9 and 1.3 percentage points, respectively. However, from 1996-2008, TFP growth dropped to 0.9 percentage points, while the capital reallocation share grew even further to 1.4 percentage points. This places our estimates much more in line with more conservative/modest estimates of total factor productivity growth for China.

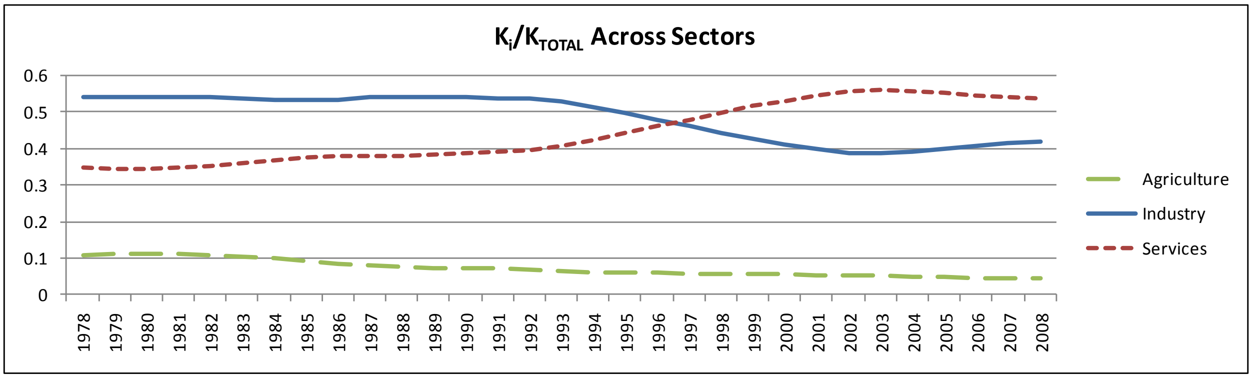
Summary Results

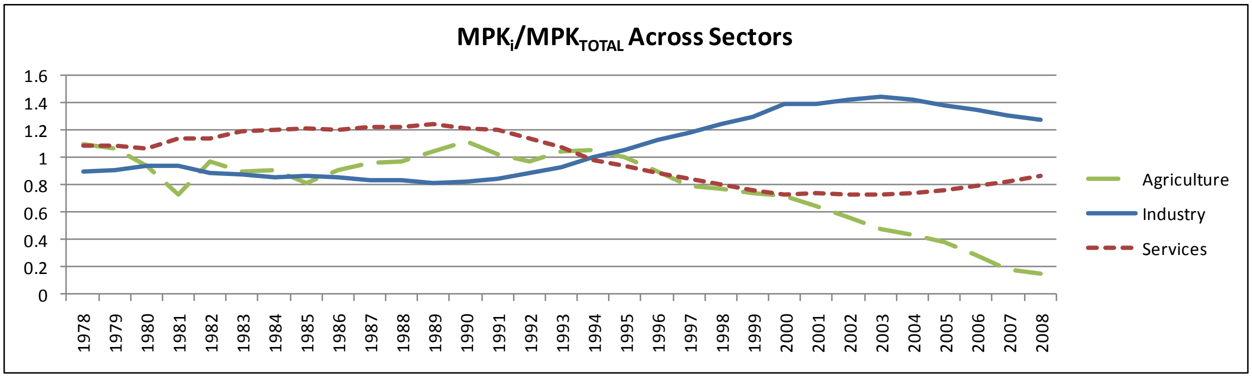
	1979-2008	1979-1995	1996-2008
Growth			
GDP	9.8	9.7	9.9
Capital Stock	10.5	9.2	12.1
Employment	1.8	2.4	1.0
Contribution to Growth			
Capital Accumulation	5.2	4.3	6.4
Labor Accumulation	0.9	1.3	0.5
Capital Reallocation	1.4	1.3	1.4
Across sectors	0.0	0.1	-0.1
Across ownership	1.4	1.3	1.5
Labor Reallocation	0.8	0.9	0.7
Across sectors	0.4	0.5	0.4
Across ownership	0.4	0.4	0.3
Total Factor Productivity	1.5	1.9	0.9

Looking at the sector and ownership contributions to capital and labor reallocation shows where this source of growth has come from. By sector, growth has been spurred by labor reallocation out of agriculture and into both industry and services. This sectoral labor reallocation has had a consistent and significant contribution to growth (0.4 percentage points annually), enabled by massive off-farm migration, while capital reallocation has been largely negligible.

By ownership, over the entire time period the growth of the non-state, non-collective sector has led to large and positive reallocation effects for both labor and capital. The non-state capital reallocation effect has been particularly large in industry for the more recent sub-period. While capital and labor reallocation to the collective sector in the earlier sub-period led to significant growth contributions, this positive effect has largely disappeared over more recent years.

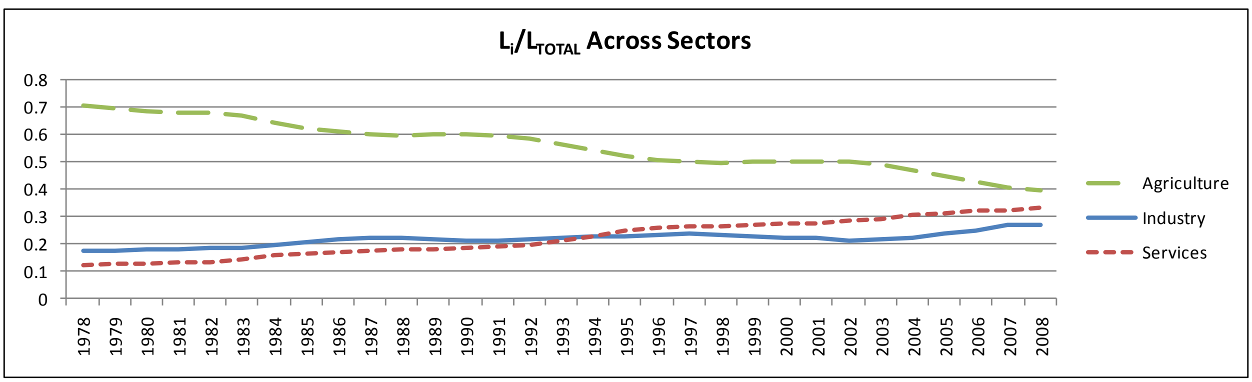
A look at the distribution of labor and capital across sectors and the trends in their marginal productivities helps explain these changing growth patterns, and in particular the changing contributions over time of reallocation of factors to overall growth. Consider first the distribution of capital and marginal products across primary, secondary and tertiary industries, shown below. Until the mid-1990s, the shares of capital across the three sectors were quite stable (top panel). Moreover, sectoral marginal products were not very different (bottom panel) However starting in the mid-1990s, substantially higher investment rates in services led to a sharp increase in capital in services, and a corresponding decline in industry. This in turn led to a widening gap between the marginal product of capital between industry and services, which has only recently begun to narrow somewhat.

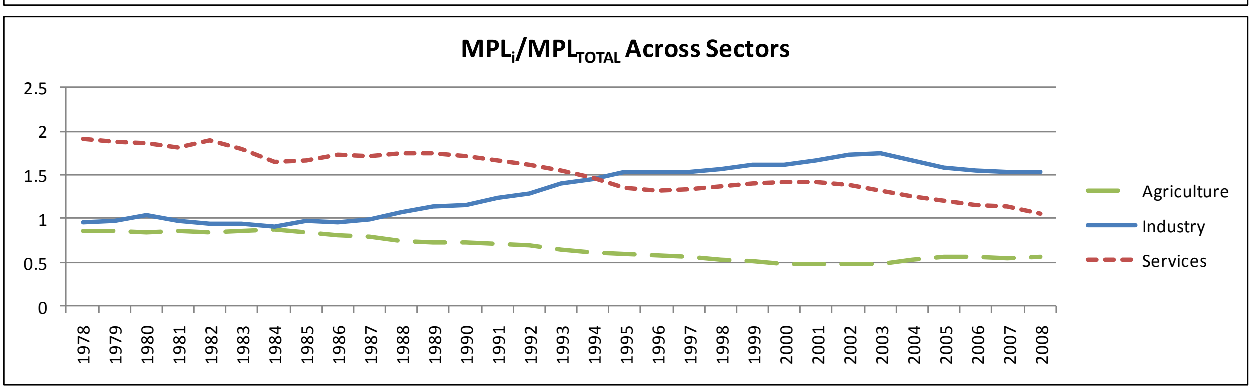




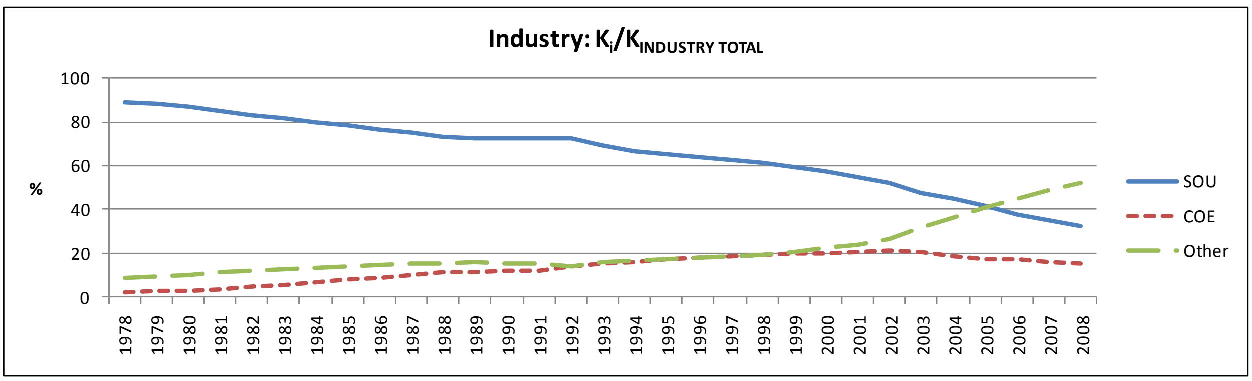
While marginal products of capital rose across sectors in the 1980s, in the 1990s, MPK in industry continued to increase while MPK in agriculture and services declined; only in the past few years have MPK across industry and services again begun to converge. As the charts above show, the share of the capital stock in agriculture has steadily declined; as agricultural MPK has also declined relative to other sectors, this has been a net boon for growth. However, looking forward, the agricultural share of capital does not have much more room to decline. Since the early 1990s, as productivity of capital has grown much faster in industry than in services (where the marginal product has actually declined), the share of capital in services has increased at the expense of industry, detracting from growth. This trend seems to have reversed in 2003/2004, as MPK in industry and services again began to converge at the same time that the capital share in industry also began to grow and the capital share in services began to shrink. The implication is that there is room for growth through larger investment in industry than services. This story contradicts the one frequently told, whereby China needs to invest heavily in services.

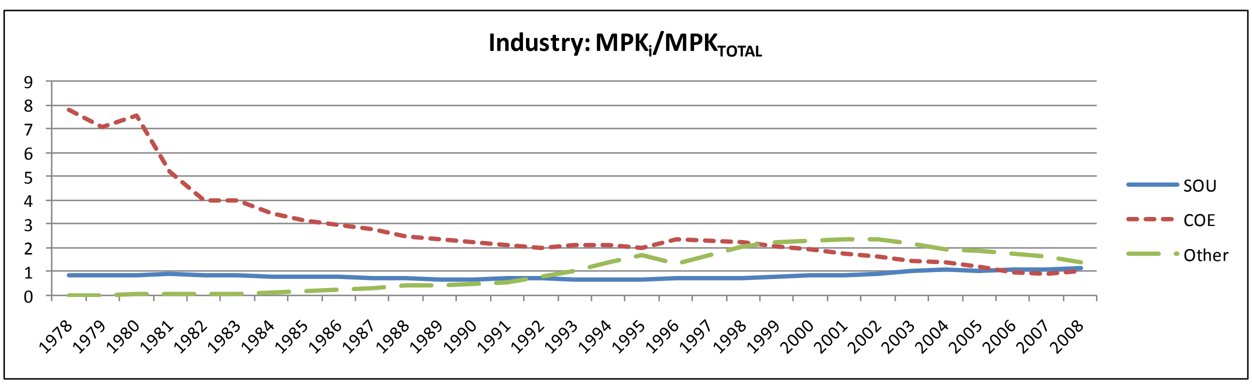
With regard to labor reallocation across sectors, the main story is a familiar one: there has been a huge shift of labor out of agriculture and into manufacturing and services. The slightly faster absorption of labor into services as opposed to industry has been accompanied by relatively slower growth in the marginal product of labor in services. Marginal products of labor in industry and services remain higher than in agriculture, suggesting continued scope for efficiency gains through further reallocation of labor out of agriculture. Interestingly, however, gaps in marginal products of labor across sectors are narrower than thirty years ago, and are also narrower than gaps in marginal products of capital.





Looking at ownership trends within industry, the last decade has seen a convergence in marginal productivities of capital, diminishing the possibilities for further growth through capital reallocation. The sharply declining state share of the industrial capital stock has contributed significantly to growth. In the 1980s, the extremely high relative marginal product of capital in the collective sector led to positive capital reallocation effects as SOU relative capital declined; for the past two decades, marginal products of capital in both collective and "other" ownership firms has been higher than state firms, leading to continued positive capital reallocation effects. However, the marginal product of capital in the collective sector is now lower than that in the state sector, and the ratio of the marginal productivity in "other" firms relative to state firms has declined from 2.9 in 1999 to 1.2 in 2008. This is a surprising story at first glance – while concerns of the state sector "the state advances as the private sector retreats" (*guojin mintui)* have cropped up recently, the dominant story over the last decade has been the opposite. Collective, private, and foreign firms may not have the same access to the banking system that state firms do, but they have still been able to finance extremely high levels of investment, either through retained earnings or external finance.[9]

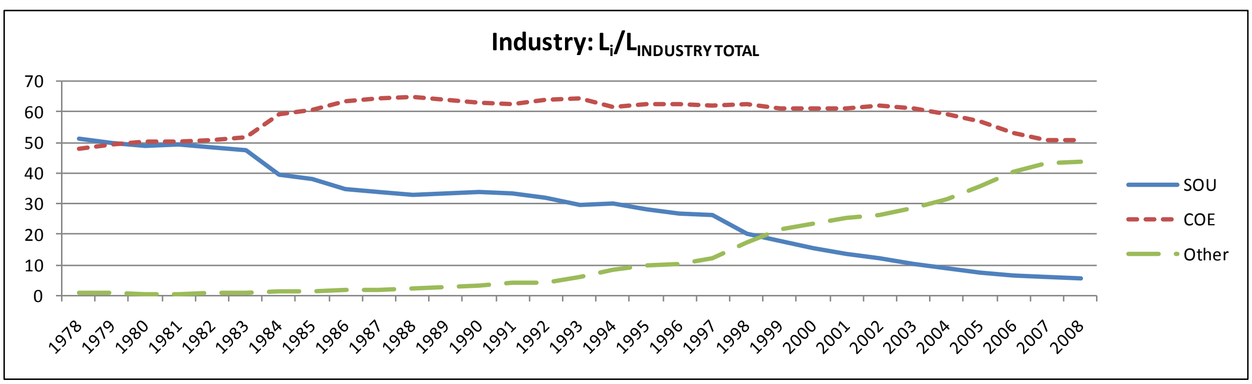


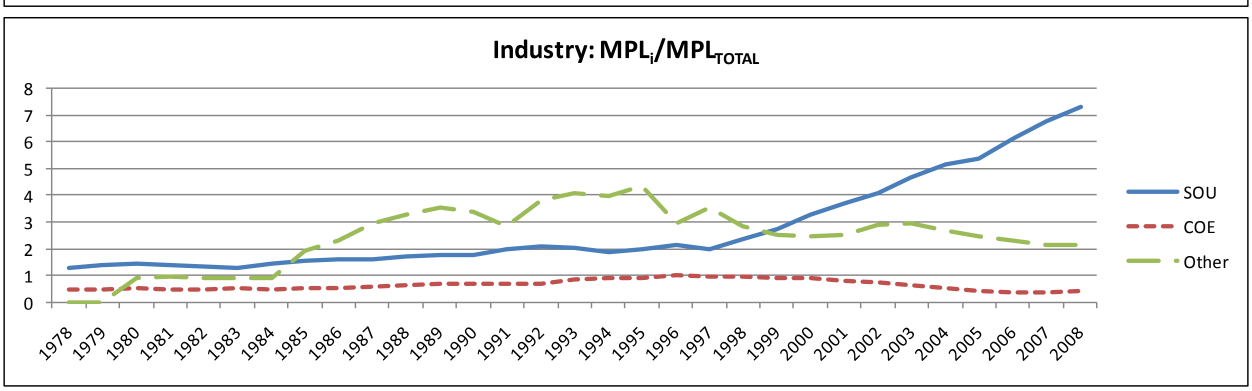


[9] According to official data, state budget and domestic loans accounted for 20.8% of FAI funds in 2008, while self-raised and foreign funds accounted for 79.2% (CSY 5-4).

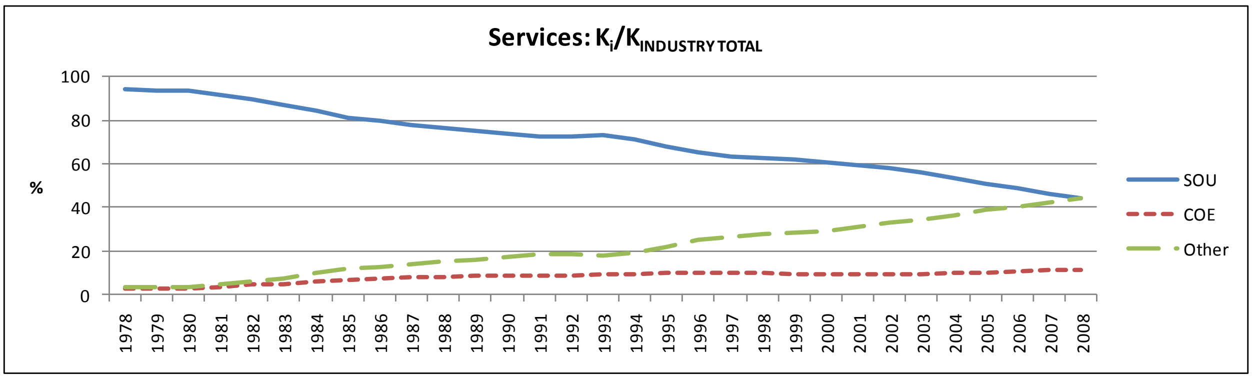
Regarding the industrial labor force, state and "other" firms have marginal labor productivities that greatly exceed both industrial collective firms and non-industrial firms; industrial collective firms are characterized by high employment and low marginal productivity. A continued decline of industrial collective employment, which has been witnessed since 2000, will continue to be a strong contribution to growth; with over 50% of the industrial labor force, collective firms still have significant room to shrink.

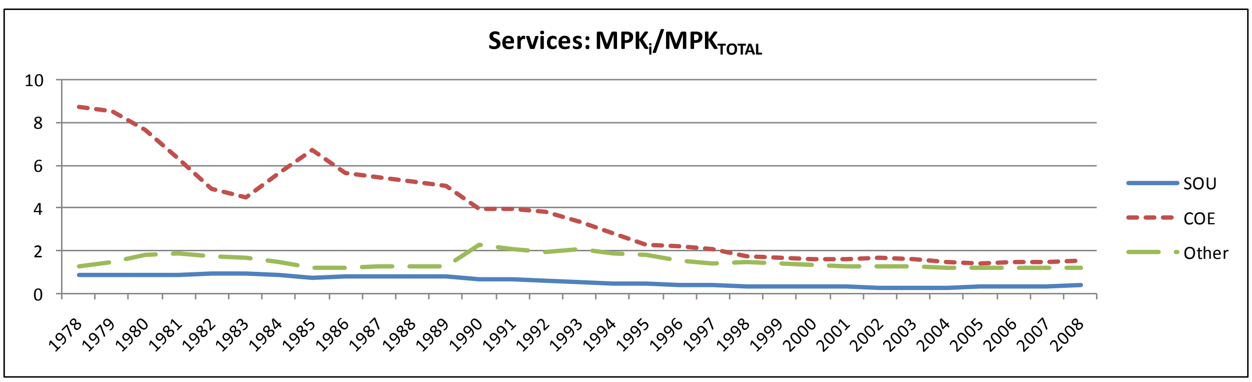
The rapid increase in SOE MPK from 1998-2008 stands out in the chart below: marginal products of labor in the state sector are higher than in the non-state sector, and have been since 1999. Mechanically, the reason for this is that employment has declined dramatically, while output has continued to increase; in particular, SOU reforms in the late 1990s led to millions of workers being laid off from SOUs. While employment has fallen in absolute terms, SOU capital continues to increase (only the relative share has fallen), leading to continued increases in capital per employee; industrial SOUs still have 19 times more capital per worker than industrial COEs, and 5 times more than "other" firms. Additionally, the trend can be partially explained by sectoral shifts (i.e., the state shift into heavy industries), although our capital share calculations attempt to account for this shift. In addition to a potentially underestimated capital share in recent years, we may also overstate the capital share in previous years, as SOUs previously were responsible for many non-wage employee contributions and benefits that may have been excluded from our capital share calculations.



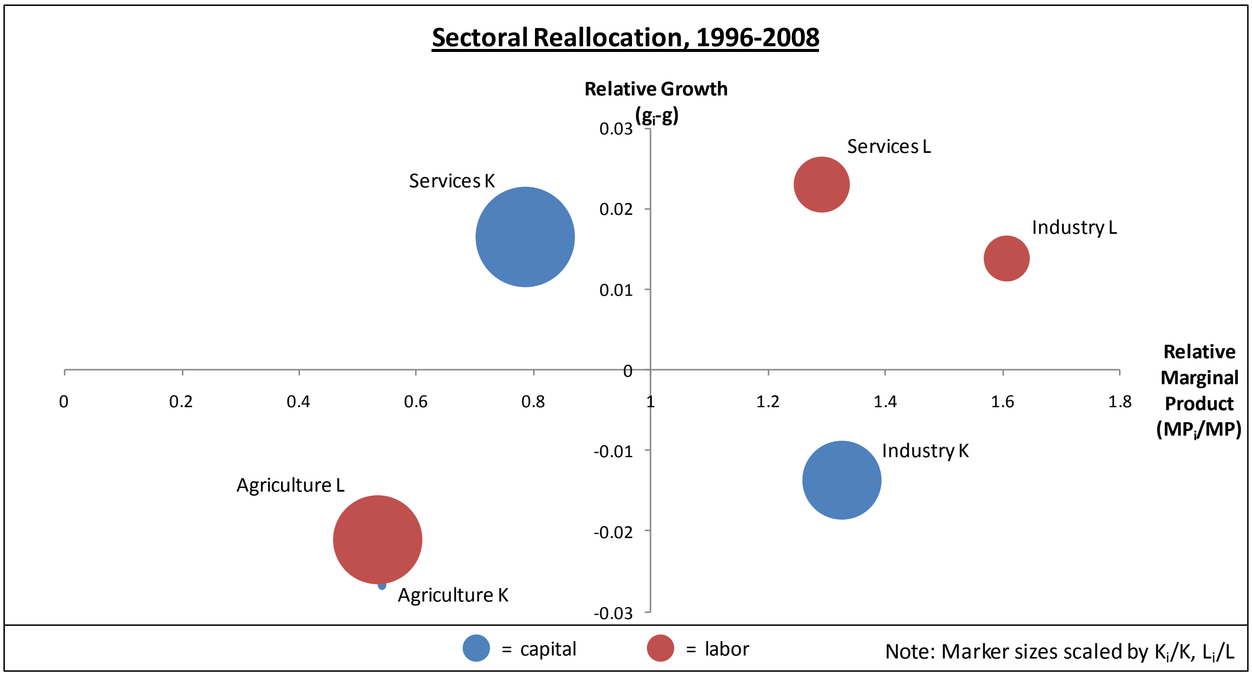


The services sector is somewhat different, as the state MPK has declined consistently and remains much lower than both collective and other enterprises; in services, collective enterprises have an MPK 4.3 times greater than the sector, while "other" firms have MPK 2.8 times greater. In the non-state, non-collective sector, this gap remains despite the massive accumulation of capital; the non-state capital stock now exceeds the state sector capital stock. Greater privatization in the services sector will enable further growth, although privatization of these sectors may be politically difficult.



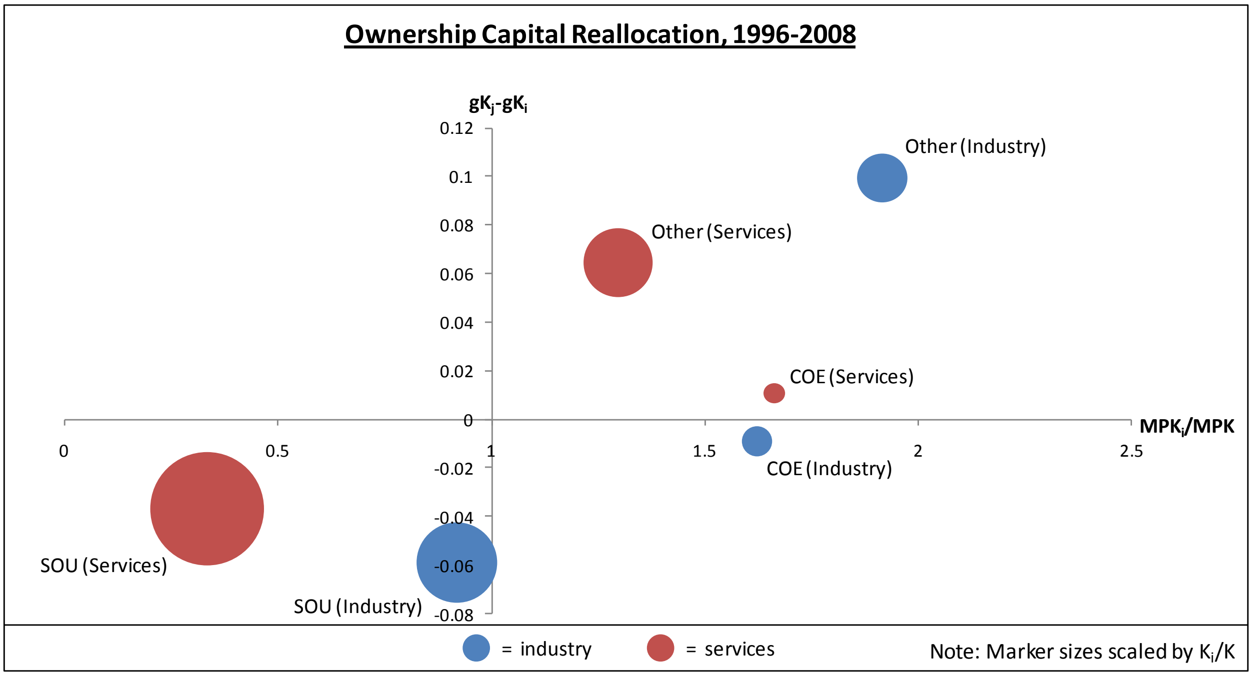


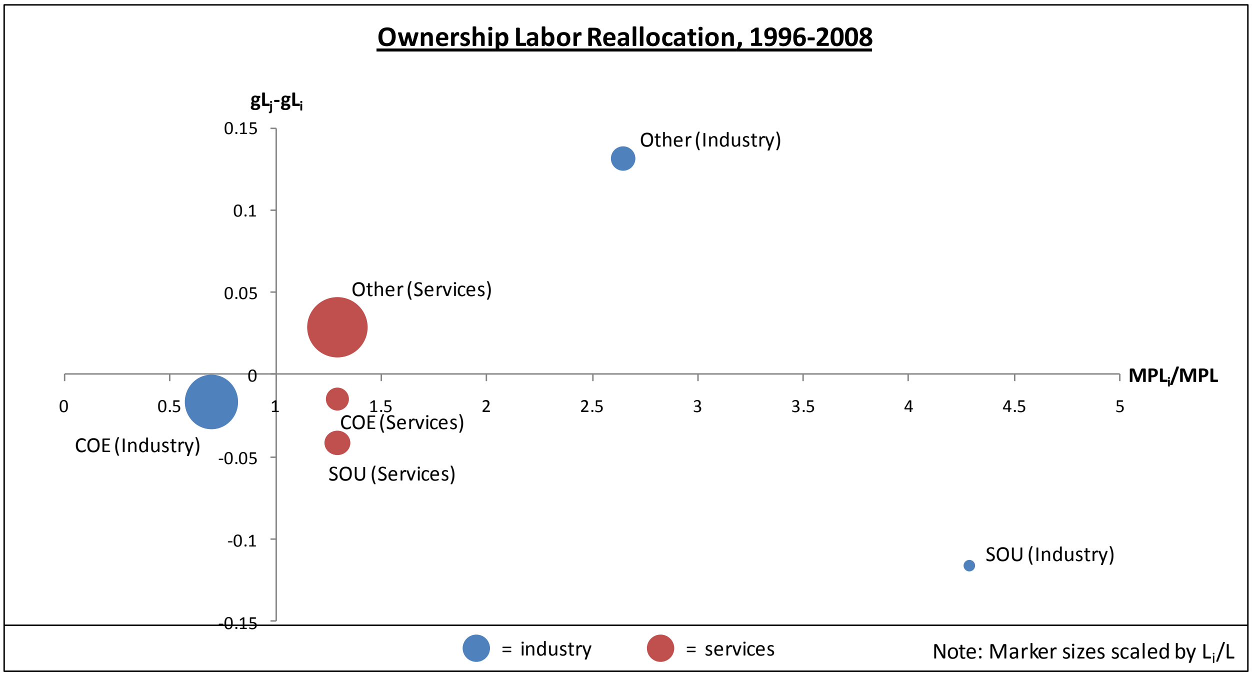
The graph below provides a visual summary of the contribution to growth of factor reallocation across sectors during the more recent 1996-2008 period. The horizontal axis plots the marginal product of capital (labor) across agriculture, industry, and services relative to the aggregate marginal product, averaged over time: points to the left of the vertical axis (at one) indicate sectors with lower-than-average marginal products, while points to the right indicate sectors with higher-than-average marginal products. The vertical axis plots the growth rate of capital (labor) in each sector relative to the average: sectors that are expanding (shrinking) relative to the entire economy have growth rates faster (smaller) than average. Finally, the size of each data point is proportional to the average share of capital (labor) in each sector. The contribution of each sector to factor reallocation is the product of its location on the horizontal axis, its location on the vertical axis, and the size of its data point. The main story in this graph is of course the huge contribution of reallocation of labor out of agriculture -- this is shown as the large circle in the south-west quadrant of the graph. The points in the northeast quadrant, representing positive contributions to growth, are industrial and services employment. Industrial capital has been more productive than average capital, but has grown slower than the aggregate, while service sector capital has grown faster but been less productive.



The subsequent two charts present the same exercise across industrial and services ownership types. The first panel shows capital reallocation, while the second shows labor reallocation. The interpretation of the charts is similar to that described above, except that the vertical access now represents the growth of capital (labor) by ownership relative to the sector as a whole (rather than the aggregate economy). Clearly, the SOU shares of capital in industry and services represent a large fraction of the total capital stock. They are both located in the south-west quadrant of the graph, indicating that (a) their shares in the total capital stock have been declining during this period, and (b) they are also sectors where the marginal product of capital is below average. The combination of these three effects (i.e. the reallocation of capital away from major sectors where it was relatively unproductive) has contributed positively to overall growth. These reallocations are largely matched by the expanding sizes of non-SOU, non-collectively-owned capital stocks in industry and services (the two large points in the north-east quadrant of the graph).

The graph for labor reallocation is symmetric to the one for capital reallocation. The labor shift out of agriculture (as well as out of low-MPL industrial collectives) shows up in the north-east quadrant as growth in employment in the non-state, non-collective sectors of industry and services.





IV. SENSITIVITY ANALYSIS

Given data limitations, the analysis above relies on several assumptions and broad estimates, as noted in the text. To add robustness to our results and conclusions, in this section we alter a range of assumptions and note the effects on our main results on TFP growth, capital and labor reallocation, and marginal product dispersion across sectors and ownership types.

We adjust several assumptions related to our construction of the four time series (output, employment, capital stock, and capital share). Specifically, for output we follow Young (2003) and Woo (1998) to use the ex-factory price deflator for industry output instead of official industry deflators, and also experiment with un-adjusted official IVA (which reflects only large enterprises) and IVA excluding construction (given the unreliability of construction data). For employment, we assume a floating population of 150 million (as compared to our baseline acceptance of official statistics). For capital stocks, rather than generate initial 1978 capital stocks as sector and ownership shares of 1978 investment, we assume that COE and other ownership types had zero capital stock in 1977, implying K_0 in 1978 equivalent to gross fixed capital formation in 1978 (with additional initial capital distributed to SOEs). Finally, for capital shares, we experiment with constant shares (0.4 and 0.5) across sectors and ownership types; 0.5 is our average aggregate over the period, while 0.4 is a low estimate frequently used in other studies. We also experiment with capital stocks calculated as time averages across our three sectors.

The chart below shows our baseline results as well as results with these new assumptions. The new assumptions result in an estimated range of total period annual TFP growth of 1.1% (using ex-factory prices to deflate industrial output) to 2.4% (assuming a constant 0.4 capital share), compared to our baseline estimate of 1.5%. The TFP decline using the alternate industrial output deflator arises because the initial period (1979-1995) annual growth estimate falls from 9.7% annually to 9.0%. Generally, however, TFP results remain similar to our baseline results, demonstrating that data assumptions and estimates are not driving results.

One of our strongest assumptions is that the official data on primary sector employment is reliable. We experiment with a floating population of 150 million workers, calculating the additional annual decline necessary from 1985-2008 to reflect this floating population (i.e., we subtract 2.8% from the official annual growth rate in agricultural employment), and redistributing migrants to industry and services based on official shares. This results in primary sector employment of 156.5 million. Somewhat counter-intuitively, accounting for this massive undocumented off-farm migration does not change estimates drastically; net TFP growth estimates decline to 1.2% (from 1.5%), as labor reallocation contributes more to growth. This relatively small effect is explained by the decline in σ_{MPL}: as workers shift out of agriculture, marginal productivity estimates of agricultural employees converge towards non-agriculture MPLs, thus diminishing the additional growth contribution of labor reallocation.

The dispersion of marginal products of capital (represented by σ_{MPK}) across sectors is affected predominantly by changes in assumptions to the capital share. Introducing a constant capital share across sectors results in significantly larger MPK dispersion, as should be expected (the sectorally varying estimates of α tend to lead to MPK convergence). Assuming a constant capital share leads to higher TFP estimates, as the growth contributions of capital reallocation decline across both sectors and ownership; clearly, the increased σ_{MPK} does not arise from higher capital growth in relatively productive sectors. σ_{MPK} across ownership types is most affected by using ex-factory price to deflate industrial output. (WHY?)

Adjusting our industrial value added statistics, both to reflect only large enterprises and to exclude construction, has only small effects. Using un-adjusted IVA (corresponding to enterprises with annual income of 5 million yuan post-1998) leads to lower estimates for COE and other output, which slightly reduces the growth contributions of capital and labor reallocation across sectors, resulting in a 0.3 percentage point higher net TFP estimate, and also increasing the dispersion of marginal labor productivities across ownership types.

Baseline Results and Sensitivity Analysis

Assumption:		GDP Growth	Factor Accum.	Capital Reallocation		Labor Reallocation		TFP	σ_{MPK}		σ_{MPL}	
				Across Sectors	*Across Ownership*	*Across Sectors*	*Across Ownership*		*Across Sectors*	*Across Ownership*	*Across Sectors*	*Across Ownership*
Baseline	1979-2008	9.8	6.1	0.0	1.4	0.4	0.4	1.5	0.1	0.3	4.1	11.0
	1979-1995	9.7	5.6	0.1	1.3	0.5	0.4	1.9	0.0	0.4	1.6	3.4
	1996-2008	9.9	6.8	-0.1	1.5	0.4	0.3	0.9	0.1	0.1	4.1	14.2
Floating population = 150 million	1979-2008	9.8	6.1	0.0	1.5	0.4	0.6	1.2	0.1	0.3	3.0	10.6
	1979-1995	9.7	5.6	0.1	1.3	0.5	0.8	1.4	0.0	0.4	1.2	2.6
	1996-2008	9.9	6.8	-0.1	1.7	0.2	0.4	0.9	0.1	0.1	2.2	14.5
Ex-factory price deflator for industry output	1979-2008	9.5	6.2	0.0	1.4	0.4	0.4	1.1	0.1	0.4	4.2	11.7
	1979-1995	9.0	5.7	0.0	1.3	0.5	0.4	1.0	0.0	0.5	1.6	3.6
	1996-2008	10.3	6.9	-0.1	1.5	0.4	0.3	1.3	0.1	0.1	4.3	15.3
Capital share = 0.5 across sectors	1979-2008	9.8	6.1	-0.3	1.2	0.8	0.4	1.6	0.3	0.3	6.0	17.3
	1979-1995	9.7	5.8	-0.4	1.1	0.8	0.4	1.9	0.3	0.4	2.3	4.3
	1996-2008	9.9	6.6	-0.2	1.3	0.7	0.3	1.2	0.2	0.1	7.1	23.5
Capital share = sector average across sectors	1979-2008	9.8	6.1	0.0	1.4	0.5	0.3	1.5	0.1	0.3	4.3	12.8
	1979-1995	9.7	5.5	0.0	1.3	0.5	0.4	2.0	0.0	0.4	1.6	3.2
	1996-2008	9.9	6.9	-0.1	1.5	0.4	0.3	0.8	0.1	0.2	4.6	17.0
Capital share = 0.4 across sectors	1979-2008	9.8	5.2	-0.2	0.9	0.9	0.5	2.4	0.2	0.2	7.2	20.8
	1979-1995	9.7	5.1	-0.3	0.9	1.0	0.5	2.5	0.3	0.3	2.7	5.1
	1996-2008	9.9	5.5	-0.1	1.0	0.8	0.4	2.3	0.2	0.1	8.6	28.1
Other K_0 = $GFCF_0$	1979-2008	9.8	6.1	0.0	1.5	0.4	0.4	1.4	0.1	0.3	4.1	11.0
	1979-1995	9.7	5.6	0.1	1.4	0.5	0.4	1.8	0.0	0.4	1.6	3.4
	1996-2008	9.9	6.8	-0.1	1.5	0.4	0.3	0.9	0.1	0.1	4.1	14.2
IVA excluding construction	1979-2008	9.8	6.1	0.0	1.3	0.4	0.4	1.5	0.1	0.3	4.1	11.4
	1979-1995	9.7	5.6	0.1	1.2	0.5	0.4	2.0	0.0	0.4	1.6	3.7
	1996-2008	9.9	6.8	-0.1	1.5	0.4	0.4	0.9	0.1	0.1	4.1	14.7
Un-adjusted IVA	1979-2008	9.8	6.1	0.0	1.2	0.4	0.2	1.8	0.1	0.3	4.1	13.4
	1979-1995	9.7	5.6	0.1	1.2	0.5	0.3	2.2	0.0	0.4	1.6	2.7
	1996-2008	9.9	6.9	-0.1	1.4	0.4	0.0	1.3	0.1	0.1	4.1	17.8

CONCLUSIONS

When disaggregated across sectors and ownership, China's growth over the past 30 years remains impressive. However, the analysis above highlights the future fragility of Chinese growth prospects. In particular, the contribution of total factor productivity to overall growth has shrunk over the last decade. While the shrinking contribution of TFP growth has been largely offset by increasing contributions of capital reallocation and still-strong contributions of labor reallocation, the future prospects for reallocation growth effects and labor accumulation are limited. China's work force is expected to peak by 2016, and, as the analysis above highlights, growth through industrial ownership reform has been largely exhausted, at least assuming current trends. To continue to benefit from capital and labor reallocation, China should focus on industry over services, shift workers out of the industrial collective sector, and continue ownership reform in the services sector. However, to maintain planned growth rates at or above 7.5%, capital accumulation will continue to be the workhorse of the Chinese economy.

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DATA APPENDIX

I. GDP and Value Added

Significant debate exists over whether China's official deflators overestimate growth; however, with no consensus on a superior deflator we opt to use official statistics.[10] Real primary, secondary, and tertiary GDP are calculated at 2000 prices, with aggregate GDP calculated as the sum across sectors.[11] 2000 nominal GDP estimates come from China Statistical Yearbook Table 2-1 (CSY 2-1), while the sector growth indices come from CSY 2-4.

Official industrial value added (IVA) comes from CSY 13-4 and CSY 13-8. These series begin in 1981. For 1978-1980, we obtain gross output value of industry (GOVI) data (CSY 12-3) and calculate aggregate and ownership IVA based on average IVA/GOVI ratios over 1981-1985. For missing IVA values for state-owned units (SOU) in 2008 and collectively owned enterprises (COE) in 2007 and 2008, nominal values are calculated by applying an implicit inflator based on nominal and real aggregate IVA growth to real growth rates by ownership reported in China National Bureau of Statistics (NBS) statistical releases.

Beginning in 1998, IVA from CSY 13-4 only includes industries "above designated size" (defined as annual income at least 5 million yuan), in effect excluding small collective units and private enterprises.[12] NBS has updated GOVI data back to 1978 using the post-1998 reporting guidelines, so to obtain an adjusted time series for IVA by ownership that reflects all firms, regardless of size, we begin by recalculating GOVI for 2000-2008 for all firms in the following manner:

- For SOU, we assume that output is equal to the "above designated size" estimate. This assumption is motivated by the equal values of these two accounting methods in 1998 and 1999 (data for these two years is presented using both accounting methods), as well as the assumption that by the late 1990s, following the *zhuada fangxiao* ("grasp the big, release the small") strategy, most SOUs under 5 million yuan had been restructured.
- For COE, we define "small" COE GOVI as the difference between adjusted and un-adjusted COE GOVI, and assume that the "small" COE growth rate is equivalent to the growth rate of TVE employment in industry (Table 7-2 of the China Labour Statistical Yearbook), adding this value to the official "above designated size" COE estimate.

[10] Young (2003) and Woo (1995) use the ex-factory price index to deflate industrial output. Perkins and Rawski (2008) argue that there is no valid justification for this choice, given that the substitution assumes that industrial output and material input prices move in tandem, which is not necessarily true. We provide results using the ex-factory price index in our sensitivity analysis.

[11] The choice of base year has a large impact on the relative sector shares of GDP. For instance, calculating in 1978 prices leads to a 2008 tertiary share 12.8 percentage points lower in than does calculating in 2008 prices.

[12] See Holz (2001) for a more in-depth discussion of the 1998 change in reporting guidelines.

- For non-SOU, non-COE, we similarly define "small" enterprise GOVI as the difference between adjusted and un-adjusted "other" GOVI, and assume the growth rate of the "small" enterprise sector is equivalent to the growth rate of employment in private and individual employment (CSY 4-2). We add this value to the residual "other" category generated from the official "above designated size" data.

To calculate adjusted IVA based on the constructed GOVI data, we assume that the reported IVA/GOVI ratios across ownership types from the official large enterprise data also hold for the adjusted set. Aggregate IVA is defined as the sum across ownership types.

To arrive at total IVA, we add in the construction sector. NBS went through frequent revisions in how to report construction output and value added, necessitating several assumptions to construct a consistent data series.[13] Total construction value added (CVA) is reported in CSY 14-3. Earlier vintages of CSY included data on CVA by ownership (Table 14-16), but this series stops in 2004. Gross output value of construction (GOVC) is reported in CSY 14-2 for 1980, 1985, and 1990-2008. However, this series seems to exclude rural TVE GOVC (reported in Table 11-31 for pre-2003 vintages of CSY). Table 25 of the "China Statistical Yearbook 1949-1999" (新中国 50 年) reports GOVC data for SOU, urban COE, and rural construction teams for 1980-1998. Over the years in which data is available (1984-1998) the difference between TVE GOVC and urban COE GOVC is very similar to rural construction team GOVC in Table 25, so we generate rural construction team GOVC based on the difference between TVE GOVC and urban collective GOVC for 1999-2008. For missing data on TVE GOVC in 2004-2008, we assume that growth rates in TVE GOVC were equivalent to growth rates in TVE employment in construction (reported in China Labor Statistical Yearbook 7-2). We add the implied rural COE data for 1999-2008 to both the aggregate series and the COE series, continuing to use SOU and urban COE data from 14-2. Non-SOU, non-COE GOVC is calculated as the residual.

To obtain CVA from GOVC, we use net output value as reported in pre-1996 vintages of CSY (CSY 13-10, 13-12, and 13-13) for 1985-1995 (available only for enterprises above the township level) and available data on GOVC to construct CVA/GOVC by ownership type for 1985, 1990, and 1995; for 1996-2008, we use GOVC and CVA data (CSY 14-2 and 14-3) to construct aggregate CVA/GOVC ratios. We apply these ratios to the constructed data on GOVC, using the ratios (by ownership) in 1985 for 1980-1985, the ratios in 1990 for 1986-1990, the ratios in 1995 for 1991-1995, and the aggregate ratio across ownership types for 1996-2008.

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[13] Construction data is unreliable; while we estimate values to our best ability, we also find it helpful to report results excluding the construction sector from IVA calculations – see the sensitivity analysis in the main paper. Note on construction data from NBS: "Data from 1980 to 1992 are the figures of State-owned and collective-owned construction enterprises. Data from 1993 to 1995 are the figures of construction enterprises of all economic types above town level. Data from 1996 to 2001 included construction enterprises at fourth or higher quality grades (old classification of grades). Data since 2002 included all general construction contractors and professional contractors (excluding construction enterprises of worker subcontractors) which possess qualification grades. Therefore the data were not comparable with the data of the previous years."

To generate ownership shares of final IVA, the sector shares in industry and construction are combined with respective weights. Without CVA data for 1978 and 1979, the ownership shares for these years are calculated as the IVA shares.

To disaggregate service sector GDP growth, ownership shares are calculated by assuming that value added shares are equivalent to employment shares across state, collective, and other categories (see next section for calculation of these series). In other words, we assume value added per worker is the same across ownership categories. This is a strong assumption (and one that prevents analysis of labor productivity across ownership in services), but there is no viable alternative.[14]

Our time series estimates for GDP and value added are presented in Table 1 at the end of this document.

II. Employment

To generate series for total employment and sectoral employment across agriculture, industry, and services, we begin with official data (CSY 4-3).[15] Two potential problems are apparent. First, official data revisions based on census data lead to a discontinuity in 1990, as total employment surges from 553.3 to 647.5 million between 1989 and 1990, with almost the entire surge attributed to the service sector (see Brandt, et al., 2008). We accept total official employment data for 1990-2008, and take advantage of pre-revision 1995 vintage CSY data to calculate a scale-up factor for 1990 (i.e., the ratio of revised to original data), which we then apply to 1978-1989 original data.[16] We accept official sectoral shares and redistribute across sectors based on the new aggregate employment numbers.

There is an additional problem concerning the potential overestimation of agricultural employment as a result of undocumented off-farm migration as well as non-farm rural self-employment.[17] China has a floating population of some 200 million migrants, and it is not clear how well the official statistics reflect this labor flow out of agriculture. As the agricultural

[14] While tertiary value-added is disaggregated (see, e.g., CSY Table 2-6), ownership within subsectors generally is not. Partial exceptions include real estate (China Tertiary Statistical Yearbook, 4-3-2), wholesale and retail trade, and art performance troupes (CSY 21-8).

[15] Note that we focus on employment, while other studies (e.g., Perkins and Rawski, 2008) focus on working-age population; this is essential for disaggregating employment across sectors. We also do not adjust employment for human capital gains, which would lower our TFP estimates.

[16] We also calculated a scale-up factor for each year in 1990-1994 from the revised data, and averaged this scaling factor over the five years – however, this average was significantly lower than the 1991 scaling factor, leading to a persistent jump from 1989-1990.

[17] Brandt et al. follow Holz (2006) to use information from 1982 census to adjust pre-1990 data on total employment, and use micro labor supply data from rural household surveys for 10 provinces to disaggregate sectoral employment trends. They calculate an agricultural labor share of 31.8% in 2004, compared to official data of 46.9%.

employment numbers are much lower than agricultural residency numbers, we can assume that at least some effort has been made. Without an alternative estimate, we start by assuming that the official employment statistics are valid, and then test our results by reducing the agricultural labor force by 150 million and calculating the additional annual decline necessary from 1985-2008 to reflect this floating population (i.e., we subtract 2.7% from the official annual growth rate in agricultural employment). The migrants are then redistributed to industry and services based on official shares.

To generate employment across ownership types, we begin with sectoral data on SOU and COE staff and workers from CSY 4-8 and CSY 4-9 (different vintages for sectoral breakdown). To scale up to total SOU employment across sectors we apply sectoral shares of SOU staff and workers to aggregate SOU employment from CSY 4-2. Similarly, urban COE employment is calculated using aggregate urban COE employment from CSY 4-2 and sector shares from “COE staff and workers” (CSY 4-9). To arrive at total COE employment by sector, we add in total TVE employment by sector (China Labor Statistical Yearbook Table 7-2). The TVE sectoral breakdown of employment in 2007 is adjusted using average shares from 2006 and 2008 and the official total for 2007, as officially reported values for 2007 are inconsistent. In all cases, industrial employment is calculated as the sum of mining/excavation, manufacturing, electric power, and construction.

“Other” employment across sectors cannot be calculated simply as the residual: due to over-reporting or part-time/dual employment, the sum of SOU and COE employment in industry exceeds the official total for multiple years in the late 1980s and early 1990s. “Other” staff and workers is calculated as the difference between total staff and workers (CSY 4-4) and SOU and COE staff and workers. To this, we add sectoral urban private and individual employment (Labour Yearbook 1-18; 1993 CSY 4-13) and rural private and individual employment. Rural private and individual employment is not recorded officially until 1990 (at which point 16 million individuals are categorized this way). As this sudden jump is implausible, we assume that the annual increase in the growth rate of rural individual employment from 1990-1994 can be applied backwards. For 1990 onwards, official rural individual employment is defined by the difference between total individual employment (CSY 4-2) and urban individual employment. We assume that rural individual employment shares in industry and service sectors are the same as for urban individual employment. This methodology is used for 1978-1998 for industry, after which other ownership employment is calculated as the residual between the official total and our SOU and COE series. For services, we begin using the residual in 1990.

With this data, we can calculate agriculture, industry, and service shares of total staff and workers, as well as SOU, COE, and “other” shares within industry and services. The estimated time series appears in Table 2 at the end of this document.

III. Fixed Capital Stock

We apply a perpetual inventory method to obtain estimates for total capital stock, following Perkins and Rawski (2008) and Nehru and Dhareshwar (1993).[18] Our estimates for total capital stock come from:

$$K_t = (1-\varphi)^t K(0) + \sum_{i=0}^{t-1} GFCF_{t-1}(1-\varphi)^i$$

where φ is the rate of decay, K(0) is the initial capital stock, and GFCF is gross fixed capital formation. We set $\varphi = 7\%$, but experiment with other values as well.[19] For the initial capital stock, we follow Perkins and Rawski (2008) and use twice the base year (1952) real GDP as our initial capital stock. Admittedly, this may be a high estimate for K(0); however, the initial stock is largely irrelevant by our base year for analysis (1978) given high investment levels over the intervening period.

We opt to use GFCF rather than fixed asset investment, as this series more accurately reflects total investment levels across large and small scale projects, excluding land sales (Bai, 2008). Nominal GFCF for 1952-2008 comes from CSY 2-18. To calculate real GFCF, we use the official FAI deflator for 1991-2008.[20] For 1952-1990, we use the implicit GFCF deflator reported in Hsueh and Li (1999). The estimated price index is used to convert nominal GFCF into 2000 prices. While this approach is much less involved than Perkins and Rawski (2008), it generates very similar results.

To calculate fixed capital shares across sectors and ownership types for 1978-2008, we first generate a disaggregated series for GFCF and then apply a similar methodology as for the aggregate. For depreciation, we continue to assume 7%, while for the initial capital stock we assume a 1978 capital stock distribution across sectors equivalent to the 1978-1982 average GFCF distribution, and a 1978 distribution across ownership within sectors equivalent to the 1978 GFCF distribution (to avoid overestimating non-state initial capital stocks). Real GCFC is generated using the same deflator as for the aggregate, discussed above, and a perpetual inventory method is applied to this series.[21]

In order to distribute investment by sector, given data availability we first construct series for FAI and then convert to GFCF using FAI shares and aggregate GFCF. We begin by aggregating

[18] See appendix to "Forecasting China's Economic Growth over the Next Two Decades" By Dwight H. Perkins and Thomas G. Rawski, Version of June 10, 2007.

[19] Perkins and Rawski (2008) experiment with both 9.6% and 7%. The 9.6% estimate that they prefer comes from Huang Yongfeng et al. (2002), who analyze service lives for buildings, equipment, and "other" assets to derive an overall depreciation rate. Nehru and Dhareshwar (1993) use 4%.

[20] Perkins and Rawski (2008) find that this deflator matches their alternate deflator over the years it is available.

[21] This is a strong assumption, as investment deflators likely differ across sectors. Moreover, assuming identical cross-sector depreciation rates may also be unjustified.

provincial data from Hsueh and Li (1999) for primary, secondary, and tertiary GFCF shares over 1978-1995, and applying these shares to aggregate FAI from CSY 6-2.[22] For 1996-2002, primary sector FAI is calculated as the sum across ownership types. For 2003-2008, primary FAI is calculated as official agricultural FAI (CSY 5-7, available for 2003-2008) plus a calculated "other" share for smaller enterprises, as CSY 5-7 excludes small enterprises and individual agricultural investment. Similarly, industrial FAI is reported in Fixed Asset Investment Yearbooks for 1996-2002, and in CSY 5-7 for 2003-2008. For 1996-2008, services FAI is calculated as a residual. Sectoral distributions within ownership types are calculated in the following manner:

- SOU: Aggregate SOU FAI comes from CSY 6-2 and Table 6 of "China Statistical Yearbook 1949-1999" (新中国 50 年). CSY 6-5 (2004 vintage) reports SOU FAI breakdown for primary, industry, and aggregate sectors from 1981-2003. CSY 5-14 presents a breakdown across sectors and ownership for urban FAI in 2003-2008, so for 2004-2008, we assume aggregate SOU FAI ratios across sectors are equivalent to urban area SOU FAI ratios. Industry and tertiary SOU FAI for 1978-1980 are calculated using the 1981 sector shares of SOU investment; primary SOU FAI for 1978-1980 is calculated as the residual.
- COE: The sectoral distribution of COE FAI over 1981-2000 is found in Statistics on Investment in Fixed Assets of China (1950-2000) (中国固定资产投资统计书典), pp 401-403. The distribution in 2001 and 2002 comes from the Fixed Asset Investment Statistical Yearbook Table 3-1. For 1978-1979, aggregate COE FAI is calculated from the residual of total and SOU FAI using the 1980 COE share of COE relative to "other" FAI. COE data for 2006-2008 is unreliable, with official statistics on FAI (CSY 6-2) reporting a four-fold FAI drop between 2005 and 2006, after a previous secular increase. To generate aggregate values over 2006-2008, we therefore add urban COE FAI (from CSY 5-14) to the rural component of growth in time *t-1* (calculated as the difference between the aggregate and the urban) scaled up by the increase in aggregate rural investment (reported in CSY 6-2) in time *t*. For 2003-2008, primary COE FAI is estimated as the residual from aggregate primary FAI and SOU and "other" primary FAI. COE industrial FAI for 2003-2008 is calculated assuming the same sector shares for total COE investment as for urban COE industrial FAI. COE services FAI is calculated as the residual. Industry and tertiary COE FAI for 1978-1980 are calculated using the 1981 share sector shares of COE investment; primary COE FAI for 1978-1980 is calculated as the residual.
- "Other": Aggregate, industry, and services "other" FAI are calculated as residuals from other ownership types, except that industry and tertiary "other" FAI for 1978-1980 are calculated using the 1981 sectoral distribution of "other" investment. Primary "other"

[22] We do not have consistent access to provincial statistical yearbooks for 1996-2008, and therefore cannot use the same methodology for later years.

FAI for 1978-1995 is also calculated as a residual, while for 1996-2008 it is calculated as rural individual investment (CSY 6-2) multiplied by the average 1991-1995 primary "other" FAI share of rural individual investment.

We apply these shares FAI by ownership and sector to the aggregate GFCF data, assuming equivalence of shares in FAI and GCFC, and then construct capital stock series as discussed above. The series estimates are presented in Table 3.

IV. Capital Share, α

To generate capital share estimates, we begin by assuming that the labor share (1-α) can be approximated by $1-\alpha = wL/pY$.[23] NBS does not consistently report GDP by income method, which would provide estimates of compensation and value added by sector. For 1978-1995, we aggregate sectoral value added and compensation at the provincial level from Hsueh and Li (1999). This gives us estimates of alpha across sectors for 1978-1995. For subsequent years, we rely on a combination of NBS Input-Output tables and Industry Statistical Yearbook data on total, SOU, and COE value-added across industry sub-sectors. Unfortunately, I-O tables only exist for 1997, 2000, 2005, and 2007, limiting the precision of this approach.

We use I-O tables for available years (1997, 2000, 2005, and 2007) to calculate capital shares for agriculture, services, and 11 industrial sub-sectors.[24] No ownership IVA breakdown exists in the service sector, so we assume that all ownership types have the same capital share as the services aggregate. To generate capital shares across industrial ownership types, we use IVA data from Industry Statistical yearbooks for 1999-2008 for aggregate, state, and collective firms across 39 industrial sub-sectors, as well as 1997 for SOU.[25] These 39 subsectors can be aggregated to match the 11 industrial sub-sectors reported in the I-O tables. Calculating capital shares across these 11 industries for the years in which the I-O tables are available enables us to estimate industrial capital shares by ownership by weighting sub-sector alphas by ownership sub-sector IVA shares. For value added in construction across ownership types, we use the series described in Section I above.

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[23] This calculation assumes that factors are paid their marginal products, which in turn assumes a competitive labor market, but China (1) doesn't have a competitive market, (2) likely has a labor surplus (or did over until recently), and (3) relies on a +150 million informal migrant labor market. All of these will tend to drive down labor share calculations.

[24] The subsectors are (1) Mining and Quarrying, (2) Manufacture of Foodstuff, (3) Manufacture of Textile, Sewing, Leather, Fur, (4) Other Manufacturing, (5) Production and Supply of Electric Power, Heat, and Water, (6) Coking, Gas, and Petro Refining, (7) Chemical Industry, (8) Manufacture Building Materials and Non-metal mineral products, (9) Metal Products, (10) Machinery and Equipment, and (11) Construction.

[25] No consistent data exists in earlier years for "other mining," "other manufacturing," and "waste product" manufacturing.

For intervening years (1999, 2001-2004, 2006, 2008), we assume constant growth-rate sub-sector capital share increases and weight these by annual ownership IVA breakdowns. For 1978-1996, SOU, COE, and other industrial capital shares are calculated using their average 1997-2000 ratio to the aggregate industrial capital share.

Using this approach, we are unable to disaggregate service sector capital shares by ownership, and the industrial capital shares by ownership are very broad estimates, particularly pre-1997. However, we still think these estimates enable a better analysis than merely using constant factor shares. The estimates are presented in Table 4 below.

Table 1: GDP at 2000 Prices, RMB billion

	TOTAL	Agriculture	Industry				Services			
			Total	*State*	*Collective*	*Other*	*Total*	*State*	*Collective*	*Other*
1978	1365.6	539.5	421.1	326.9	94.2	0.0	404.9	303.8	85.7	15.4
1979	1465.0	572.6	455.6	357.6	98.1	0.0	436.7	321.8	94.7	20.3
1980	1544.5	564.1	517.5	392.0	123.1	2.4	462.9	335.6	97.3	30.1
1981	1641.8	603.5	527.1	411.2	113.0	2.9	511.2	366.9	105.3	39.0
1982	1807.0	673.1	556.4	429.4	123.2	3.8	577.5	410.5	116.2	50.8
1983	2008.4	729.1	614.1	446.6	162.7	4.8	665.1	463.8	129.7	71.6
1984	2319.9	823.1	703.1	495.0	198.6	9.4	793.8	471.9	225.7	96.2
1985	2609.8	838.2	833.6	558.5	249.7	25.4	938.0	466.2	359.9	112.0
1986	2835.8	866.0	918.8	589.0	293.2	36.6	1051.0	534.5	378.4	138.1
1987	3153.3	906.8	1044.6	623.5	361.8	59.3	1201.9	591.6	438.3	172.0
1988	3486.2	929.9	1196.3	687.6	424.2	84.5	1360.0	654.9	494.4	210.7
1989	3632.7	958.4	1241.3	703.0	439.9	98.5	1432.9	686.5	505.2	241.2
1990	3775.8	1028.7	1280.7	719.9	440.5	120.3	1466.4	576.2	414.3	475.9
1991	4108.0	1053.4	1458.1	843.0	473.7	141.5	1596.5	633.0	448.5	515.0
1992	4664.6	1102.9	1766.6	982.2	562.1	222.3	1795.1	695.4	520.7	579.0
1993	5286.2	1154.7	2117.5	995.9	756.8	364.9	2013.9	723.3	591.7	698.8
1994	5944.5	1200.9	2506.3	1022.5	909.1	574.8	2237.3	777.6	627.9	831.7
1995	6572.4	1261.0	2854.1	1111.2	966.7	776.2	2457.4	796.0	611.5	1050.0
1996	7213.9	1325.3	3199.6	1280.4	1265.1	654.1	2689.0	844.9	671.6	1172.6
1997	7883.8	1371.7	3534.9	1275.3	1315.7	943.9	2977.2	921.4	722.0	1333.8
1998	8496.0	1419.7	3849.8	1252.5	1378.7	1218.7	3226.5	900.5	700.0	1626.0
1999	9150.0	1459.4	4163.1	1343.1	1374.3	1445.7	3527.5	949.1	763.9	1814.5
2000	9921.5	1494.5	4555.6	1518.5	1391.3	1645.7	3871.4	991.2	816.6	2063.6
2001	10745.0	1536.3	4940.1	1607.8	1369.8	1962.5	4268.5	1046.2	896.9	2325.4
2002	11720.8	1580.9	5425.7	1707.2	1339.8	2378.6	4714.2	1079.0	991.5	2643.8
2003	12895.9	1620.4	6113.3	1890.7	1299.5	2923.0	5162.2	1124.4	1054.2	2983.6
2004	14196.4	1722.5	6792.6	2141.0	1254.0	3397.6	5681.4	1172.6	1095.5	3413.3
2005	15802.1	1812.6	7613.3	2221.6	1159.6	4232.1	6376.2	1270.2	1215.9	3890.1
2006	17813.7	1903.2	8632.8	2480.3	1084.7	5067.8	7277.7	1407.2	1470.6	4399.9
2007	20348.6	1974.5	9933.2	2809.5	1138.0	5985.7	8440.9	1630.6	1733.7	5076.6
2008	22314.0	2080.7	10914.4	3135.1	1392.9	6386.3	9319.0	1767.7	1899.0	5652.4

Table 2: Employment (millions)

	TOTAL	Agriculture	Industry				Services			
			Total	*State*	*Collective*	*Other*	*Total*	*State*	*Collective*	*Other*
1978	458.2	323.2	79.3	40.7	37.9	0.6	55.8	41.9	11.8	2.1
1979	468.1	326.8	82.3	41.1	40.6	0.6	59.1	43.5	12.8	2.7
1980	483.4	332.3	87.9	43.2	44.3	0.5	63.1	45.8	13.3	4.1
1981	499.0	339.8	91.3	44.9	45.9	0.5	67.8	48.7	14.0	5.2
1982	516.9	352.1	95.2	46.1	48.5	0.7	69.5	49.4	14.0	6.1
1983	529.9	355.5	99.0	47.1	51.2	0.8	75.4	52.6	14.7	8.1
1984	550.0	352.3	109.4	43.1	64.9	1.4	88.3	52.5	25.1	10.7
1985	569.1	355.2	118.5	44.9	71.9	1.8	95.4	47.4	36.6	11.4
1986	585.2	356.7	128.0	44.8	81.1	2.1	100.5	51.1	36.2	13.2
1987	602.3	361.3	133.8	45.2	86.0	2.5	107.2	52.8	39.1	15.3
1988	620.0	368.0	138.7	45.7	89.8	3.2	113.4	54.6	41.2	17.6
1989	631.4	379.1	136.7	45.7	87.5	3.5	115.6	55.4	40.8	19.5
1990	647.5	389.1	138.6	46.8	87.3	4.4	119.8	47.1	33.8	38.9
1991	654.9	391.0	140.2	46.6	87.7	5.8	123.8	49.1	34.8	39.9
1992	661.5	387.0	143.6	45.9	91.5	6.1	131.0	50.7	38.0	42.2
1993	668.1	376.8	149.7	44.3	96.6	8.8	141.6	50.9	41.6	49.1
1994	674.6	366.3	153.1	45.7	94.6	12.8	155.2	53.9	43.5	57.7
1995	680.7	355.3	156.6	43.8	97.8	15.0	168.8	54.7	42.0	72.1
1996	689.5	348.2	162.0	43.5	101.6	17.0	179.3	56.3	44.8	78.2
1997	698.2	348.4	165.5	43.4	102.3	19.8	184.3	57.0	44.7	82.6
1998	706.4	351.8	166.0	33.3	103.6	29.1	188.6	52.6	40.9	95.0
1999	713.9	357.7	164.2	28.9	100.0	35.4	192.1	51.7	41.6	98.8
2000	720.9	360.4	162.2	25.4	99.0	37.8	198.2	50.8	41.8	105.7
2001	730.3	365.1	162.8	22.3	99.1	41.4	202.3	49.6	42.5	110.2
2002	737.4	368.7	157.8	19.1	97.6	41.1	210.9	48.3	44.4	118.3
2003	744.3	365.5	160.8	16.7	98.1	45.9	218.1	47.5	44.5	126.0
2004	752.0	352.7	169.2	15.3	100.3	53.6	230.1	47.5	44.4	138.2
2005	758.3	339.7	180.8	13.4	102.5	64.9	237.7	47.4	45.3	145.0
2006	764.0	325.6	192.3	12.7	101.9	77.6	246.1	47.6	49.7	148.8
2007	769.9	314.4	206.3	12.3	104.5	89.5	249.2	48.1	51.2	149.9
2008	774.8	306.5	211.1	12.1	106.8	92.2	257.2	48.8	52.4	156.0

Table 3: Capital Stock, 2000 prices, RMB billion

	TOTAL	Agriculture	Industry				Services			
			Total	*State*	*Collective*	*Other*	*Total*	*State*	*Collective*	*Other*
1978	2864.1	314.2	1553.6	1379.4	38.3	135.9	996.3	937.7	26.2	32.4
1979	3097.2	348.3	1678.6	1478.6	44.0	156.0	1070.3	1003.2	29.6	37.5
1980	3360.6	378.4	1823.5	1589.1	51.6	182.9	1158.6	1079.7	34.1	44.7
1981	3570.7	394.2	1934.6	1644.3	71.1	219.2	1242.0	1137.8	46.2	58.0
1982	3842.9	414.1	2073.5	1723.9	97.1	252.6	1355.2	1212.0	63.8	79.5
1983	4155.4	430.7	2231.2	1825.0	124.1	282.0	1493.5	1301.2	77.5	114.8
1984	4553.9	450.2	2432.4	1938.7	164.3	329.4	1671.3	1405.0	101.9	164.4
1985	5025.5	460.7	2679.8	2098.7	211.1	370.0	1885.1	1525.1	131.4	228.6
1986	5539.2	475.5	2965.0	2273.5	259.6	432.0	2098.7	1666.4	161.6	270.6
1987	6137.6	497.9	3312.2	2480.3	331.6	500.4	2327.5	1812.2	191.0	324.3
1988	6770.5	521.6	3671.0	2688.7	416.3	566.1	2577.9	1969.8	218.7	389.4
1989	7225.6	538.1	3921.5	2836.9	460.5	624.1	2766.0	2080.5	240.4	445.2
1990	7678.8	559.5	4156.9	3014.2	494.8	647.8	2962.5	2185.6	255.9	521.0
1991	8242.4	587.1	4442.2	3224.9	545.1	672.3	3213.0	2332.5	275.8	604.7
1992	9004.8	619.2	4835.0	3490.9	665.5	678.6	3550.6	2579.2	308.3	663.1
1993	10028.4	639.9	5310.6	3666.9	809.1	834.6	4077.9	2973.0	382.6	722.3
1994	11275.2	686.8	5806.4	3877.8	944.0	984.5	4782.0	3388.3	467.9	925.8
1995	12705.8	767.6	6303.8	4126.7	1080.9	1096.2	5634.4	3828.9	573.9	1231.6
1996	14274.2	843.0	6840.6	4386.0	1244.9	1209.8	6590.5	4286.9	661.8	1641.8
1997	15884.3	925.0	7376.1	4618.6	1396.0	1361.5	7583.2	4799.0	751.3	2032.8
1998	17649.2	1009.3	7849.6	4789.0	1524.8	1535.8	8790.3	5501.9	862.9	2425.5
1999	19500.0	1107.8	8334.3	4950.6	1650.3	1733.4	10057.9	6237.1	977.4	2843.4
2000	21519.5	1206.0	8885.1	5099.7	1800.9	1984.4	11428.5	6965.1	1097.8	3365.6
2001	23773.5	1280.4	9489.6	5218.7	1978.8	2292.1	13003.5	7743.0	1230.1	4030.3
2002	26446.5	1374.2	10290.2	5345.7	2183.3	2761.1	14782.1	8541.0	1368.9	4872.2
2003	29797.9	1533.3	11569.0	5505.4	2374.7	3688.9	16695.6	9401.6	1559.8	5734.2
2004	33709.7	1682.9	13205.0	5900.6	2499.8	4804.5	18821.9	10065.3	1873.9	6882.6
2005	38358.1	1852.9	15346.5	6350.2	2697.5	6298.8	21158.6	10806.8	2164.8	8187.0
2006	43724.9	2033.5	17820.9	6737.7	3046.0	8037.3	23870.5	11594.1	2588.1	9688.3
2007	49727.6	2229.3	20609.7	7161.5	3371.0	10077.1	26888.7	12401.3	3053.3	11434.1
2008	56209.3	2480.3	23603.4	7650.3	3661.6	12291.6	30125.6	13302.0	3460.7	13362.9

<u>Table 4: Capital Share, α</u>

	TOTAL	**Agriculture**	**Industry**				**Services**			
			Total	*State*	*Collective*	*Other*	*Total*	*State*	*Collective*	*Other*
1978	0.44	0.13	0.70	0.73	0.67	0.70	0.56	0.56	0.56	0.56
1979	0.44	0.13	0.69	0.72	0.66	0.69	0.55	0.55	0.55	0.55
1980	0.45	0.13	0.69	0.72	0.65	0.69	0.55	0.55	0.55	0.55
1981	0.43	0.09	0.68	0.72	0.65	0.69	0.55	0.55	0.55	0.55
1982	0.44	0.12	0.68	0.71	0.65	0.68	0.55	0.55	0.55	0.55
1983	0.44	0.11	0.68	0.71	0.65	0.68	0.57	0.57	0.57	0.57
1984	0.44	0.11	0.67	0.70	0.64	0.67	0.57	0.57	0.57	0.57
1985	0.45	0.11	0.65	0.69	0.62	0.66	0.58	0.58	0.58	0.58
1986	0.46	0.12	0.65	0.68	0.62	0.65	0.57	0.57	0.57	0.57
1987	0.48	0.13	0.65	0.68	0.62	0.65	0.58	0.58	0.58	0.58
1988	0.48	0.13	0.64	0.67	0.61	0.64	0.58	0.58	0.58	0.58
1989	0.48	0.14	0.63	0.66	0.60	0.63	0.58	0.58	0.58	0.58
1990	0.47	0.14	0.61	0.64	0.58	0.62	0.57	0.57	0.57	0.57
1991	0.48	0.14	0.61	0.64	0.58	0.61	0.58	0.58	0.58	0.58
1992	0.50	0.14	0.63	0.66	0.60	0.63	0.58	0.58	0.58	0.58
1993	0.49	0.15	0.60	0.63	0.57	0.60	0.56	0.56	0.56	0.56
1994	0.49	0.16	0.60	0.63	0.57	0.60	0.54	0.54	0.54	0.54
1995	0.48	0.15	0.58	0.60	0.55	0.58	0.53	0.53	0.53	0.53
1996	0.47	0.14	0.57	0.59	0.54	0.57	0.51	0.51	0.51	0.51
1997	0.45	0.12	0.56	0.58	0.54	0.54	0.49	0.49	0.49	0.49
1998	0.45	0.12	0.56	0.58	0.53	0.56	0.48	0.48	0.48	0.48
1999	0.45	0.12	0.55	0.59	0.53	0.57	0.46	0.46	0.46	0.46
2000	0.45	0.12	0.57	0.59	0.53	0.57	0.45	0.45	0.45	0.45
2001	0.48	0.12	0.58	0.61	0.55	0.59	0.48	0.48	0.48	0.48
2002	0.50	0.11	0.60	0.64	0.58	0.61	0.51	0.51	0.51	0.51
2003	0.53	0.10	0.63	0.66	0.61	0.63	0.55	0.55	0.55	0.55
2004	0.56	0.10	0.66	0.70	0.64	0.65	0.58	0.58	0.58	0.58
2005	0.59	0.09	0.68	0.72	0.67	0.68	0.62	0.62	0.62	0.62
2006	0.59	0.07	0.67	0.70	0.66	0.67	0.63	0.63	0.63	0.63
2007	0.59	0.05	0.66	0.68	0.65	0.65	0.64	0.64	0.64	0.64
2008	0.60	0.04	0.66	0.68	0.64	0.64	0.66	0.66	0.66	0.66