State Reform and China's Productivity Deceleration: Firm-level Evidence

Jorge, Alvarez, Tuo Chen, Grace Li

February 2019, Preliminary

Abstract

This paper documents the total factor productivity (TFP) growth path in China from 1998 to 2015 using both the aggregate and the firm-level data. We find that measured TFP growth is positive from 1998 to 2011, before turning flat and even negative. A careful comparison between state-owned enterprises (SOEs) and private firms reveals that the slowing down of TFP growth of SOEs is the major contributor to the TFP growth reversal of the whole manufacturing sector. The reversal is not due to changes in the composition of production in different sub-sectors, but mostly due to changes within existing firms.

1 Introduction

The end of the 20th century and beginning of the 21st century witnessed extraordinarily high growth of economy in China. The high growth has been attributed to rapid capital accumulation, improvements in technology adoption, and remarkable reallocation of the production between the state and the private agents. The driver(s) of the recent deceleration in Chinese economy, however, is(are) still unclear. Using a combination of firm- and sector-level evidence, we study the drivers of this deceleration. We argue that past growth gains from state-ownership reform have lost steam recently, contributing to a perceived deceleration and even decline in measured TFP growth. Furthermore, we find that deceleration in measured TFP within firms is not necessarily driven by worsening technologies, but from past investments resulting in over-capacity problems.

This paper has three main contributions. First, we document TFP dynamics of Chinese manufacturing sector using both the sectoral and firm-level data. We compute firm-level TFP measures using data from the Chinese Industrial surveys, and compare trends and dynamics to aggregate TFP computed from sector-level data from China's Industrial Statistical Yearbook. All the data and different methodologies show the same pattern for TFP growth: TFP growth was impressive in the early 2000s, then decelerated after 2007 and turned flat or slightly negative after 2011.

Second, we decompose the TFP change between firms and state-ownership status using a novel statistical decomposition technique. The exercise decomposes TFP changes into a between SOE/Non-SOE component (driven by privatization), and within SOE/Non-SOE components. Moreover, within SOE/Non-SOE components are further decomposed into between-firm reallocation and within-firm TFP change components. This statistical decompositions allows for an assessment of the quantitative importance of past privatization efforts as well as the role of reallocation of capital labor and capital between firms in both state-controlled and private production.

Third, we consider the role of capital underutilization in explaining the recent deceleration. We do this by linking subsectors covered by the Chinese Industrial Survey to sub-sector level production and capacity data from Chinese statistical year book. The data shows a moderate improvement of capital utilization metrics in most sectors up to 2007, with a sharp decline in the years where TFP is decelerated. An assessment of the quantitative importance of the capital utilization channel indicates that this can explained a significant share of the Chinese deceleration.

The rest of the paper proceeds as follows. Section 3.2 describes the data and procedures used in computing TFP at the firm and sector level. Section 3.3 documents the aggregate trends of these measures. Section 3.4 documents gaps in TFP between SOE and non-SOEs and their evolution over time. Section 3.5 conducts a statistical decomposition of aggregate TFP changes between and within firms. Section 3.6 evaluates the role of capital utilization in explaining TFP dynamics. Section 3.7 concludes.

2 Empirical strategy

2.1 Data Description

We employ two main sources of data in this paper. Aggregate data is downloaded from the China Industry Statistical Yearbook, including the sales income, sales cost, number of people employed, and total assets. This is complemented with the aggregate wage bill from China's Labor Statistical Yearbook. The two-digit sectoral price data is downloaded from the China Statistical Yearbook[1].

Firm-level data is from Chinese Industrial Survey (1998 - 2013). This dataset has been widely used in the literature, including the seminal work on capital by Chang-Tai Hsieh (2009). The main difference of our dataset compared to previous ones is that the it covers a longer time span. While the literature has

[1]The China Statistical Yearbook data can be accessed through the website of National Bureau of Statistics of China, while the China Industry Statistical Yearbook and the China Labor Statistical Yearbook can be accessed through the website of China Knowledge Resource Integrated Database (http://www.cnki.net/).

focused on the period between 1998 and 2007, we expand this to include years up to 2014.

In doing this, there are several gaps in the data which we attempt to circumvent. The commonly used sample of the Chinese Industrial Survey covering 1998 - 2007, is relatively homogeneous: each year has almost identical variables and a unique identifier. In contrast, the data after 2007 presents several shortcomings. First, the 2008 year data has no firm-level identifier and 2009 misses one-third of the identifiers. This complication make it is impossible to include 2008 and 2009 data in the panel dataset. Because of this, we prepare two versions of data set. One version includes 2008 and 2009 data which we treat as cross-sectional dataset for the calculation of the yearly cross-sectional aggregate statistics. The other version excludes the data of these two years and is a panel dataset at the firm-level.

Second, some variables needed for the proper calculation of firm-level TFP are missing in the later years. In particular, the key variable of value added, which serves as output in the production function, is missing after year 2007. To address this, we calculated our own measure of total factor productivity that does not subtract intermediate inputs from total production. We validate this approach by comparing our measure to the traditional measure of TFP using the pre-2007 data. We will show in the next subsection that the shortcoming does not have great effects on measured TFP growth in the 1998-2007 period. Finally, the 2010 year data is incomplete along several dimensions, and we therefore exclude this year from our sample.

2.2 TFP measurement methodology

In this section, we describe the different methodologies used to measure TFP at both the aggregate and the firm level.

We start with the estimation method using aggregate data. This assumes a Cobb-Douglas production function and constant returns to scale. We use value added as a measure of output; therefore, the production function has two inputs: capital and labor. The weight parameter is determined by the labor share, which is calculated as the total wage bill over the value added. TFP in this approach is simply calculated as a Solow residual. The whole procedure can be summarized by the following set of equations:

$$\begin{aligned}
&\text{VA}_t = \text{Sales Income}_t - \text{Sales Cost}_t \\
&\text{Real VA}_t = \tfrac{\text{VA}_t}{P_t} \\
&\alpha_t^L = \tfrac{w_t L_t}{\text{VA}_t} \\
&\alpha_t^K = 1 - \alpha_t^L \\
&K_t = \tfrac{\text{Total Asset}_t}{P_t^K} \\
&A_t = \tfrac{\text{Real VA}_t}{L_t^{\alpha_t^L} K_t^{\alpha_t^K}}
\end{aligned} \tag{1}$$

where VA_t stands for the valued added, and Real VA_t is VA_t deflated by the producer price index P_t, capital measure K_t is equivalent to assets deflated by the price index of investment in fixed assets P_t^K, $w_t L_t$ is the total wage bill, α_t^L and α_t^K are respectively the labor share and capital share. Variables "Sales Income", "Sales Cost", P, P^K, L_t, $w_t L_t$ and "Total Asset" are all directly observed.

The analogous Cobb-Douglas constant returns to scale approach is also applied to the firm-level data as well, with some modifications. The value added, assets, labor and wage bill are now all calculated at the firm level. Ideally, the producer price index and investment price index would be observed at firm-level as well, but firm-level prices are not available in our data set. We instead use use the two-digit sectoral producer price index and the same industrial level investment price index as in the aggregate approach. The labor share and capital share here are measured at the two-digit sectoral level. The estimation is summarized by the following equations:

$$\text{Real } va_{ist} = \frac{va_{ist}}{P_{st}}$$

$$\alpha^L_{st} = \frac{\sum\limits_{i\in s} w_{ist} L_{ist}}{\sum\limits_{i\in s} \text{va}_{ist}}$$

$$\alpha^K_{st} = 1 - \alpha^L_{st} \tag{2}$$

$$K_{ist} = \frac{\text{Fixed Asset}_{ist}}{P^K_t}$$

$$A_{ist} = \frac{\text{Real } va_{ist}}{L_{ist}^{\alpha^L_{st}} K_{ist}^{\alpha^K_{st}}}$$

where va_{ist} stands for the valued added of firm i in the two-digit sector at time t, and Real va_{ist} is va_{ist} deflated by the two -digit sectoral producer price index P_{st}, capital measure K_{ist} reflects reported fixed assets deflated by the price index of investment in fixed assets P^K_t[2], $\sum\limits_{i\in s} w_{ist} L_{ist}$ is the total wage bill of the firms within two-digit sector s, α^L_{st} and α^K_{st} are respectively the labor share and capital share in sector s. Variables va_{is}, P_s, P^K, L_{is}, $w_{is}L_{is}$ and Total Asset_{is} are all directly observed.

In addition, we compute firm-level TFP using three methodologies that exploit the panel dimension of the dataset: Olley and Pakes (1996), Levinsohn

[2]When using total assets instead, results do not change significantly.

and Petrin (2003) and De Loecker (2011). Both Olley and Pakes (1996) and Levinsohn and Petrin (2003) try to reduce the bias induced by the correlation between firm-level productivity and input choices. The bias comes from the possibility that a specific firm may have private information about its own productivity and make input decisions accordingly. This correlation between inputs and productivity makes the OLS estimates biased.

The key assumption made in Olley and Pakes (1996) is that the firm-level productivity is a function of investment and this function is invertible. The paper also assumes a Cobb-Douglas production function, but it no longer assumes constant returns to scale. More specifically, the approach is designed to estimate the coefficients of the following equation

$$y_{ist} = \beta^l l_{ist} + \beta^k k_{ist} + \Sigma_s \delta_s Ind_s + \Sigma_t \delta_t year_t + \beta^{\mathrm{SOE}} SOE_{ist} + \beta^{exp} exp_{ist}$$
$$+\omega_{ist}(age_{ist}, k_{ist}, inv_{ist}) + \varepsilon_{ist} \tag{3}$$

where lower-case letters are the log values of the variables: $y_{ist} = \ln(\text{Real } VA_{ist})$, $l_{ist} = \ln L_{ist}$, $k_{ist} = \ln K_{ist}$, and ω_{ist} is the residual TFP that is not captured by the observables. age captures firm's the length of existence. inv is the log value of firm's investment. Ind_{ist} is the variable for two-digit sector. $year_{ist}$ captures the time fixed effect. SOE_{ist} is a dummy indicate whether a firm is a state-owned enterprise. And exp_{ist} is a dummy indicate whether a firm exports or not.

The goal is to estimate β_l and β_k and back out the production function. Then the TFP can be measured as the firm-level Solow residual. Since estimating equation 3 using OLS produces biased estimated coefficients due to dependence of ω on k [3], a two-step instrumental approach is needed. In the first step, we run the following regression:

$$y_{ist} = \beta^l l_{ist} + \Sigma_s \delta_s Ind_s + \Sigma_t \delta_t year_t + \beta^{\mathrm{SOE}} SOE_{ist} + \beta^{exp} exp_{ist} \phi(age_{ist}, k_{ist}, inv_{ist}) + \varepsilon_{ist}, \tag{4}$$

where $\phi(age_{ist}, k_{ist}, inv_{ist}) = \beta^k k_{ist} + \omega(age_{ist}, k_{ist}, inv_{ist})$. The functional form of $\phi(age_{ist}, k_{ist}, inv_{ist})$ is approximated by a higher-order polynomial of the input variables. Moreover, we assume that ω_{ist} follows a Markov-chain process: $\omega_{ist+1} = g(\omega_{ist}) + \mu_{ist+1}$, and μ_{ist} is iid. The second-step regression can be therefore expressed

$$\widehat{\phi}_{ist+1} = \beta^k k_{ist+1} + g(\omega(age_{ist}, k_{ist}, inv_{ist})) + \eta_{ist} \tag{5}$$

where the function $g(\omega(.,.,.))$ can also be approximated by a high-order polynomial.

The methodology in Levinsohn and Petrin (2003) is very similar to Olley and Pakes (1996). But instead of using investment as the proxy for the unobserved productivity, intermediate inputs are used. That is

$$y_{ist} = \beta^l l_{ist} + \beta^k k_{ist} + \Sigma_s \delta_s Ind_s + \Sigma_t \delta year_t + \beta^{\mathrm{SOE}} SOE_{ist} + \beta_{exp} exp^{ist}$$

$$+\omega_{ist}(age_{ist}, k_{ist}, m_{ist}) + \varepsilon_{ist} \tag{6}$$

where m_{iit} is the measure of total operation inputs deflated by the intermediate input price index.

[3] There are ways to deal with the bias of β_l if ω is a function of l too. In the estimation we employ the methodology in Ackerberg, Caves and Frazer (2015) to correct for the estimate of β_l. But for the purpose of illustration, we do not talk about it here.

For both Olley and Pakes (1996) and Levinsohn and Petrin (2003) approaches, estimated firm-level productivity is given by

$$a_{ist} = y_{ist} - \widehat{\beta}^k k - \widehat{\beta}^l l \tag{7}$$

The final approach is that of De Loecker (2011). This addresses the implicit assumption made by Olley and Pakes (1996) and Levinsohn and Petrin (2003) that the difference between the firm-level price and two-digit sectoral level price is not correlated with the input choice. This assumption could be broken, for example, when a monopolistic firm could charges higher prices than the average sectoral price and enlarges its size (in terms of value added) as a result. In this scenario, $P_{ist} - P_{st}$ could be positively correlated with capital and labor. The methodology in De Loecker (2011) take the potential bias caused by the price difference seriously and incorporate a CES demand system into the estimation. The regression specification is as follows:

$$\begin{aligned} y_{ist} = {} & \beta^{l*} l_{ist} + \beta^{k*} k_{ist} + \beta^s y_{st} + \Sigma_s \delta_s Ind_s + \Sigma_t \delta year_t + \beta^{\mathrm{SOE}} SOE_{ist} \\ & + \beta^{exp} exp_{ist} + \omega_{ist}(age_{ist}, k_{ist}, m_{ist}) + \varepsilon_{ist} \end{aligned} \tag{8}$$

where y_{st} is the log value of the real term of two-digit sectoral value added, defined as $y_{st} \equiv \ln(\Sigma_{i \in s} va_{ist}) - \ln(P_{st})$, and β_s is interpreted as the inverse of the elasticity of substitution of sector s. TFP is therefore estimated as:

$$a_{ist} = (y_{ist} - \widehat{\beta}^{k*} k - \widehat{\beta}^{l*} l - \widehat{\beta}^s y_{st}) \frac{1}{1 + \widehat{\beta}^s} \tag{9}$$

3 TFP growth deceleration

This section shows the results from the TFP estimation procedures described above. First, we show that all TFP measures from different methodologies are highly correlated and the main conclusions are robust to different estimation procedures. Second, we show the trends of TFP over the period, which show a TFP deceleration in the most recent years.

Table 1 and table 2 shows how closely the four measures of firm-level TFP growth correlated with each other. "DL" stands for the methodology of TFP measure using De Loecker (2011) described in equation 8 , "LP" for Levinsohn and Petrin (2003) in equation 6, "OP" for Olley and Pakes (1996) in equation 3 and "CD" for the Cobb-Douglas methodology in equation 2. The reason for having two tables with high similarity is that the variable value added is only observable between years 1999 and 2007. After year 2007, we have to construct our own measure of value added. This approach is reflected in the "Pseudo VA" measure used in table 2, which is calculated as the difference between the firm-level "sales income" and "sales cost". Because of the gaps in value added availability, we present correlations of TFP estimates using value added from 1998 to 2007 in 1 and TFP estimates using "Pseudo VA" from 1998 to 2013 in table 2. In both samples and both types of estimation approach, we find high correlation across all measures.

Table 1: DlnTFP Correlation measured by VA

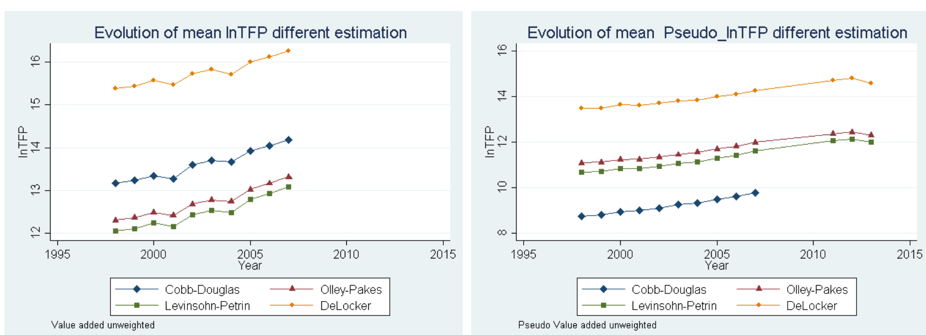
Variables	DL	LP	OP	CD
DL	1.000			
LP	0.998	1.000		
OP	0.995	0.997	1.000	
CD	0.942	0.945	0.966	1.000

Figure 1 shows the unweighted average TFP growth path measured by different methodologies. The left panel uses the officially calculated value added

Table 2: DlnTFP Correlation measured by Pseudo VA

Variables	DL	LP	OP	CD
DL	1.000			
LP	0.997	1.000		
OP	0.991	0.997	1.000	
CD	0.969	0.977	0.982	1.000

while the right panel uses the "Pseudo value added" calculated as the difference between "sales income" and "sales cost". The level difference by different measures of TFP is caused by the normalization, therefore does not reveal any information. The informative pattern in this figure is the trend. We observe that the growth path of TFP is very similar across different measures in both sub-figures. This observation is consistent with the high correlation in table 1 and table 2. The right panel tells us that starting around year 2011, the TFP growth rate starts to decline, and it even becomes negative from year 2012 to year 2012.

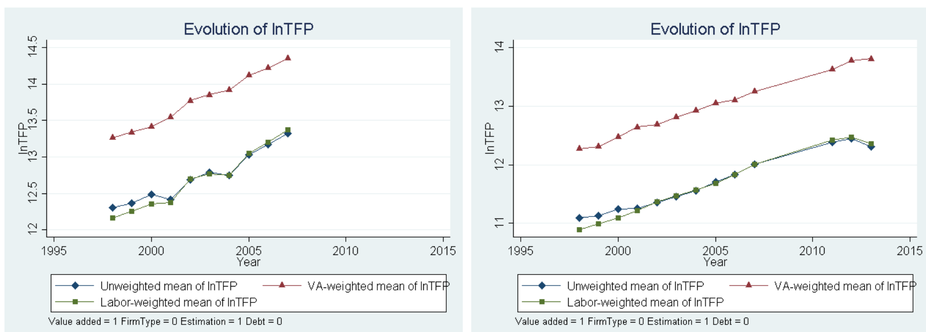


(a) Directly Observed VA

(b) Pseudo VA = Sales Income - Sales Cost

Figure 1: Unweighted Mean of lnTFP by different measures

Figure 2 plots the mean lnTFP paths by different weights using the firm-level TFP measured by methodology in De Loecker (2011). Similarly, the left panel uses officially calculated value added and the right panel uses the "pseudo value added". The slowing down of TFP growth starting from year 2011 can be observed in any type of weighted mean lnTFP on the right panel, be it the unweighted, value added weighted or labor weighted mean lnTFP. Another interesting point of figure 2 is that the labor weighted mean is about the same as the unweighted mean, while the value-added weighted mean is much higher in both sub-figures. The reason for that is that the firms with higher TFP tend to have a higher value added. However there is no clear correlation between the labor employment and TFP.



(a) Directly Observed VA

(b) Pseudo VA = Sales Income - Sales Cost

Figure 2: Mean of lnTFP by different weights

Figure 3 compares the firm-level TFP measure to the aggregate TFP measure, and shows that both measures have the same trend. The red curve plots the unweighted mean of value-added lnTFP measure, and the blue curve unweighted mean of pseudo-value-added lnTFP measure using the methodology in Olley and Pakes (1996) with the firm-level data. And we find that the two have the same trend between the period from year 1998 to 2007. The green curve plots the aggregate lnTFP measure using equation 1. It can be seen that after 2011, we observe the same reversal of TFP growth path that we observe in the firm-level data. Moreover, the aggregate TFP series has a longer historical data, indicating that after 2013, the TFP continues to drop.

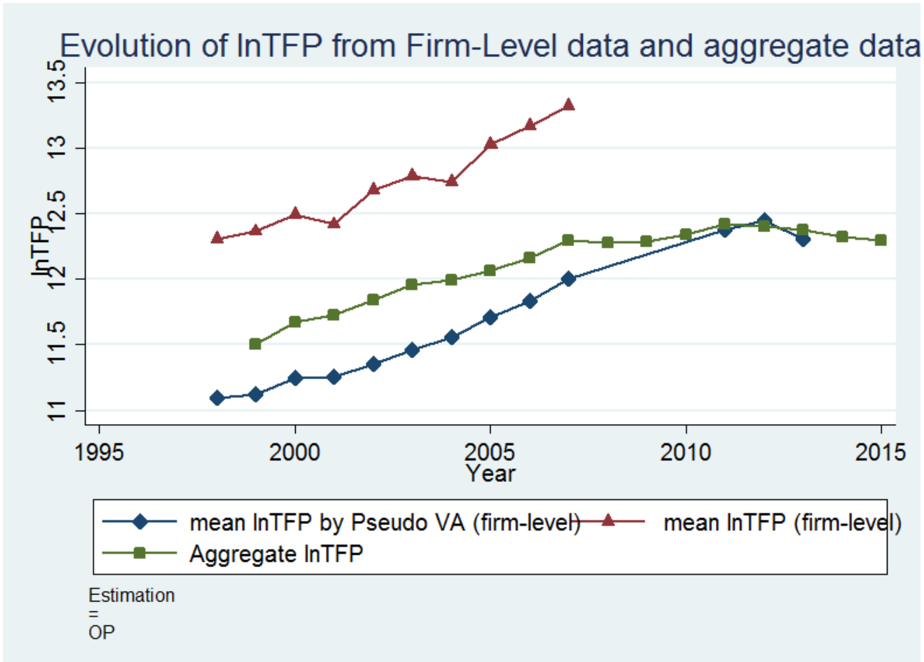


Figure 3: Firm-level Estimation and Aggregate Estimation

4 The Role of SOEs in TFP

In this section, we demonstrate that the state-owned enterprises (SOEs) are different from the non-state-owned-enterprises (Non-SOEs) in many aspects and how the timing the growth and slowdown in privatization coincides with the timing of TFP growth and growth and slowdown of manufacturing TFP. Moreover, we show evidence that the TFP deceleration cannot be due to any sectoral difference since the growth pattern of TFP of almost all sectors are the similar to that of the whole manufacturing sector.

4.1 Productivity of SOEs vs Non-SOEs

The empirical framework in this subsection is as follows:

$$lnTFP_{it} = \beta_{0t} + \Sigma_g^{N_g} \beta_{gt} D_{it}^g + \varepsilon_{it} \tag{10}$$

where i is the firm identifier, t is the year subscript, g is the characteristic group subscript. N_g stands for the number of groups. D_{it}^g is a dummy variable, defined as $D_{it}^g = 0$ if $i \notin g$ and $D_{it}^g = 1$ if $i \in g$.

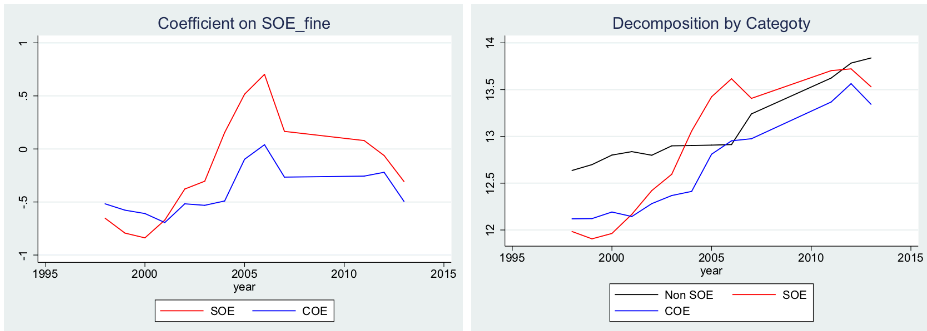
When we divide firms into three categories: SOEs, collectvity-owned enterprises (COEs)[4] and non-SOEs, and run the regression in equation 10 year by year, we can plot the graph in 4. Here we set the baseline group to be the group of non-SOE firms. That is why in the left panel, there are only two series of coefficients standing for the SOEs and COEs while on the right panel there are three lines including the one for the baseline group. Why we cannot have clear interpretation of the coefficnets time series, the predicted average of lnTFP in has different patten. From 1998 to 2004, SOEs are relatively less productive compared to the Non-SOEs. Then SOEs catches up with the Non-SOEs in terms of productivity and even surpass the Non-SOEs after 2005. However, Starting from year 2011, we see a decelaraton of TFP growth in SOEs but not in non-SOE firms.

Figure 5 plots the dispersion of the marginal revenue product of capital (MRPK). The calculation of MRPK follows Chang-Tai Hsieh (2009). And the dispersion is measured as the standard deviation of the log value of MRPK. The definition is shown in equation 11.

$$\begin{gathered} MRPK_{it} \propto \frac{va_{it}}{K_{it}} \\ \text{Dispersion}_t = std(\ln MRPK_{it}) \end{gathered} \tag{11}$$

Now we divide firms by sectors and run the same year-by-year regression

[4] COEs can be considered as one type of SOEs, which are owned by local governments. We will show later that COE are less important in terms of size compared to the other two types.



(a) Coefficients

(b) Predicted average lnTFP

Figure 4: Decomposition by SOE category

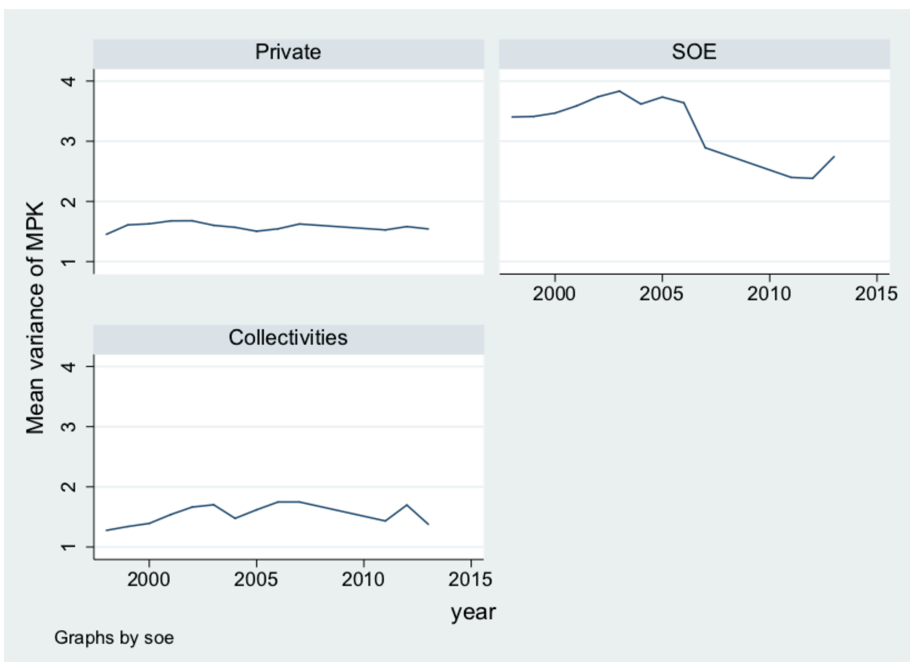


Figure 5: Dispersion of MRPK

in equation 10. We can get the predicted average lnTFP by sectors as shown in Figure 6. Here the sectors are grouped by their main characteristics for the purpose of clear presentation. Although it seems a bit messy in early years, the average lnTFP of all sectors displays the dip that is similar to that of the average lnTFP of the total industry as a whole. This means that the deceleration of TFP growth exists in every sectors, which contrasts to the observation that it does not in every SOE category.

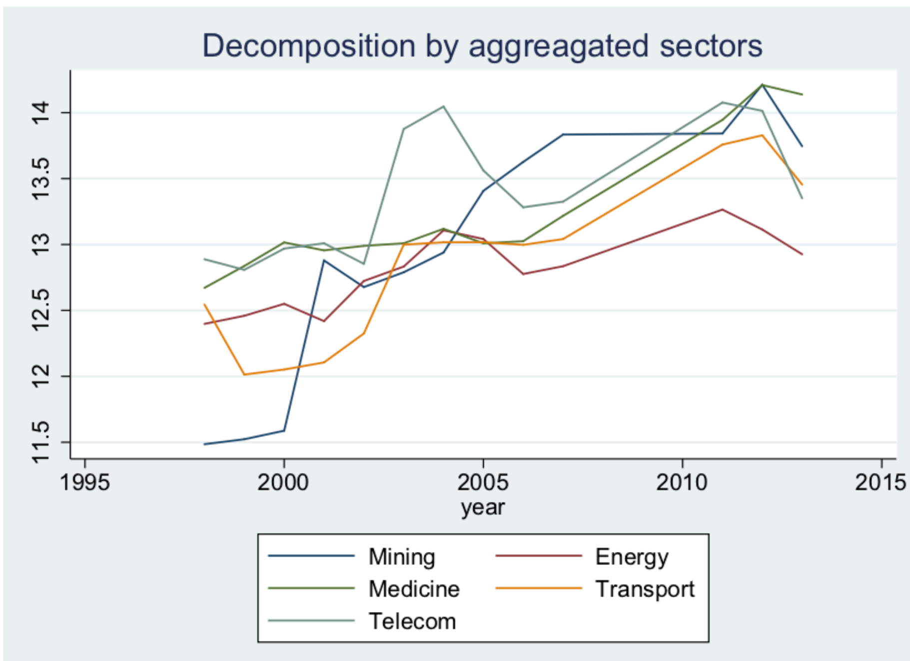


Figure 6: Decomposition by Sectors

4.2 Privatization Slowing Down

In this subsection, we show more difference between the SOEs and non-SOEs. More specifically speaking, we are going to show that the privatization process has slowed down and even reversed. And a possible reason for that is that the borrowing cost for non-SOEs have gone up too much.

Figure 7 presents a mirroring pattern by construction. The blue curve presents the share of real capital of non-SOEs and the red curve that of SOEs. From year 1998 to 2011, the share of real capital of non-SOEs is always increasing except for year 2004. This is mainly because of the privatization process in China. However, this privatization process seems to stop or even reverse starting from year 2011. More detailed break down can be found in table 3. The SOE category in Figure 7 contains the SOE and COE in table 3, while the non-SOE category contains the other two, POE stands for private owned firms, and FOE for foreign investor owned firms.

In table 4 and table 5 show respectively the share of labor by different ownership and the share of value added by different ownership. Both tables show a similar pattern to table 3. All three tables reveal the same signal: by any type size measure (share of capital, labor employment or value added), the SOEs have experienced a significant share drop in the economy due to the privatization process. However, the process slows down starting from 2011, which coincides with the timing of TFP drop.

In Figure 8, we show the average interest rate by SOE categories. The average interest rate is measured as the interest expense over the debt. And in Figure 8 we only include the interest rate between 0 and 1. We can see the borrowing cost of SOEs are much lower than POEs. In all the years of the data set, the average interest rate of SOEs are below 4%, while most of the years, the average interest rate of POEs are above 4% and but below 6%. After 2004, the difference between the average interest rate is even widening between the SOEs and POEs.

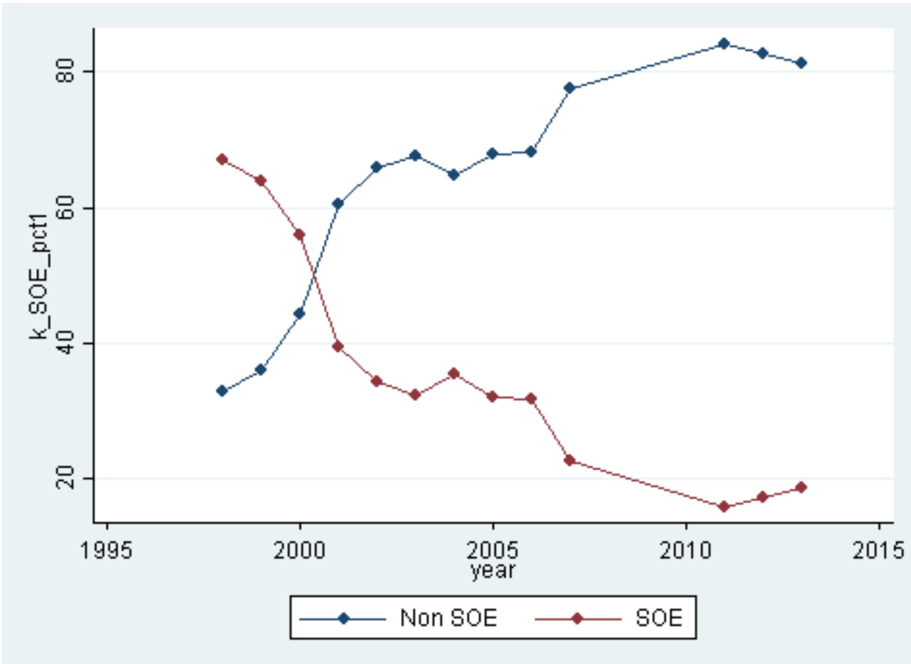


Figure 7: Shares of by SOE category

Table 3: Summary Statistics Capital by Ownership

	Ownership			
year	**POE** %	**SOE** %	**COE** %	**FOE** %
1998	12.1	57.7	9.4	20.7
1999	13.8	55.2	8.8	22.2
2000	22.9	48.0	7.8	21.2
2001	38.6	33.7	5.8	21.9
2002	43.3	29.5	4.8	22.4
2003	44.6	28.2	4.0	23.1
2004	40.5	32.7	2.6	24.1
2005	41.8	30.0	2.0	26.1
2006	42.0	30.1	1.6	26.3
2007	50.8	21.1	1.4	26.6
2011	61.2	15.0	0.8	23.0
2012	58.1	16.2	1.0	24.7
2013	59.7	18.2	0.4	21.6
Total	45.8	40.1	5.9	24.0

Table 4: Summary Statistics Labor by Ownership

	Ownership			
year	**POE** %	**SOE** %	**COE** %	**FOE** %
1998	16.2	52.8	19.8	11.2
1999	19.3	48.5	18.8	13.4
2000	24.5	42.5	17.1	15.9
2001	37.1	31.8	13.8	17.4
2002	41.2	28.0	11.9	18.9
2003	45.0	23.1	9.7	22.2
2004	49.2	19.4	5.5	25.9
2005	50.5	17.2	5.0	27.4
2006	52.1	15.6	4.0	28.3
2007	55.6	12.0	3.4	29.0
2011	61.4	6.6	1.3	30.7
2012	61.4	6.5	1.3	30.8
2013	64.2	6.3	1.2	28.2
Total	50.5	33.4	13.0	24.6

Table 5: Summary Statistics Value Added by Ownership

	Ownership			
year	**POE** %	**SOE** %	**COE** %	**FOE** %
1998	18.0	43.1	16.7	22.2
1999	21.1	37.5	14.8	26.7
2000	28.8	29.6	11.9	29.7
2001	44.3	20.9	7.8	27.0
2002	45.9	20.4	6.9	26.9
2003	45.6	19.1	5.5	29.8
2004	37.9	26.7	3.3	32.2
2005	40.1	27.1	3.4	29.5
2006	41.9	26.0	2.9	29.2
2007	55.3	13.1	2.4	29.3
2011	62.5	8.8	1.1	27.6
2012	64.0	7.9	1.1	27.0
2013	65.1	7.9	0.6	26.4
Total	47.9	28.0	9.3	28.4

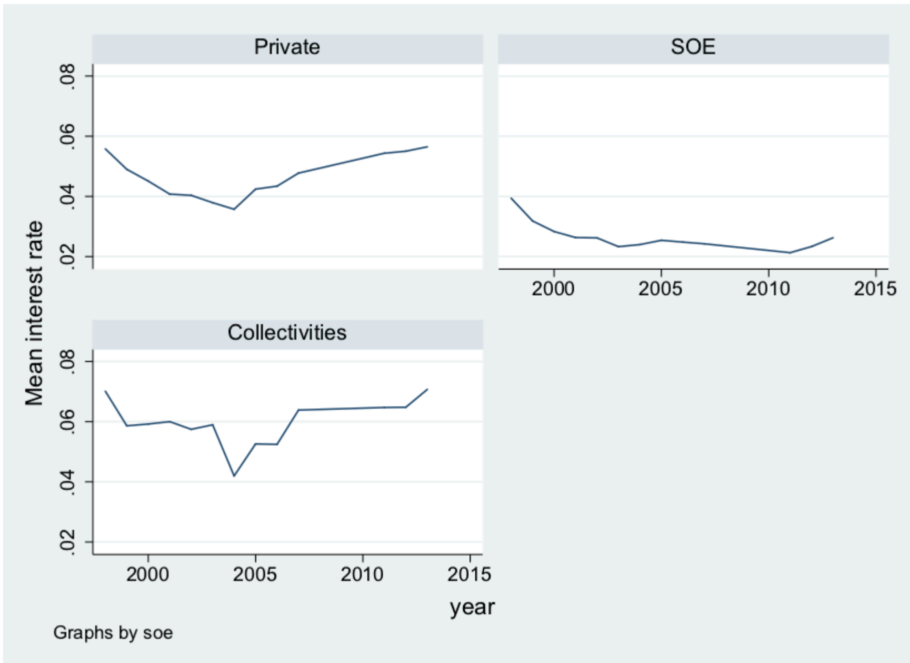


Figure 8: Interests by SOE category

5 Compositional Transition Between SOEs and Non-SOEs

In this section, we attempt to decompose the contributions of SOEs and Non-SOEs to aggregate TFP dynamics. We present evidence showing that in the early period (1998 - 2011), the TFP increase is mainly due to the within Non-SOEs TFP growth; while in the late period (2011 - 2013), the TFP decrease is mainly related to the within SOE TFP decline. The reallocation between SOEs and non-SOEs also plays a role in explaining the change of the TFP growth path of the two periods. With more detailed decomposition within SOEs and non-SOEs, there is a within firm TFP growth flip in SOEs, but not in non-SOEs.

We now describe the decomposition. First, we start with the definition of total production as the sum of real value added by each firm, which we assume to be the product of Cobb-Douglas production function.

$$Y_t = \Sigma A_{it} k_{it}^{\alpha} l_{it}^{\beta} \tag{12}$$

Moreover, to understand the connection between firm-level dynamics and a standard measure of aggregate TFP, we define aggregate TFP as the Solow residual of an aggregate production function with aggregate inputs K_t and L_t. That is, the aggregate TFP measure can be expressed as follows:

$$\text{TFP}_t \equiv A_t = \frac{Y_t}{K^{\alpha} L^{\beta}} = \Sigma_i A_{it} \frac{k_{it}^{\alpha} l_{it}^{\beta}}{K_t^{\alpha} L_t^{\beta}}$$

$$= \Sigma_s \frac{\Sigma_{i \in s} k_{it}^{\alpha} l_{it}^{\beta}}{K_t^{\alpha} L_t^{\beta}} \underbrace{\Sigma_{i \in s} \frac{k_{it}^{\alpha} l_{it}^{\beta}}{\Sigma_{i \in s} k_{it}^{\alpha} l_{it}^{\beta}} A_{it}}_{\equiv TFP_t^s} \tag{13}$$

$$= \Sigma_s \frac{\Sigma_{i \in s} k_{it}^{\alpha} l_{it}^{\beta}}{K_t^{\alpha} L_t^{\beta}} TFP_t^s$$

where s is the subscript for the SOE/non-SOE categories and is the firm identifier. The expression above therefore links firm-level TFP measures to the aggregate measure. In particular, the aggregate TFP measure is simply a weighted average of SOE and Non-SOE TFP respectively, with the weights of each firm category given by $\Sigma_i \frac{k_{it}^{\alpha} l_{it}^{\beta}}{\Sigma_{i \in s} k_{it}^{\alpha} l_{it}^{\beta}} A_{it}$.

Using this construct, we can also decompose the change in aggregate TFP between two years into three parts as shown in equation 14: changes within SOE categories, changes between SOE/non-SOE (driven by changes in privatization trends) and a covariance term.

$$\Delta TFP_t^* \equiv \underbrace{\Sigma_s \frac{\Sigma_{i\in s} k_{ir}^{\alpha} l_{ir}^{\beta}}{K_r^{\alpha} L_r^{\beta}} \Sigma_{i\in s} \frac{k_{ir}^{\alpha} l_{ir}^{\beta}}{\Sigma_{i\in s} k_{ir}^{\alpha} l_{ir}^{\beta}} A_{ir}}_{\text{TFP}_r} - \underbrace{\Sigma_s \frac{\Sigma_{i\in s} k_{it}^{\alpha} l_{it}^{\beta}}{K_t^{\alpha} L_t^{\beta}} \Sigma_{i\in s} \frac{k_{it}^{\alpha} l_{it}^{\beta}}{\Sigma_{i\in s} k_{it}^{\alpha} l_{it}^{\beta}} A_{it}}_{\text{TFP}_t}$$

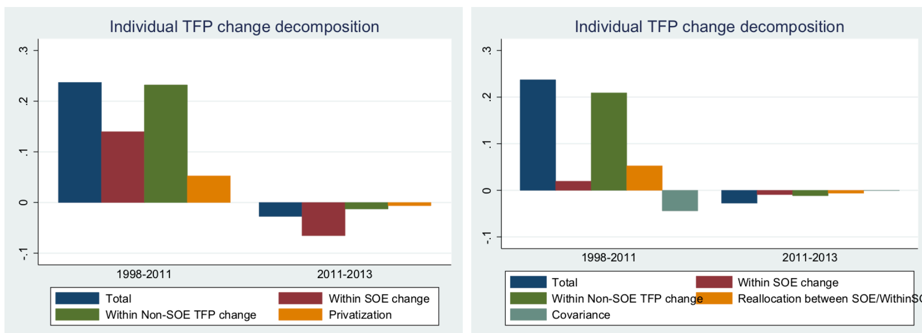
$$= \underbrace{\Sigma_s \frac{\Sigma_{i\in s} k_{ir}^{\alpha} l_{ir}^{\beta}}{K_r^{\alpha} L_r^{\beta}} [TFP_r^S - TFP_t^S]}_{\text{Within SOE/non-SOE changes}} + \underbrace{\Sigma_s [\frac{\Sigma_{i\in s} k_{ir}^{\alpha} l_{ir}^{\beta}}{K_r^{\alpha} L_r^{\beta}} - \frac{\Sigma_{i\in s} k_{it}^{\alpha} l_{it}^{\beta}}{K_t^{\alpha} L_t^{\beta}}] TFP_r^S}_{\text{Privatization}}$$

$$\underbrace{-\Sigma_s (TFP_r^S - TFP_t^S)(\frac{\Sigma_{i\in s} k_{ir}^{\alpha} l_{ir}^{\beta}}{K_r^{\alpha} L_r^{\beta}} - \frac{\Sigma_{i\in s} k_{it}^{\alpha} l_{it}^{\beta}}{K_t^{\alpha} L_t^{\beta}})}_{\text{Covariance term}} \quad (14)$$

where r is the reference year, which we set to 2011, and t is the year in question. We perform TFP growth decomposition for the 1998-2011 and between 2011–2013 separately.

The result of the decomposition in equation 14 is presented in 9a. The results are presentend with and without sector weights ($\Sigma_i \frac{k_{it}^{\alpha} l_{it}^{\beta}}{\Sigma_{i\in s} k_{it}^{\alpha} l_{it}^{\beta}} A_{it}.$). There are several features worth noting in the unweighted results. First, there is a shift from positive to negative contributions to aggregate TFP growth in both the within Non-SOE component (green) and the within SOE component (red). Second, the contribution in the second period is more negative in the SOE component than in the non SOE component. Third, movements of capital and labor away from SOEs and into SOEs also had positive effects during the period, though these contribution only accounts for a small share of the total aggregate TFP growth in TFP. Fourth, mirroring the privatization slow-down, the component switched from positive to negative in the later sub-period.

Because there is a significant movement away from SOEs in this period, weighted results assessing the quantitative impact of SOE growth depend on the year of reference weights used. Since 2011 weights are used, this understates the quantitative impact of SOE changes and overstates the impact of SOE changes. Using the labeling of 2011, we can see that most of the contribution to TFP growth was driven by firms that were not SOEs in 2011, as well as by the privatization efforts leading to 2011. Consistent with the unweighted results, the contribution of these forces reversed in the period between 2011-2013.



(a) Unweighted between-within SOE TFP Changes

(b) Weighted between-within SOE TFP Changes

Figure 9: TFP Changes by SOE Category

The exercise above motivates our study of changes within the SOE and Non-SOE TFP component. Each of these components can be further decomposed into five subcomponents: within firm changes in TFP, reallocation of capital and labor between firms within each SOE/Non-SOE category, entry and exit, and covariance between within firm TFP changes and the reallocation of capital and labor. The decomposition method is expressed in equation 15.

$$\Delta TFP_t^S \equiv TFP_r^s - TFP_t^s$$

$$= \Sigma_{i\in s}\frac{k_{ir}^{\alpha}l_{ir}^{\beta}}{\Sigma_{i\in s}k_{ir}^{\alpha}l_{ir}^{\beta}}A_{ir} - \Sigma_{i\in s}\frac{k_{it}^{\alpha}l_{it}^{\beta}}{\Sigma_{i\in s}k_{it}^{\alpha}l_{it}^{\beta}}A_{it}$$

$$= \underbrace{Weight_{stay^s,r}\Sigma_{i\in stay^s}\frac{k_{ir}^{\alpha}l_{ir}^{\beta}}{\Sigma_{i\in stay^s}k_{ir}^{\alpha}l_{ir}^{\beta}}[A_{ir} - A_{it}]}_{\text{Within Firm}}$$

$$+\underbrace{Weight_{stay^s,r}\Sigma_{i\in stay^s}[\frac{k_{ir}^{\alpha}l_{ir}^{\beta}}{\Sigma_{i\in stay^s}k_{ir}^{\alpha}l_{ir}^{\beta}} - \frac{Weight_{stay^s,t}}{Weight_{stay^s,r}}\frac{k_{it}^{\alpha}l_{it}^{\beta}}{\Sigma_{i\in stay^s}k_{it}^{\alpha}l_{it}^{\beta}}]A_{it}}_{\text{Between Firm}}$$

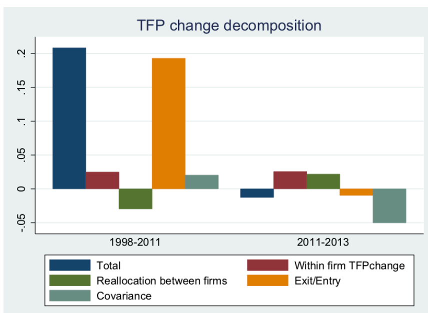
$$+\underbrace{Weight_{enter^s,r}\Sigma_{i\in enter^s}\frac{k_{ir}^{\alpha}l_{ir}^{\beta}}{\Sigma_{i\in enter^s}k_{ir}^{\alpha}l_{ir}^{\beta}}A_{ir}}_{\text{Enry}} - \underbrace{Weight_{exit^s,t}\Sigma_{i\in exit^s}\frac{k_{it}^{\alpha}l_{it}^{\beta}}{\Sigma_{i\in exit^s}k_{it}^{\alpha}l_{it}^{\beta}}A_{it}}_{\text{Exit}}$$

$$-\underbrace{\Sigma_{i\in stay^s}(A_{ir} - A_{it})(\frac{k_{ir}^{\alpha}l_{ir}^{\beta}}{\Sigma_{i\in s}k_{ir}^{\alpha}l_{ir}^{\beta}} - \frac{k_{it}^{\alpha}l_{it}^{\beta}}{\Sigma_{i\in s}k_{it}^{\alpha}l_{it}^{\beta}})}_{\text{Covariance}} \tag{15}$$

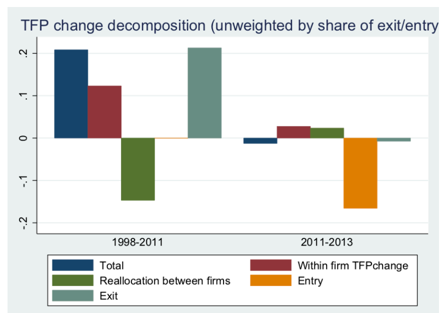
where $stay^s$ is the subset of s, standing for firms that exist both in year t and in reference year r in the category s; $enter^s$ is the subset of s, standing for firms that newly enter into the market in reference year r and do not exist in year t in the category s; $exit^s$ is the subset of s, standing for firms that exit in year t but do not exit in reference year r in the category s. Moreover,

$$
\begin{aligned}
Weight_{stay^s,r} &\equiv \frac{\Sigma_{i\in stay^s} k_{ir}^{\alpha} l_{ir}^{\beta}}{\Sigma_{i\in s} k_{ir}^{\alpha} l_{ir}^{\beta}} \\
Weight_{stay^s,t} &\equiv \frac{\Sigma_{i\in stay^s} k_{it}^{\alpha} l_{it}^{\beta}}{\Sigma_{i\in s} k_{it}^{\alpha} l_{it}^{\beta}} \\
Weight_{enter^s,r} &\equiv \frac{\Sigma_{i\in enter^s} k_{ir}^{\alpha} l_{ir}^{\beta}}{\Sigma_{i\in s} k_{ir}^{\alpha} l_{ir}^{\beta}} \\
Weight_{exit^s,t} &\equiv \frac{\Sigma_{i\in exit^s} k_{it}^{\alpha} l_{it}^{\beta}}{\Sigma_{i\in s} k_{it}^{\alpha} l_{it}^{\beta}}
\end{aligned} \tag{16}
$$

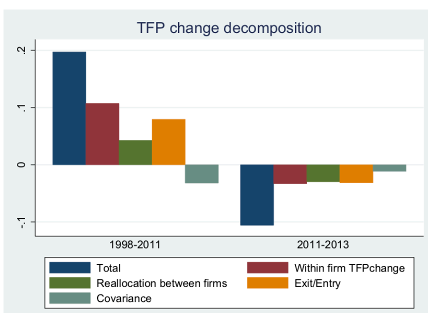
The result of the decomposition described in equation 15 is shown in Figure 10. The first row is the weighted and unweighted within non-SOE TFP change while the second row is the counterpart for the SOE TFP change. The first column is the weighted TFP change while the second column is the unweighted TFP change. One interesting pattern is that for SOEs, the within firm TFP change (maroon bar) flips from positive in the first sub-period to negative in the second sub-period, while we do not observe the same change in non-SOEs. This means that on average the measured TFP experience a decline for the existing SOEs but not for the existing non-SOEs. Anther point is that the reallocation between firms (green bar) causes a TFP growth flip in SOEs but not in non-SOEs, indicating that SOEs may suffer more misallocation in the second sub-period compared to the non-SOEs.



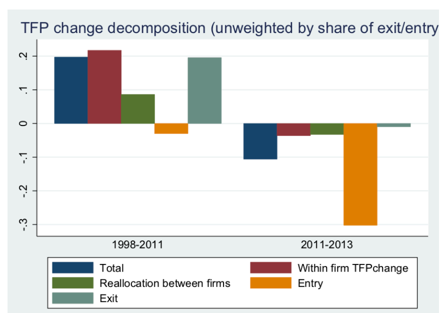
(a) Weighted within non-SOE TFP Changes



(b) Unweighted within non-SOE TFP Changes



(c) Weighted within SOE TFP Changes



(d) Unweighted within SOE TFP Changes

Figure 10: TFP Changes by within SOE/Non-SOE

Table 6: Correlations between changes in TFP and changes in capacity utilization

	All	1998–2007	2008–2013	1998–2011	2012–2013
	D.lnTFP	D.lnTFP	D.lnTFP	D.lnTFP	D.lnTFP
D.Utilization	0.00144	0.00178	-0.0357	0.00178	-0.0357
	(0.00171)	(0.00144)	(0.0285)	(0.00144)	(0.0285)
Constant	0.0907**	0.0969**	0.0464	0.0969**	0.0464
	(0.0435)	(0.0388)	(0.212)	(0.0388)	(0.212)
Observations	72	63	9	63	9
R-squared	0.010	0.025	0.183	0.025	0.183

Standard errors in parentheses. *** p¡0.01, ** p¡0.05, * p¡0.1

6 TFP trends and capacity dynamics

An alternative explanation for the patterns documented is that these are driven by capacity utilization dynamics. This is certainly a possibility since, our measures of TFP, can are affected by capacity utilization changes. In particular, the slow-down of TFP might be the product of lagging capacity utilization.

To assess this potential challenge, we gathered data from Chinese Statistical Year Book on capacity and production for available manufacturing sectors. A utilization variable was constructed by dividing total production in that sector by the capacity measure. Sectors with enough observations before and after 2008 were selected. Figure 11 present the trends in average TFP and industry-level capacity for industries with available data and table 6 documents the correlation between changes in utilization and mean TFP at the sectoral level. We find no evidence of strong correlation between changes in TFP and changes in measured capacity utilization. Moreover, from the limited available evidence, we find no evidence of a decrease in capacity utilization that could explain the deceleration in TFP.

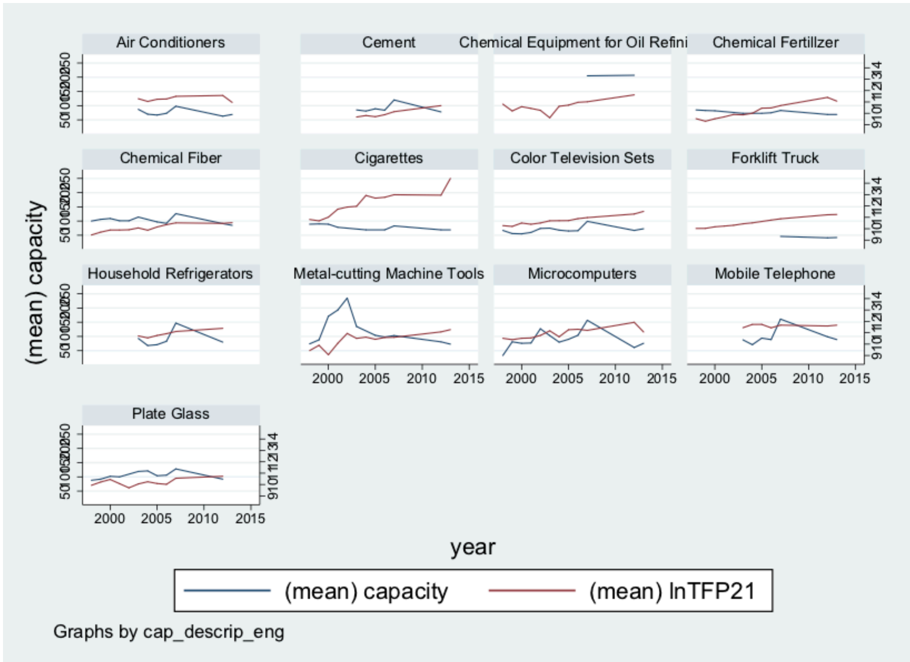


Figure 11: Trends in capacity utilization and TFP by industry

7 Conclusion

After a decade of growth, manufacturing TFP measured from both and aggregate and micro perspective seems to have decelerated in China after 2007. When decomposing this changes, within-firm TFP changes among SOEs and privatization, which were drivers of growth before 2007, seem to have reversed in the years after 2011. In particular, earlier lags in productivity in SOEs when compared to POEs seem to have shrunk, suggesting that an past avenue of growth might have been exhausted.

References

Ackerberg, Daniel A., Kevin Caves, and Garth Frazer. 2015. "Identification Properties of Recent Production Function Estimators." *Econometrica*, 83(6): 2411–2451.

Chang-Tai Hsieh, Peter J. Klenow. 2009. “Misallocation and Manufacturing TFP in China and India.” *The Quarterly Journal of Economics*, 124(4): 1403–1448.

De Loecker, Jan. 2011. “Product Differentiation, Multiproduct Firms, and Estimating the Impact of Trade Liberalization on Productivity.” *Econometrica*, 79(5): 1407–1451.

Levinsohn, James, and Amil Petrin. 2003. “Estimating Production Functions Using Inputs to Control for Unobservables.” *The Review of Economic Studies*, 70(2): 317–341.

Olley, G. Steven, and Ariel Pakes. 1996. “The Dynamics of Productivity in the Telecommunications Equipment Industry.” *Econometrica*, 64(6): 1263–1297.