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Productivity Dynamics of Chinese Manufacturing Firms*

Qu Feng Zhifeng Wang Guiying Laura Wu

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Abstract

China has experienced high-speed catch-up growth with an average annual rate of over 8% in per capita GDP in the past four decades. Using growth accounting, Zhu (2012) finds that the growth of total factor productivity (TFP) accounts for 77% of China's per capita GDP growth during 1978-2007, and argues that China's TFP growth is mainly driven by resource reallocation due to market liberalization and institutional reforms. This paper aims to estimate China's aggregate productivity growth by applying three leading methods of estimating firm-level production function on Chinese manufacturing firms during 1998-2007, and quantify the contribution of resource reallocation to productivity growth. In addition, we also empirically compare the three estimation methods in this large data set.

Keywords: China's economic growth, TFP growth, production function, resource reallocation

JEL Classification: D24 O14

1 Introduction

In the past four decades China has experienced high-speed catch-up growth with average annual rates of nearly 10% and over 8% in GDP and per capita GDP, respectively.

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To explain the Chinese economic miracle, along with other 12 successful economies, *The Growth Report* from the World Bank emphasizes on some important ingredients, including globalization, strong government leadership, market allocation and high investment in physical capital and human capital. In terms of the role of government on economic growth, Jin, Qian, and Weingast (2005) establish the association between fiscal incentives of Chinese local governments and the development of non-state enterprises. Using growth accounting, Zhu (2012) finds that the growth of total factor productivity (TFP) accounts for 77% of China's per capita GDP growth during 1978-2007, and argues that China's TFP growth is mainly driven by resource reallocation due to market liberalization and institutional reforms. Song, Storesletten and Zilibotti (2011) also point out that reallocation within the manufacturing sector due to financial frictions is an important source of productivity growth in China.

Literature on China's productivity growth using aggregate-level data includes Young (2003), Zheng, Bigsten, and Hu (2009), Brandt and Zhu (2010), to name a few. In these studies the estimates of TFP growth vary a lot due to different treatments on official deflator, capital share and human capital. In contrast to the studies using aggregate level data that are usually silent on industry variation, firm heterogeneity, and the link between productivity and observables, the recent literature focuses on productivity from estimating firm-level production function.

Jefferson, Rawski and Zhang (2008) use OLS and fixed effects estimation on data of China's annual industrial survey during 1998-2005. Using the same data set, Brandt, Van Biesebroeck and Zhang (2012) conduct a more thorough study on estimating firm productivity and its determinants. Based on Tornqvist index and the recent proxy methods of estimating firm-level production function proposed by Olley and Pakes (1996, OP hereafter) and Ackerberg, Caves and Frazer (2006, 2015, ACF hereafter), they find that up to two-thirds of the aggregate TFP growth in Chinese manufacturing is due to entry and exit during 1998-2007. In a study on the effect of reductions in tariffs on productivity of Chinese exporting firms, Yu (2015) also use the OP method and the system GMM method proposed by Blundell and Bond (2000, BB hereafter) to estimate firm-level production function. Recently, Ding, Guariglia and Harris (2016) also employ the BB method to estimate firm-level productivity and examine the determinants of productivity of Chinese manufacturing firms.[1]

This paper aims to understand China's economic growth from the view of firm-level

[1] For a detailed literature review on estimating and explaining China's TFP growth, see Ding, et al. (2016).

productivity growth. We present the productivity dynamics of Chinese manufacturing firms during 1998-2007, including productivity trend over time, industry pattern, and the link between firm productivity and observable firm characteristics, such as region, ownership, entry and exit, and exporting. In addition, as in Pavcnik (2002), we also examine how much the aggregate productivity growth can be explained by reallocation of resources from low productivity firms to high productivity ones within each industry.

Another motivation of this paper is to empirically compare the leading methods of estimating firm-level production function, that is, ACF and BB with the traditional OLS in this large data set.[2] OLS has the advantage of being computationally simple and stable. Compared with OLS, the ACF approach is able to deal with endogeneity issue due to the correlation between inputs and unobserved productivity. However, in the ACF approach firm fixed effects and firm productivity are not distinguishable. Different from the ACF approach, the BB approach is able to control for firm fixed effects, but its assumption on the productivity process is more restrictive.[3]

Based on estimating revenue-measured firm-level production function, our findings are as follows. First, the average annual aggregate TFP growth of Chinese manufacturing firms ranges from 3.75% to 5.99% during 1998-2007, supporting Zhu's (2012) estimate of annual TFP growth of 4.68% using aggregate-level data. Second, the contribution to aggregate weighted productivity growth from resource reallocation only happens in the late 1990s and the early 2000s thanks to the reforms of state-owned enterprises and the entry to the WTO, and declines to almost zero in 2007 in most industries. Third, among the observable characteristics, location and ownership robustly explain the firm-level productivity variation across different industries and from different estimation methods.

Regarding the comparison of OLS, ACF and BB methods, using the large data set of Chinese manufacturing firms, we find that: first, these three estimates produce the same patterns on productivity growth over time and the contribution of resource reallocation to productivity growth. Second, in terms of magnitude, BB method gives a generous estimate of productivity growth, while ACF produces a conservative one. Third, the analysis of determinants of firm-level productivity based on OLS, ACF and

[2] The motivation of empirically comparing 3 leading methods of estimating firm-level production function distinguishes our paper from Brandt et al. (2012). In addition, we quantify the role of resource reallocation in promoting productivity growth by a decomposition based on Olley and Pakes (1996) and Pavcnik (2002).

[3] For a theoretical comparison between these two approaches, see Section 5.3 of Ackerberg, Caves and Frazer (2006). The limitation of the proxy methods is also discussed by Bond and Söderbom (2005).

BB estimates gives same signs of effects of region and ownership on productivity, but ACF and BB produce conflicting evidence on the exporting effect, either pooling all industries or among individual industries. This finding suggests that one should be cautious to analyze the determinants of productivity based on only one estimation method of production function.

This paper is organized as follows. Section 2 briefly describes the ACF and BB approaches of estimating firm-level production function. Section 3 gives a brief description of data and variables used in our empirical exercises. Section 4 reports the empirical results on firm productivity, and links it to observables by regression analyses. Finally, Section 5 concludes.

2 Estimating Firm Productivity

2.1 ACF approach

In a firm-level production function,

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it}, \tag{1}$$

y, l, k and m represent log of revenue, labor, capital, intermediate input, respectively. ω denotes firm's unobservable productivity, and ε stands for random shocks to production. Since the decision of inputs l, k and m depends on the unobservable productivity ω, OLS estimate for $(\beta_l, \beta_k, \beta_m)$ is inconsistent.

To deal with this endogeneity issue, following the ideas of Olley and Pakes (1996), Levinsohn and Petrin (2003), Ackerberg et al. (2006) use the intermediate input m as a proxy for ω. Specifically, from profit maximization m_{it} is solved out as an increasing function of productivity, conditional on capital and labor:

$$m_{it} = f(l_{it}, k_{it}, \omega_{it}). \tag{2}$$

Assuming that f is invertible for ω_{it}:

$$\omega_{it} = g(l_{it}, k_{it}, m_{it}), \tag{3}$$

implies that

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + g(l_{it}, k_{it}, m_{it}) + \varepsilon_{it} = \phi(l_{it}, k_{it}, m_{it}) + \varepsilon_{it}. \tag{4}$$

To consistently estimate $(\beta_l, \beta_k, \beta_m)$, a two-step procedure is applied. For estimation details, see Ackerberg et al. (2006).

2.2 BB approach

Blundell and Bond (2000) allow for firm fixed effects η_i in the production function:

$$y_{it} = \alpha_l l_{it} + \alpha_k k_{it} + \alpha_m m_{it} + \eta_i + \upsilon_{it} + \xi_{it}. \tag{5}$$

The productivity shock υ_{it} strictly follows an AR(1) process,

$$\upsilon_{it} = \theta \upsilon_{it-1} + e_{it}, \tag{6}$$

implying a dynamic panel model of production function:

$$\begin{aligned} y_{it} &= \theta y_{it-1} + \alpha_l l_{it} - \theta \alpha_l l_{it-1} + \alpha_k k_{it} - \theta \alpha_k k_{it-1} + \alpha_m m_{it} - \theta \alpha_m m_{it-1} \\ &\quad + \eta_i (1-\theta) + e_{it} + \xi_{it} - \theta \xi_{it-1}. \end{aligned} \tag{7}$$

Due to the persistence of productivity shock υ_{it}, Blundell and Bond (2000) suggest using system GMM, instead of the first-difference GMM, to estimate the dynamic panel data model (7). The original input parameters α_l, α_k and α_m can be recovered by the estimates of parameters in (7). For estimation details, see Blundell and Bond (2000).

Besides ACF and BB approaches of estimating firm-level production function, we also use OLS for comparison. After obtaining input coefficient estimates, firm-level productivity is defined as the Solow residual, that is the difference between output (revenue) and its fitted value.

This paper is closely related to Ding et al. (2016) with some important differences as follows. First, to obtain robust results, we report empirical findings based on 3 methods: OLS, ACF and BB, instead of only on BB estimates. Second, Ding et al. (2016) use the one-stage approach including observable firm characteristics in addition to inputs in the production function, while this paper follows Brandt et al. (2012) and Yu (2015) to estimate firm-level production function and productivity, so that the input coefficient estimates are more comparable to the vast literature. Third, time dummies, instead of time trend, are used to control for year-specific effects in the production function estimation in this paper. Fourth, we deal with data slightly differently from Ding, et al. (2016), who combine some industries together. Finally, we highlight the importance of resource reallocation in TFP growth using a Pavcnik (2002) decomposition, besides the Haltiwanger (2007) decomposition as in Ding et al. (2016).

3 Data and Variables

The data set used in this paper, same as Brandt et al. (2012), is the Annual Survey of Industrial Firms conducted by China's National Bureau of Statistics covering 1998-2007. Firms are either state-owned or are non-state firms with sales above 5 million RMB. For the details of data, see Brandt et al. (2012).

We follow Brandt et al. (2012) to construct the real capital stock with a depreciation rate of 9%. The number of the employees is used as labor input. The intermediate input is defined as the input minus financial cost. Output and input data are deflated by the price indices provided by Brandt et al. (2012). Table 1 gives the description of the key variables.

The value of entry dummy is set to be 1 when the firm is observed in the sample for the first time, 0 otherwise. The exit dummy specifies whether a firm will exit the sample in year t+1. The export dummy has a value of 1 if the export revenue is positive in a firm-year observation.

Since the geographic differentiation and regional disparity is an important feature of China's economy (Naughton, 2007), we include regional effect when examining the determinants of firm-level productivity. Following Jefferson, Rawski and Zhang (2008), we classify Chinese provinces into four regions: coastal, central, western and northeastern regions. The coastal region includes 10 provinces, i.e., Beijing, Fujian, Guangdong, Hainan, Hebei, Jiangsu, Shanghai, Shandong, Tianjin and Zhejiang. The northeastern region only includes 3 provinces, Heilongjiang, Jilin and Liaoning. 9 provinces of Anhui, Guangxi, Henan, Hubei, Hunan, Inner Mongolia, Jiangxi and Shanxi belong to the central region. The western region consists of the rest of 10 provinces, Chongqing, Gansu, Guizhou, Ningxia, Qinghai, Shaanxi, Sichuan, Xinjiang, Tibet, and Yunnan.

The ownership dummy is defined by the registration types, including state-owned enterprises (SOE), collective-owned enterprises (COE), domestic private-owned enterprises (DPE), Hong Kong, Macao or Taiwan owned enterprises (HMT), foreign invested enterprise (FIE), and other types (Others).

4 Empirical Findings

This section presents some empirical findings on productivity dynamics of Chinese manufacturing firms, and links the firm-level productivity to observables, including entry and exit, exporting status, location and ownership. In addition, the Pavcnik

(2002) decomposition allows us to study how much productivity growth is accounted for by reallocation within each industry. Different from the existing literature, we present the results using three different methods of estimating firm-level production function, and emphasize on the robustness of the findings and cross industry variation.

4.1 Productivity dynamics

Table 2 reports the estimated coefficients of production function by industry. According to our identification assumption, OLS is inconsistent due to endogenity issue, while ACF and BB are consistent. The trade-off is, however, also clear. Among these 29 industries, there are only 2 negative and small coefficients for OLS, while there are 7 and 6 negative coefficients for ACF and BB, respectively. Since OLS is less demanding in solving out the estimates from the minimization problems than ACF and BB, it seems that OLS could be more reliable in terms of calculation.

Similar to Yu (2015), we find that from all three methods, the coefficients of labor and capital are relatively small, below 0.1 in most cases, while the coefficients of intermediate input are relatively large, compared with the general literature on estimating production function using firm-level data, such as Pavcnik (2002). This reflects the facts of the low value-added generated by the Chinese manufacturing sector. For β_l and β_k, the BB estimates are generally bigger than the OLS and ACF estimates. Consequently, the BB's β_m estimates are smaller than the OLS and ACF estimates.

Figure 1 plots aggregated productivity growth of manufacturing firms during 1999-2007. These productivity growth rates are aggregated from firm-level productivity using firm revenue as the weights. The dashed-spots, solid and dotted lines represent productivity estimates based on OLS, ACF and BB approaches, respectively. Figure 1 shows that three productivity growth estimates are positive and fluctuate over years with a similar pattern. There is a big drop of productivity growth in 2001, followed by a steady increase until 2005. Table 3 reports annual aggregate productivity growth of the manufacturing sector and the 29 individual industries. The average annual productivity growth rates are 4.16%, 3.75% and 5.99% for OLS, ACF and BB estimates reported in columns 1, 5, 9 of the first row, larger than 2.85% obtained by Brandt et al. (2012) based on gross output. These estimates support Zhu's (2012) estimate of annual TFP growth of 4.68% based on aggregate-level data during the same period.

To explore cross industry variation, we also report aggregated productivity growth in Figures 2a, 2b and 2c for three industries: textile, raw chemical materials and chemical products, and electronic and telecommunications equipment. These 3 industries are chosen because they belong to downstream, upstream and middle stream industries, respectively (Li, Liu and Wang, 2015). In addition, as shown in Table 3 below, they present different productivity growth rates. The electronic and telecommunications equipment industry grows at a second highest rate in the whole manufacturing sector, while the growth rates of textile and raw chemical materials industries are lower than the average. First, same as the all-industry aggregate productivity growth in Figure 1, these figures of industry-level productivity growth based on three different estimates follow a similar pattern over time. The OLS, ACF and BB estimates of productivity growth have positive annual averages, e.g., 3.30%, 2.47% and 3.80% for the industry of raw chemical materials and chemical products (code 26) reported in columns 1, 5, 9 of Table 3.

Second, however, different from aggregate productivity growth of the manufacturing sector, productivity growth in specific industry can be negative in some years. For example, the OLS, ACF and BB estimates of minimal annual productivity growth in the tobacco industry (code 16) are -2.23%, -1.50% and -1.59%, reported in columns 4, 8, 12 of Table 3. Some industries even experience negative annual aggregate productivity growth rates based on OLS and ACF estimates. Third, productivity growth varies across industry in terms of the average growth rate, volatility and pattern over time. For example, the annual average productivity growth rates of electronic and telecommunications equipment (code 40) are 8.49%, 8.68% and 10.44% for OLS, ACF and BB estimates, much higher than all-industry annual averages.

Finally, Figures 2a, 2b and 2c of the three industry cases also indicate that there is no uniform order of the three different estimates of productivity growth. The ranking of OLS, ACF and BB can be random across industry, although a rule of BB > OLS > ACF seems more common in 17 out of 29 industries,[4] and a similar magnitude is observed in 6 out of the rest 12 industries.

Different from the negative productivity growth in 5 industries reported in Table 4 of Ding et al. (2016), our BB estimates of average annual productivity growth are always positive in column 9 of Table 3. In addition, it seems that our BB estimates of productivity growth are much larger than theirs.

[4]This is consistent with production function coefficient estimates. More than half of the ACF capital and labor coefficint estimates are smaller than those OLS estimates. The BB intermediate input coefficient estimate is generally smaller than the OLS estimate.

4.2 Productivity growth and reallocation

Similar to Olley and Pakes (1996) and Pavcnik (2002), Table 4 presents the decomposition of aggregate weighted productivity into unweighted productivity and the covariance between a firm's productivity and its share of the industry output (revenue). A positive covariance indicates the contribution to the aggregate weighted productivity resulting from the reallocation of resources from low-productivity firms to high-productivity firms within the industry.

Table 4 reports the decomposition for 3 industries: textile, raw chemical materials and chemical products, and electronic and telecommunications equipment. Column 1 reports the OLS weighted aggregate productivity levels, minus its level in 1998, so that they can be interpreted as growth relative to 1998. For example, in textile industry the aggregate productivity grows by 6.7% in 2000 relative to 1998 based on OLS. Unweighted productivity and covariance growth are 4.8% and 1.9%, reported in columns 2 and 3, indicating that the contribution of resource reallocation to aggregate weighted productivity growth is 28% in 2000. This contribution declines to 6.4% in 2002. The same decomposition based on ACF and BB estimates, reported in columns 4-9 of Table 4, delivers the same message that efficient reallocation of resources and market shares only happens during 1999-2001 in the textile industry.

In the electronic and telecommunications industry the contributions of resource reallocation to aggregate weighted productivity growth are mostly positive, but declining to almost 0 at the end of period of 1999-2007. This pattern is robust to OLS, ACF and BB estimates of productivity.

In the appendix, we also report the decomposition for other 26 industries. Consistent with the finding in Table 4 above, reallocation of the resources and market share from the less to more productive firms diminishes in late years. This suggests that resource reallocation of manufacturing firms due to the major reforms of state-owned enterprises in the late 1990s and the entry to the WTO in 2001 has been realized. To further promote productivity growth, more market liberalizations in factor markets and financial systems are needed.

4.3 Productivity determinants

To explain the productivity variation among different industries, regions and ownerships, we link firm-level productivity to these observables. In addition, we also include firm-level characteristics, e.g., entry, exit and exporting status, which are beyond the existing analysis using aggregate-level data.

Table 5 reports the regression results of pooling all industries based on the three estimates of firm-level productivity: OLS, ACF and BB. First, consistent with the analysis using aggregate-level data, firm-level productivity varies significantly across regions and ownerships. On average firms in costal regions have higher productivity than those in central and western provinces. In addition, foreign and private firms are more productive than state-owned firms, after controlling for other factors, industry and year dummies.

Second, in line with Table 3 of Brandt et al. (2012), we also find positive association between new entry and productivity in columns 4 and 7 of Table 5 for ACF and BB. Consistent with Table 4 of Ding et al. (2016), using Haltiwanger (1997) decomposition, Table 6 also shows that around two-thirds of productivity growth comes from new entering firms. However, as shown in columns 6 and 9 of Table 5, after controlling for year dummies and other variables the impact of new entry becomes much smaller using ACF and BB estimates, even ignorable using OLS. This indicates that entry is not random and the new entrants that drive China's productivity growth could be those foreign and private firms established in costal regions in late years.

Third, consistent with Brandt et al. (2012) and Ding et al. (2016), firm exit is negatively associated with productivity. On average exiting firms are less productive than continuing firms by 7.4% based on the BB estimate in column 9 of Table 5, implying that the exit of low-productivity firms is an important source of the productivity growth of the Chinese manufacturing sector. The firm exit is accompanied with market competition and resource reallocation from low-productivity firms and industries to high-productivity firms and industries.

Fourth, Table 5 also reports the effect of exporting on firm productivity based on the three estimates of productivity. The results based on ACF estimates in columns 5 and 6 suggest a small but negative exporting effect on productivity after controlling for regional and ownership characteristics, while the coefficients of exporting variable based on BB estimates in columns 8 and 9 are positive. Thus, one should be cautious to claim that Chinese exporters are more productive than non-exporters in general. This point is confirmed in the regression by industry in Table 7 containing the results on three industries of textile, raw chemical materials and chemical products, and electronic and telecommunications equipment. The exporting effect on firm productivity is consistently negative based on the three estimates for the industry of electronic and telecommunications equipment in columns 7-9, while it is consistently positive in the textile industry in columns 1-3. This finding is consistent with Ding et al. (2016), who find positive exporting effect in only 9 out of 26 industries. This is also in line with Lu's (2010) argument that exporters are not necessarily more productive than non-exporters. It could be industry specific.

It is worth noting that OLS, ACF and BB deliver conflicting evidences on the firm exit effect in textile industry and exporting effect in raw chemical materials.

4.4 Robustness checks

Table 8 presents robustness checks using the data pooling all industries. The ACF results reported in column 6 of Table 5 are based on 4th order polynomials for the productivity process. Here, columns 1-3 of Table 8 give the similar regression results to Table 5 including only one entry dummy with a productivity process in the ACF estimation that is of linear form, 2nd and 3rd order polynomials, respectively. Compared with the column 6 of Table 5, these 3 columns present very similar results.

Column 4 of Table 8 replaces the system GMM (or BB) with the first-difference GMM estimates. Compared with column 9 of Table 5, the first-difference GMM estimates deliver similar effects of location and ownership on productivity, but different sign on exporting effect. This confirms the robustness of location and ownership effects, and the uncertainty of exporting effect, as discussed in the previous subsection.

5 Conclusion

This paper aims to understand China's high-speed economic growth from the view of TFP growth. Different from the analyses based on aggregate-level data, we estimate the aggregate productivity growth by employing a large data set of Chinese manufacturing firms during 1998-2007 and the state-of-art estimation methods of firm-level production function. In addition, we also quantify how much China's productivity growth can be explained by the resource reallocation from low-productivity firms to high-productivity ones.

Using revenue-measured firm-level production function estimates, we find that the average annual TFP growth rate of Chinese manufacturing is comparable to Zhu's (2012) estimate using growth accounting during 1998-2007. In addition, the firm-level evidence shows that the contribution of resource reallocation to TFP growth seems only appear in early years of the sample period. In this sense, the importance of resource reallocation to China's economic growth cannot be overemphasized nowadays without further reforms in factor markets and financial systems.

We also empirically compare OLS, ACF and BB methods in the large data set of Chinese manufacturing firms. It seems that these 3 methods work equally well in estimating productivity growth, and quantifying the contribution of resource reallocation to productivity growth. However, they may lead to conflicting results when estimating the exporting effect on productivity and in by-industry analyses.

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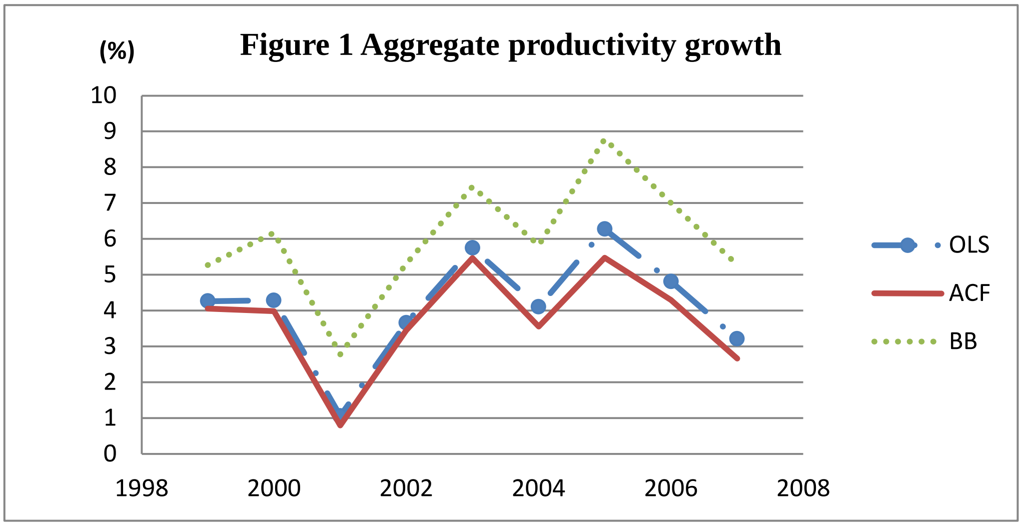
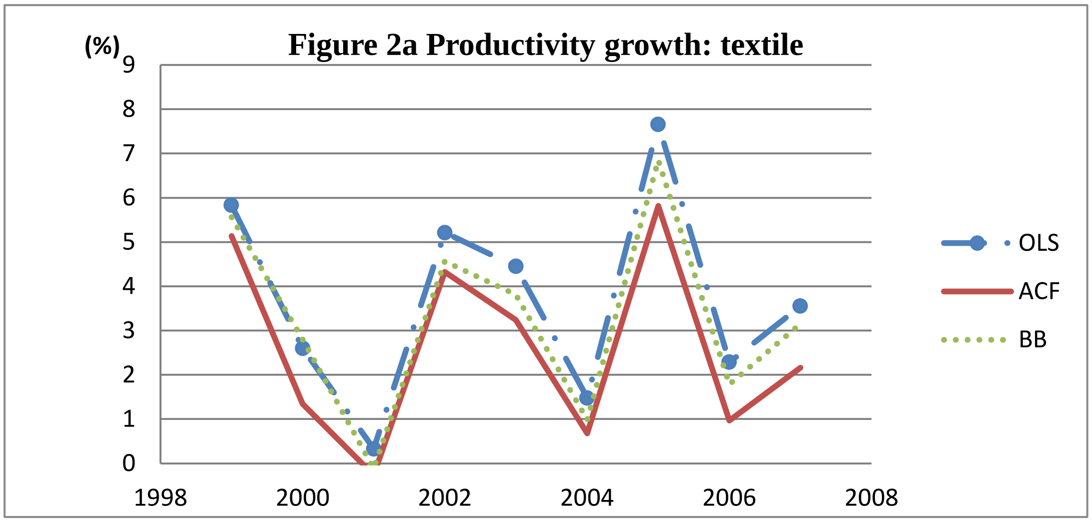
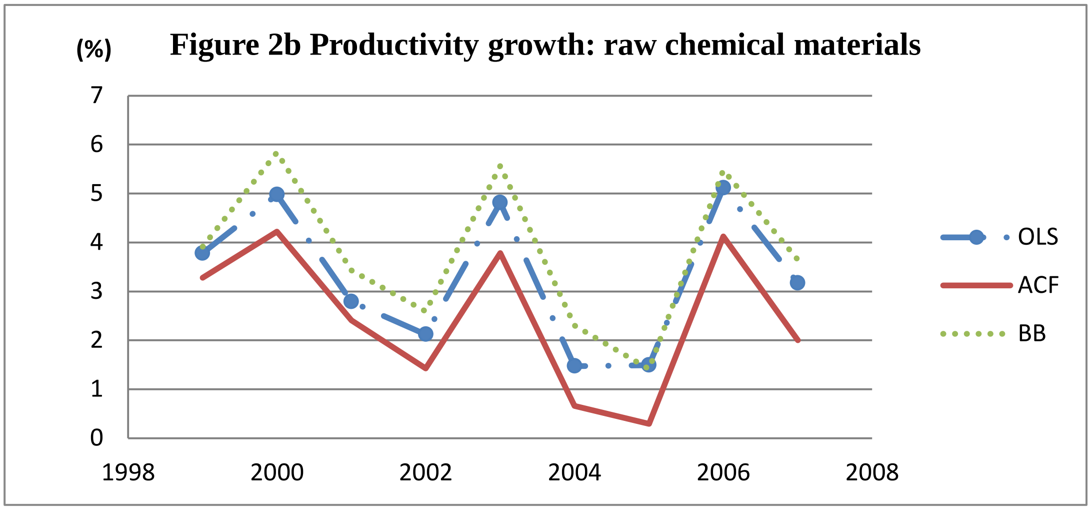
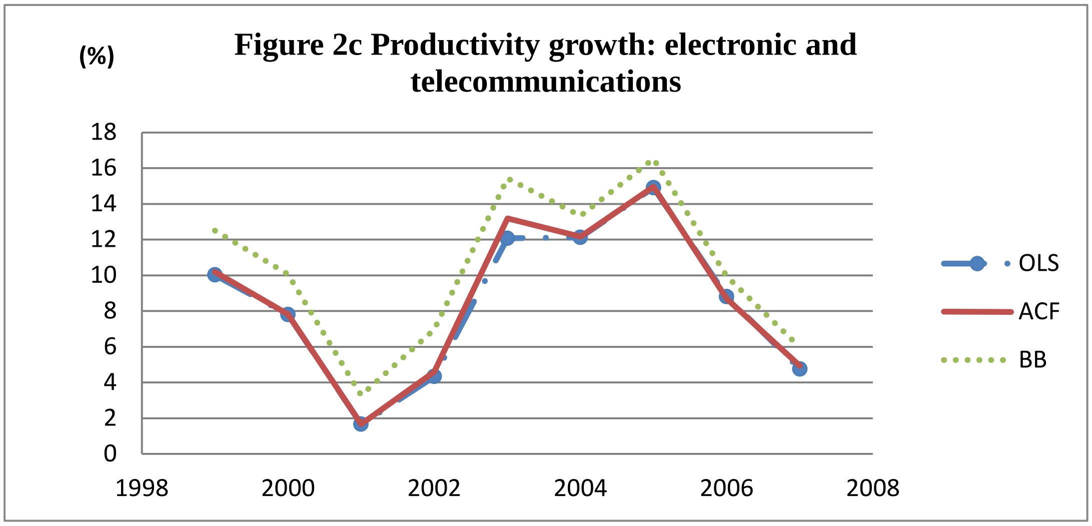


Figure 1 Aggregate productivity growth

Note: 1. This figure reports revenue-weighted aggregate productivity growth of all manufacturing industries.
2. OLS, ACF and BB represent productivity estimates based on OLS, Ackerberg, Caves and Frazer (2006), and Blundell and Bond (2000) approaches, respectively.







Note: 1. Figures 2a, 2b and 2c report revenue-weighted productivity growths of industries of textile, raw chemical materials, and electronic and telecommunications equipment, respectively.
2. For the definition of OLS, ACF and BB, please refer to Figure 1.

Table 1 Summary statistics of variables

Symbol	Definition and variables	Unit	Mean	Std. D	Form in regression	# of Obs.
l	Number of employees		4.739	1.165	log	2,019,897
m	Intermidiate input minus financial costs	1,000 yuan	9.477	1.449	log	2,004,491
k	Capital stock following Brandt et al. (2012)	1,000 yuan	8.453	1.658	log	2,014,493
y	Revenues	1,000 yuan	9.789	1.432	log	2,010,324
	Entry	dummy	0.187	0.390		2,049,297
	Exit	dummy	0.104	0.306		2,049,297
	Exporting	dummy	0.269	0.443		2,049,297
	Regional variables:					
	Central	dummy	0.175	0.380		2,049,297
	Costal	dummy	0.677	0.468		2,049,297
	Western	dummy	0.084	0.277		2,049,297
	Northeastern	dummy	0.064	0.245		2,049,297
	Ownership variables:					
	SOE	dummy	0.118	0.322		2,049,297
	COE	dummy	0.120	0.325		2,049,297
	DPE	dummy	0.359	0.480		2,049,297
	HMT	dummy	0.108	0.310		2,049,297
	FIE	dummy	0.098	0.297		2,049,297
	OTHER	dummy	0.197	0.398		2,049,297

Data source: National Bureau of Statistics of China over years of 1998-2007

Table 2 Production function estimation

Industry	OLS β_l	OLS β_k	OLS β_m	ACF β_l	ACF β_k	ACF β_m	BB β_l	BB β_k	BB β_m	# of obs.
13	0.054	0.040	0.892	0.043	0.035	0.910	0.111	-0.007	0.932	122,720
14	0.046	0.047	0.910	0.006	0.051	0.938	0.134	0.035	0.909	48,640
15	0.053	0.054	0.900	-0.063	0.055	0.998	-0.090	0.106	0.848	33,534
16	0.119	0.214	0.785	0.620	0.251	0.542	0.404	0.401	0.541	2,397
17	0.038	0.032	0.888	0.002	0.014	0.979	0.064	0.161	0.824	170,680
18	0.103	0.043	0.823	0.162	-0.014	0.893	0.112	0.073	0.824	95,148
19	0.082	0.027	0.875	0.070	0.008	0.940	0.160	0.140	0.685	47,176
20	0.030	0.039	0.882	0.133	-0.032	0.982	0.040	0.281	0.771	42,771
21	0.087	0.039	0.872	0.067	0.025	0.923	0.159	0.009	0.617	22,984
22	0.011	0.047	0.905	0.070	0.078	0.835	0.092	0.164	0.789	58,947
23	-0.006	0.104	0.890	0.222	0.040	0.845	-0.133	0.387	0.565	41,749
24	0.071	0.056	0.843	0.095	0.026	0.905	0.175	-0.040	0.529	26,066
25	0.059	0.061	0.855	0.129	0.044	0.836	0.015	0.214	0.680	17,400
26	0.031	0.054	0.876	0.017	0.031	0.938	0.161	0.064	0.823	144,141
27	0.000	0.092	0.883	0.088	0.146	0.764	0.152	0.152	0.551	41,182
28	0.027	0.032	0.916	0.006	0.018	0.957	0.214	0.022	0.766	10,009
29	0.043	0.050	0.870	-0.006	0.028	0.971	0.439	0.439	0.439	23,516
30	0.050	0.048	0.863	0.060	0.063	0.856	-0.005	0.054	0.869	92,200
31	-0.004	0.048	0.920	0.088	0.157	0.810	0.005	0.079	0.901	169,436
32	0.052	0.039	0.897	0.051	0.013	0.946	0.098	0.167	0.657	47,344
33	0.085	0.030	0.871	-0.010	0.013	0.953	0.026	0.045	0.709	35,214
34	0.054	0.047	0.869	0.062	0.031	0.923	0.017	0.082	0.797	107,054
35	0.021	0.045	0.893	-0.011	0.039	0.950	0.071	0.034	0.704	149,652
36	0.004	0.045	0.904	0.068	0.076	0.824	0.253	0.285	0.524	82,886
37	0.054	0.049	0.874	0.215	-0.028	0.891	0.184	0.149	0.654	94,958
39	0.066	0.042	0.866	0.051	0.038	0.903	-0.089	0.173	0.758	117,375
40	0.076	0.050	0.858	0.052	0.162	0.779	0.119	0.170	0.657	65,487
41	0.038	0.053	0.852	0.097	0.011	0.891	0.070	-0.008	0.240	27,950
42	0.080	0.042	0.847	0.081	0.038	0.868	0.226	0.198	0.642	38,510

Note: 1.For the definition of OLS, ACF and BB, please refer to Figure 1.

2. Number of observations refers to number of observations used in OLS estimation of production function.

Table 3 Annual aggregate productivity growth during 1999-2007 (%)

Industry code	Industry	OLS				ACF				BB			
		average (1)	std (2)	max (3)	min (4)	average (5)	std (6)	max (7)	min (8)	average (9)	std (10)	max (11)	min (12)
	all-industry	**4.16**	1.51	6.27	1.06	**3.75**	1.43	5.48	0.79	**5.99**	1.69	8.79	2.78
13	Food processing	3.14	4.71	7.91	-6.31	2.90	4.78	7.89	-6.72	2.60	4.80	7.72	-7.17
14	Food manufacturing	3.12	3.05	6.89	-1.89	2.80	3.06	6.61	-2.14	2.71	3.13	6.88	-2.34
15	Beverage	3.14	2.70	8.08	-0.37	2.16	2.84	7.89	-1.57	4.20	3.12	8.75	0.23
16	Tobacco	1.97	3.45	7.07	-2.23	4.02	3.58	9.30	-1.50	3.39	3.71	7.99	-1.59
17	Textile	3.71	2.31	7.66	0.33	2.60	2.14	5.81	-0.26	3.26	2.21	6.85	-0.12
18	Garments and fiber	4.55	2.08	8.15	1.05	3.70	1.90	6.44	0.28	4.10	2.00	7.40	0.65
19	Leather, furs	3.33	1.11	4.82	0.81	2.46	1.07	3.96	0.13	4.79	1.57	6.54	2.05
20	Timber, bamboo	10.90	9.28	23.01	-4.89	9.92	9.71	23.17	-5.83	9.32	8.28	20.26	-5.07
21	Furniture	5.95	3.75	13.92	1.14	5.48	3.93	13.88	0.59	10.12	3.30	16.70	5.63
22	Papermaking and paper	5.24	3.10	12.50	1.46	5.71	3.06	12.82	1.82	5.30	2.95	12.00	1.60
23	Printing	4.47	3.53	8.50	-2.30	4.70	3.17	8.14	-1.80	6.51	3.49	10.75	-0.38
24	Cultural, educational	4.92	3.08	10.19	0.62	4.24	3.00	9.17	0.16	9.65	4.06	17.73	4.26
25	Petroleum	-1.92	5.43	4.29	-11.83	-1.52	5.44	4.36	-11.35	0.59	5.39	7.79	-9.55
26	Raw chemical materials	3.30	1.45	5.12	1.47	2.47	1.48	4.22	0.29	3.80	1.57	5.84	1.41
27	Medical and pharmaceutical	6.30	2.19	9.44	2.82	6.88	2.02	10.34	3.52	7.68	2.12	12.00	4.41
28	Chemical fiber	2.08	6.15	10.09	-8.69	1.54	6.28	9.59	-9.87	4.11	5.95	12.82	-4.55
29	Rubber	4.71	2.64	7.51	0.69	3.44	2.52	6.05	-0.26	10.31	4.38	18.34	1.91
30	Plastic	6.44	3.37	13.96	2.25	6.30	3.34	13.77	2.21	6.71	3.39	14.26	2.38
31	Nonmetal mineral	6.42	4.09	10.68	0.64	6.78	3.90	10.82	1.32	6.40	4.03	10.59	0.69
32	Ferrous metals	2.17	4.50	9.71	-4.24	1.37	4.73	9.34	-5.44	5.84	3.78	11.17	0.43
33	Nonferrous metals	-0.94	6.44	7.55	-10.24	-2.25	7.17	7.65	-13.14	3.05	4.43	8.03	-3.37
34	Metal products	3.41	0.91	4.60	1.92	2.56	0.79	3.66	1.25	4.57	1.21	5.89	2.37
35	Ordinary machinery	3.25	1.42	6.14	0.78	2.30	1.29	4.93	0.04	6.94	2.38	11.61	3.41
36	Special purpose equipment	3.91	2.14	6.47	0.30	4.81	2.06	7.25	1.24	7.48	2.09	9.88	4.32
37	Transport	4.05	2.34	6.56	-0.34	3.32	1.98	5.45	-0.59	7.04	2.73	10.38	3.76
39	Electric	1.47	2.41	5.26	-2.29	0.85	2.57	4.71	-3.19	3.34	2.07	6.65	0.24
40	Electronic and telecom	8.49	4.30	14.90	1.66	8.69	4.40	14.95	1.67	10.44	4.45	16.52	3.28
41	Instruments, meters	4.98	1.92	9.74	3.21	4.08	1.84	8.68	2.49	17.16	3.98	22.23	9.27
42	Other manufacturing	3.65	1.80	5.31	0.57	3.32	1.76	5.09	0.32	3.92	2.13	6.24	0.80

Note: For the definition of OLS, ACF and BB, please refer to Figure 1.

Table 4 Decomposition of aggregate productivity growth: 3 industries

		OLS			ACF			BB		
		Aggregate productivity	Unweighted productivity	Covariance	Aggregate productivity	Unweighted productivity	Covariance	Aggregate productivity	Unweighted productivity	Covariance
Industry	year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Textile	1998	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1999	0.050	0.024	0.026	0.040	0.019	0.021	0.041	0.025	0.016
	2000	0.067	0.048	0.019	0.045	0.030	0.014	0.066	0.065	0.002
	2001	0.055	0.048	0.007	0.026	0.023	0.003	0.069	0.089	-0.020
	2002	0.095	0.089	0.006	0.057	0.058	-0.001	0.113	0.140	-0.027
	2003	0.121	0.129	-0.008	0.073	0.091	-0.017	0.142	0.192	-0.049
	2004	0.107	0.147	-0.040	0.063	0.106	-0.043	0.171	0.256	-0.085
	2005	0.176	0.208	-0.032	0.115	0.156	-0.041	0.226	0.302	-0.076
	2006	0.185	0.220	-0.035	0.117	0.162	-0.045	0.240	0.321	-0.082
	2007	0.215	0.253	-0.038	0.136	0.185	-0.050	0.275	0.359	-0.084
Raw chemical materials	1998	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1999	0.025	0.012	0.013	0.014	0.011	0.004	0.006	0.016	-0.010
	2000	0.082	0.048	0.034	0.057	0.040	0.017	0.081	0.066	0.015
	2001	0.105	0.061	0.044	0.074	0.046	0.028	0.119	0.097	0.023
	2002	0.127	0.068	0.058	0.090	0.046	0.045	0.153	0.118	0.035
	2003	0.176	0.131	0.045	0.126	0.103	0.023	0.217	0.191	0.026
	2004	0.175	0.136	0.039	0.117	0.103	0.014	0.244	0.227	0.017
	2005	0.167	0.136	0.031	0.101	0.097	0.004	0.240	0.224	0.016
	2006	0.198	0.176	0.022	0.126	0.133	-0.007	0.287	0.273	0.014
	2007	0.215	0.195	0.020	0.136	0.144	-0.008	0.319	0.301	0.018
Electronic and telecommunications	1998	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1999	0.059	-0.011	0.070	0.068	-0.010	0.078	0.106	0.001	0.105
	2000	0.144	0.048	0.095	0.151	0.057	0.094	0.218	0.084	0.133
	2001	0.130	0.041	0.089	0.151	0.056	0.095	0.247	0.093	0.154
	2002	0.120	0.070	0.050	0.147	0.091	0.056	0.254	0.138	0.116
	2003	0.243	0.139	0.104	0.296	0.169	0.126	0.428	0.234	0.194
	2004	0.393	0.312	0.081	0.449	0.359	0.090	0.585	0.403	0.182
	2005	0.465	0.437	0.029	0.511	0.472	0.039	0.643	0.525	0.118
	2006	0.545	0.539	0.006	0.583	0.573	0.010	0.718	0.633	0.085
	2007	0.576	0.610	-0.034	0.609	0.648	-0.038	0.741	0.712	0.028

Note: 1. The decomposition is based on Olley and Pakes (1996) and Pavcnik (2002).

2. For the definition of OLS, ACF and BB, please refer to Figure 1.

Table 5 Determinants of productivity: all industries

Dependent variable: productivity	OLS (1)	(2)	(3)	ACF (4)	(5)	(6)	BB (7)	(8)	(9)
Entry (t_0)	0.007***	0.029***	0.003***	0.040***	0.056***	0.032***	0.035***	0.044***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
t+1	0.010***	0.046***	0.004***	0.034***	0.064***	0.025***	0.047***	0.071***	0.022***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
t+2	0.008***	0.065***	0.002*	0.027***	0.078***	0.019***	0.043***	0.092***	0.018***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
t+3	0.004***	0.085***	-0.002**	0.018***	0.094***	0.010***	0.036***	0.116***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
t+4	0.009***	0.092***	0.002	0.019***	0.098***	0.011***	0.036***	0.118***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Exit		-0.074***	-0.045***		-0.051***	-0.022***		-0.108***	-0.074***
		(0.001)	(0.001)		(0.001)	(0.001)		(0.002)	(0.002)
Age		-0.000***	-0.000***		-0.000***	-0.000***		-0.000***	-0.000***
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
Exporting		0.011***	0.013***		-0.005***	-0.003***		0.032***	0.034***
		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)
Region:									
Costal		0.012***	0.014***		0.013***	0.015***		0.046***	0.048***
		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)
Western		-0.025***	-0.023***		-0.033***	-0.031***		-0.046***	-0.043***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
Northeastern		0.005***	-0.002		0.010***	0.002		-0.008***	-0.017***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
Ownership:									
COE		0.100***	0.103***		0.101***	0.104***		0.267***	0.270***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
DPE		0.175***	0.088***		0.170***	0.086***		0.362***	0.259***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
HMT		0.161***	0.105***		0.153***	0.100***		0.321***	0.256***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
FIE		0.216***	0.146***		0.206***	0.139***		0.404***	0.322***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
OTHER		0.153***	0.094***		0.142***	0.086***		0.312***	0.242***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
Industry dummy	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year dummy	Y	N	Y	Y	N	Y	Y	N	Y
# of obs.	1,977,126	1,976,355	1,976,355	1,977,126	1,976,355	1,976,355	1,977,126	1,976,355	1,976,355
R-squared	0.200	0.175	0.208	0.257	0.235	0.262	0.833	0.832	0.839

Notes: 1. Robust standard errors are reported in parentheses. The stars, *, ** and *** indicate the significance level at 10%, 5% and 1%, respectively.

2. For the definition of OLS, ACF and BB, please refer to Figure 1.

3. COE stands for collective owned enterprises, DPE for domestic private-owned enterprises, HMT for HongKong, Macau or Taiwan owned enterprises, FIE for foreign-invested enterprises, OTHER for other ownership types.

4. The baseline group for region is Central and the baseline group for ownership is SOE.

Table 6 Haltiwanger decomposition: all industries

estimates	productivity growth over 1998-2007 (%)	within firm	between firm	cross firm	exitors	**enterers**
	(1)	(2)	(3)	(4)	(5)	**(6)**
OLS	28.0	9.1	-1.5	0.4	-0.9	**19.1**
						(68.2)
ACF	29.0	8.3	-0.8	0.1	-0.7	**20.8**
						(71.7)
BB	56.2	11.8	-1.2	3.6	-5.7	**36.4**
						(64.7)

Notes: 1. For the decomposition method, please refer to Haltiwanger (1997).

2. The numbers in parentheses are the contribution of new entering firms to productivity growth over a 10-year period of 1998-2007.

3. For the definition of OLS, ACF and BB, please refer to Figure 1.

Table 7 Determinants of productivity: 3 industries

Dependent variable: productivity	Textile			Raw chemical materials			Electronic and telecom		
	OLS	ACF	BB	OLS	ACF	BB	OLS	ACF	BB
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Entry (t_0)	-0.009***	0.016***	0.122***	-0.001	0.019***	0.055***	0.007	0.070***	0.018***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)
t+1	-0.001	0.009***	0.104***	0.008**	0.016***	0.065***	0.012**	0.065***	0.035***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)
t+2	0.004	0.009***	0.086***	0.009**	0.015***	0.059***	-0.002	0.041***	0.016**
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)
t+3	-0.001	0.001	0.062***	0	0.003	0.042***	-0.004	0.028***	0.010
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.007)
t+4	0.007**	0.008**	0.049***	0.012**	0.014***	0.045***	-0.009	0.014*	0.011
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.008)	(0.008)	(0.009)
Exit	-0.031***	0.000	0.002	-0.052***	-0.025***	-0.030***	-0.027***	-0.035***	-0.089***
	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.009)	(0.010)	(0.010)
Age	0.000	0.000	-0.000***	0.000	0.000	-0.000***	0.000	0.000	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Exporting	0.028***	0.011***	0.019***	0.020***	0.001	-0.036***	-0.036***	-0.054***	-0.027***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.005)
Region:									
Costal	0.014***	-0.009**	0.030***	0.000	-0.021***	0.066***	0.094***	0.132***	0.153***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.010)	(0.010)	(0.011)
Western	-0.046***	-0.033***	-0.093***	-0.030***	-0.025***	-0.040***	0.051***	0.031**	0.046***
	(0.008)	(0.009)	(0.009)	(0.005)	(0.005)	(0.005)	(0.014)	(0.015)	(0.016)
Northeastern	-0.062***	-0.048***	-0.082***	-0.014**	-(0.008)	0.011*	0.054***	0.042***	0.050***
	(0.009)	(0.009)	(0.009)	(0.006)	(0.006)	(0.006)	(0.015)	(0.016)	(0.017)
Ownership:									
COE	0.124***	0.059***	0.303***	0.087***	0.041***	0.203***	0.121***	0.262***	0.358***
	(0.009)	(0.009)	(0.009)	(0.006)	(0.006)	(0.006)	(0.015)	(0.015)	(0.016)
DPE	0.118***	0.048***	0.309***	0.076***	0.031***	0.194***	0.120***	0.273***	0.393***
	(0.009)	(0.009)	(0.009)	(0.005)	(0.005)	(0.005)	(0.013)	(0.013)	(0.013)
HMT	0.143***	0.083***	0.249***	0.108***	0.061***	0.236***	0.137***	0.229***	0.356***
	(0.009)	(0.009)	(0.009)	(0.006)	(0.006)	(0.006)	(0.013)	(0.013)	(0.013)
FIE	0.166***	0.103***	0.302***	0.150***	0.097***	0.284***	0.210***	0.286***	0.472***
	(0.009)	(0.009)	(0.009)	(0.006)	(0.007)	(0.006)	(0.013)	(0.013)	(0.013)
OTHER	0.134***	0.066***	0.256***	0.077***	0.032***	0.149***	0.200***	0.307***	0.443***
	(0.009)	(0.009)	(0.009)	(0.005)	(0.005)	(0.005)	(0.013)	(0.013)	(0.014)
Year dummy	Y	Y	Y	Y	Y	Y	Y	Y	Y
# of obs.	170,646	170,646	170,646	144,101	144,101	144,101	65,461	65,461	65,461
R-squared	0.061	0.030	0.130	0.034	0.016	0.097	0.208	0.228	0.245

Notes: 1. Robust standard errors are reported in parentheses. The stars, *, ** and *** indicate the significance level at 10%, 5% and 1%, respectively.

2. For the definition of OLS, ACF and BB, please refer to Figure 1.

3. For the definition of COE, DPE, HMT, FIE and OTHER, please refer to Table 5.

4. The baseline group for region is Central and the baseline group for ownership is SOE.

Table 8 Robustness checks

Dependent variable: productivity	ACF			BB_DIF
	1st	2nd	3rd	
	(1)	(3)	(3)	(4)
Entry (t_0)	0.011***	0.017***	0.021***	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Exit	-0.032***	-0.028***	-0.024***	-0.089***
	(0.001)	(0.002)	(0.001)	(0.002)
Age	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Exporting	0.003***	-0.008***	-0.005***	-0.025***
	(0.001)	(0.001)	(0.001)	(0.001)
Region:				
Costal	0.018***	0.026***	0.019***	0.121***
	(0.001)	(0.001)	(0.001)	(0.001)
Western	-0.027***	-0.040***	-0.034***	-0.075***
	(0.002)	(0.002)	(0.002)	(0.002)
Northeastern	0.004**	0.004**	0.002	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
Ownership:				
COE	0.081***	0.125***	0.126***	0.460***
	(0.002)	(0.002)	(0.002)	(0.002)
DPE	0.067***	0.114***	0.113***	0.472***
	(0.002)	(0.002)	(0.002)	(0.002)
HMT	0.085***	0.127***	0.124***	0.432***
	(0.002)	(0.002)	(0.002)	(0.002)
FIE	0.115***	0.175***	0.169***	0.544***
	(0.002)	(0.002)	(0.002)	(0.002)
OTHER	0.068***	0.110***	0.109***	0.415***
	(0.002)	(0.002)	(0.002)	(0.002)
Industry dummy	Y	Y	Y	Y
Year dummy	Y	Y	Y	Y
# of obs.	1,976,355	1,976,355	1,976,355	1,976,355
R-squared	0.437	0.731	0.337	0.582

Notes: 1. Robust standard errors are reported in parentheses. The stars, *, ** and *** indicate the significance level at 10%, 5% and 1%, respectively.

2. 1st, 2nd and 3rd represent productivity processes in ACF approach that are of linear form, 2nd and 3rd order polynomials, respectively.

3. BB_DIF refers to productivity estimate obtained by first-diffenerce GMM in Blundell and Bond (2000).

4. For the definition of COE, DPE, HMT, FIE and OTHER, please refer to Table 5.

5. The baseline group for region is Central and the baseline group for ownership is SOE.