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Institutional change and productivity growth in China's manufacturing: the microeconomics of knowledge accumulation and "creative restructuring"

Xiaodan Yu[1,*], Giovanni Dosi[2], Jiasu Lei[3] and Alessandro Nuvolari[4]

[1]Scuola Superiore Sant'Anna, Piazza dei Martiri della Libertà, 33, 56127 Pisa, Italy. email: x.yu@sssup.it, [2]Scuola Superiore Sant'Anna, Piazza dei Martiri della Libertà, 33, 56127 Pisa, Italy. e-mail: giovannidosi@sssup.it, [3]Tsinghua University, Beijing, China. e-mail: leijiasu@163.com and [4]Scuola Superiore Sant'Anna, Piazza dei Martiri della Libertà, 33, 56127 Pisa, Italy. e-mail: alessandro.nuvolari@sssup.it

*Main author for correspondence.

Abstract

This article investigates the microeconomics underlying the spectacular growth of productivity in China's manufacturing sector over the period 1998–2007. Underlying the aggregate evidence of such dramatic growth, one observes a large, albeit shrinking, intra-sectoral heterogeneity coupled with an even more important process of learning and knowledge accumulation. A major process of both catching-up and dying out among the least efficient ones occurs. Furthermore, we explore the effect of the characteristics of firms according to the ownership and governance structure upon the productivity distributions, highlighting the importance of the transformation of domestic firms as drivers of technical learning. In essence, China's fast catching-up process entails more of learning and "creative restructuring" of domestic firms rather than sheer "creative destruction" and even less so a multinational corporation-led drive.

JEL classification: O1, O3, O4

1. Introduction

This article analyzes the microeconomics of the spectacular productivity growth in manufacturing in China over the period 1998–2007, disentangling the contribution of the various types of organizational carriers, distinguished according to their institutional characteristics, related to ownership and governance structures (e.g. State-owned, foreign multinational corporations [MNCs], private-owned). Exploiting a unique firm-level database, we investigate the micro evidence on the dynamic of labor productivity distributions across and within groups underlying the revealed dramatic increase of China's productivity in manufacturing.

The first major question we address regards the micro statistical properties of the process of industrial development. How diverse are the degrees of technological efficiency across firms within each industrial sector? And how do they change throughout the development process? In doing that, we study the relative importance as drivers of productivity growth of (i) idiosyncratic, firm-specific learning (the so-called *within* effect), (ii) competitive selection among incumbents (the so-called *between* effect), and (iii) entry and exit.

Second, we focus on the institutional "Identity Cards" of the firms involved. Who are the major drivers of the catching-up dynamics? Domestic firms? Foreign direct investments? And among the formers, what is the relative role of State-owned enterprises (SOEs), public–private partnerships, and greenfield private firms?

Concerning the empirical evidence, an extremely robust feature emerging from our study is the high degree of heterogeneity in production efficiency at all levels of sectoral disaggregation. This is indeed a striking aspect of the development process but also a persistent one of "mature" industrial dynamics. However, the support of the labor productivity distributions shrinks over time. The degree of productivity dispersion among low-productivity firms diminishes, while that of high-productivity ones increases slightly, reflecting both catching-up by the former and a forging-ahead some of the latter.

Indeed, the dynamics in the support of productivity distributions and especially in the left tail is not just the sheer effect of market selection, but also the outcome of deeply rooted patterns of firm-level learning and institutional changes within the corporate sector. The contribution to productivity growth of various types of firms significantly changes over time. To analyze it, we compare labor productivity distributions and their dynamics across six major ownership types: State-owned, collective-owned, foreign-invested, shareholding, and domestic private enterprises.

In general, foreign-invested enterprises (FIEs) enter with a relatively high productivity, but their contributions change relatively little thereafter. Conversely, all other types of firms display a pronounced change in both the mean and the support of the productivity distribution, showing learning and "catching-up," particularly during the period of the deepening of institutional reforms. The transformations of State-owned, "shareholding" (public–private joint ventures [JVs]), and private enterprises significantly affect the decreasing dispersion of labor productivity especially among the less-efficient firms, but also contribute to the fattening of upper echelon. Moreover, a (small) group of private enterprises also contributes to catching-up to the technology-frontier but to a relatively lower degree and mostly in "lower tech" sectors.

The rest of this article is organized as follows. Section 2 reviews some of the incumbent literature on China's industrial productivity. Section 3 briefly depicts the changing institutional context from 1978 to 2007. Section 4 introduces China's micro manufacturing data set. Next, Section 5 discusses the broad microeconomic picture underlying the striking overall productivity growth. Section 6 analyzes the micro-evidence on labor productivity at sectional level in terms of levels and growth. Finally, Section 7 investigates the properties of such distributions and their dynamics across different ownership categories. Section 8 concludes.

2. China's contemporary growth

China's GDP per capita increased from 524 in 1980 to 5239 dollars in 2007 (PPP constant price and exchange rate, 2005 dollars, cf. The World Bank, 1997). Productivity growth was a major driver of overall economic growth, as also indicated by several recent growth accounting exercises (Bosworth and Collins, 2008; Zheng *et al*., 2009; Brandt and Zhu, 2010).

With respect to the aggregate evidence, Young (2003) estimates that labor productivity growth has been 2.6% per year between 1978 and 1998, for the non-agriculture sector. For the manufacturing sector, Szirmai *et al*. (2005) and Wang and Szirmai (2008) estimate a growth of 2.3% between 1980 and 1990, and 15.9% per year during the period 1990–2002, witnessing a rapid and accelerating process of catch up.

Brandt *et al*. (2012)—on the grounds of longitudinal data set rather similar to the one used below—finds an impressive growth rate of total factor productivity (TFP) of 7.7% yearly in manufacturing over the period 1998–2006.[1]

There are several policy and institutional drivers of the productivity performance of Chinese manufacturing, many of which we can only telegraphically mention here. They include the reform of SOEs; industrial policies affecting investment, innovation, finance, and trade; competition policies; and the expansion of private companies. (For a thorough discussion, whose spirit we broadly share, see Dahlman, 2009.) The end-result of the foregoing policies and institutional changes yielded contributions to productivity growth which have been significantly different among

1 Notwithstanding the limitation of such measure of productivity (for a more detailed discussion cf. Dosi and Grazzi, 2006).

different types of enterprises and across different periods. Such differences are also at the center of the analysis that follows.

In the early stage of reform, Goodhart and Xu (1996) show that township and village enterprises (TVEs) were the main engine of Chinese productivity growth during early 1990s, although starting from very low levels. Jefferson and Rawski (1994) estimate that the annual growth rates of labor productivity of TVEs were the highest between 1980 and 1992, and conversely in the State sector it was the lowest. More precisely, the growth in the State sector fluctuated between 3.8% and 6.3% during the period 1978–1992, peaking in the years 1984–1988, while the productivity of TVEs grew at 5.8% between 1980 and 1984, then increased to 14.4% (1984–1988) and to 17.7% (1988–1992).

In late 1990s, Deng *et al*. (2005) estimate annual labor productivity growth at 20.4% between 1995 and 2003, according to a large firm-level databank of industrial large and medium enterprises, with a major contribution stemming from the conversion of SOEs to "shareholding" ones (Jefferson and Su, 2006): see below.

Wang and Szirmai (2008) decompose the overall labor productivity growth in terms of sectors and forms of ownership. Interestingly, in the 80s changes in the sectoral composition of output, i.e. *structural change*, bear an important contribution to aggregate industrial productivity growth, while, as we shall see, this is not any longer the case in the subsequent period, when firm restructuring is the main driving force. Together, shifts in the weights of ownership categories account a substantial part of productivity growth during the productivity boom in 1990s, with the expanding foreign-invested category (MNCs and JVs) taking up a good deal of the shift.

The literature on the micro-evidence on China's productivity and industrial dynamics (cf. Jefferson *et al*., 2008) finds a paramount contribution to productivity growth seemingly by exiting and entering firms, even if entering led with restructuring by incumbents. Moreover, the literature highlights the importance of ownership on the average efficiency of Chinese industrial firms, with FIEs exhibiting the highest, and SOEs exhibiting the lowest, efficiency levels.

Along similar lines, Dougherty *et al*. (2007) in the period 1998–2003 show an overall higher productivity of private firms. Irrespectively of the ownership, and irrespectively of the criteria of measurements, the performance is truly impressive. So, for example, Fu and Gong (2011) try to estimate TFP and find that the latter appears to grow at an average of 4.8% over the period 2001–2005. However, as informative as means and their dynamics are, they hide profound and long-lasting differences across individual firms.

Indeed, there is an emerging tradition of analysis of the microeconomics behind aggregate means and dynamics, pointing at the stylized fact concerning large and persistent heterogeneity in productivity among firms even within the same narrowly defined industries (see the evidence and reviews in Nelson, 1981; Geroski, 1998, 2002; Bartelsman and Doms, 2000; Ahn, 2001; Foster *et al*., 2001, 2008; Dosi, 2007; Dosi and Nelson, 2010; Syverson, 2011; Dosi *et al*., 2012). While this literature mostly focuses on developed countries, micro-heterogeneity applies, even more so, to emerging economies. Note that such persistent heterogeneities bear far-reaching implications for any analysis of industrial evolution and development more generally. First, and straightforwardly, any dynamic analysis ought to concentrate upon the shape of the distributions of whatever firm characteristics and their dynamics over time. Second, one ought to address the drivers of such dynamics. Third (an often neglected point), ample and persistent heterogeneity in the input/output relation at any time renders analyses in terms of "production function" and TFP, quite dubious or even deeply biased.[2] On that we offer some evidence below supporting our choice using *labor* productivities (even if for the skeptical reader we present some TFP estimates in the Appendix).[3]

Moreover, firms differ also in their ownership, forms of governance, and origins. This will be the other focus of our study. The longitudinal data below will help indeed in highlighting the movements of sector-specific and organization-specific productivity distributions among firms, that is the very microeconomic action behind the dynamics of the observed means.[4]

2 The point is well argued in Hulten (2001) and sophistications do not alter the basic property that if, micro production functions are not identical up to a scalar the TFP estimates are basically meaningless. This adds to even deeper flaws in the production function construct itself [more in Dosi and Grazzi (2006), and earlier in Pasinetti (1959), Fisher (1971), Shaikh (1974) among many nowadays neglected others].

3 For a recent work on China using our same data trying to estimate the allocative distortions stemming from inter-firm heterogeneity in a production function framework, see Hsieh and Klenow, 2009.

4 A large literature on *transition economies*, whose acknowledgment is here beyond search is interested into impact of firms' institutional setups upon performances. For an early, similarly micro-castered analysis, cf. Brada *et al*. (1997).

However, before looking of the details of the data, it is useful to place the transformation of the Chinese industry against the background of at least equally profound institutional and policy changes.

3. The changing institutional context

Unlike the "big bang" transformation of the economy systems of Eastern Europe and the Soviet Union, China has adopted the "gradualist approach" of economic reform. The reforms which occurred within China's industrial sector since 1978, occurred at three different levels, namely (i) reforms concerning SOEs, (ii) the political economy of non-State sector, and (iii) the "opening up" policy, and in three temporal stages (Qian, 2000, 2002; Zou, 2008).

The first stage (1978–1992) featured the transfer of SOEs' power of control and governance without touching issues of property rights, the stated aim being "putting plan and market on equal footing" (Qian, 2000). The period up to the early 1990s corresponded to distributions of labour productivities generally displaying an efficiency lead of FIEs.[5] Interestingly, JVs in quite a few sectors display "best-performers" more efficient than "best-performers" of MNCs (evidence available by the authors upon request).

In the second period (1993–2003) of institutional change, the focus of SOEs reform shifted to corporate governance, and the adjustment in their product portfolios.

The first strategy was to establish a "modern corporate system," involving the transformation of SOEs into modern enterprises with clear property rights, well-defined responsibility and authority, separation of enterprises from the government, and professional internal management (Qian, 1996).

The second policy step was meant to streamline SOEs output structure, highlighted by the slogan "retain the large while release the small." The central government defined five groups of sectors kept under the control of the State, i.e. national security sectors, natural monopolies, sectors providing public goods or services, strategic natural resources, and key enterprises in "pillar" and high-tech sectors.[6] Note that, since most SOEs were in net loss until 1997, the transition of large and medium SOEs to some "market discipline" involved deep and often socially painful reforms.[7]

The third step involved the "shareholding system" and the development of a "mixed ownership economy" within large SOEs. This meant transforming SOE in proper shareholder-owned firms possibly involving also private, domestic, and foreign investors, yielding an ensemble of "shareholding firms" characterized by mixed ownership. In 1994, thousands of SOEs were selected to conduct such an experiment. Among them, 540 (23%) were transformed into mixed shareholding enterprises (SHEs); 909 (38.8%) turned into companies having the State as the only shareholder; the rest did not implement changes in corporate governance and ownership (Zou, 2008). In 1999, the shareholding system was promoted over all large and medium SOEs, with the State maintaining ultimate control rights over the large/strategic SOEs.

A crucial property of the whole process has been the deep transformation but *not the destruction* of the technological capabilities embodied in incumbent SOEs (a more articulated discussion of the transformation of SOEs in the 80s in Groves *et al.*, 1994).

Thereafter, in the period 1998–2002 "the State retreats and the private sector moves forward" has been the main strategy, which was designed according to the timetable of China's WTO accession. SOEs were withdrawn from so-called "competitive" sectors, while have been strengthened in "pillar" industries. Together, a major employment shake-out took place (Cao *et al.*, 1999): the number of workers employed in State-owned manufacturing enterprises fell from 35 million in 1992 to 9.8 million in 2002, with most of the decline in late 1990s (NBS, 2003). The restructuring and consolidation of large and medium SOEs were mainly conducted by merger with domestic or foreign firms, conglomeration, and initial public offering on the stock market (Cao *et al.*, 1999). Overall the background examples and inspiring objectives of these policies were the Japanese Keiretsu and the Korean Chaebol. Large State-controlled enterprises were and are mainly in resource-based, capital-intensive, and high-tech industries, such as coal, steel, oil, petrochemicals, aluminum, ship-building, and industrial machinery which all qualify for government "preferential policies" (Brandt *et al.*, 2008).

5 Here and throughout we treat MNCs and JVs within the same broad category.

6 Government designated five "pillar" industries: machinery, electronics, petrochemicals, automobiles, and infrastructure construction (The World Bank, 1997).

7 Through workers layoff, merger and reorganization, separation of social corporate-paid services, debt-to-equity swap, etc.: the goal was achieved roughly by the year 2000.

At the same time a significant process of privatization of small SOEs and COEs at the county level took place, involving between 50% and 70% of small SOEs, dependent on the provinces. In cities, privatization has occurred in two waves and peaked after 2000 (Garnaut *et al.*, 2006). During the first wave, in mid-1990s, more than half of the firms were privatized in three forms, namely, sale to a private domestic or foreign firm; transformation into a limited liability or joint stock company; and "stock cooperatives" which are essentially employee/manager ownership with some features of cooperatives (Cao *et al.*, 1999). The second wave occurred around 1997, with management buyouts as the most frequent mode.

At the same time, a huge amount of private firms have entered the market, particularly into "competitive sectors," i.e. sectors outside the "pillar industries." The output share of domestic private enterprises increased from 3% in 1995 to 22% in 2004 (Wang, 2009).

Prior to WTO membership, during the negotiations in the 1990s, China has gradually liberalized trade and FDI regimes (Branstetter and Lardy, 2008). Huang (2003) highlights three patterns in FDI inflows into China and in the corresponding strategies of MNCs. Early on, a significant portion of FDI inflow into China originated from small and medium enterprises typically from China's neighboring regions—Hong Kong, Macao, and Taiwan—and operating relatively simple and labor-intensive production and assembly processes. Conversely, investments by large Western and Japanese MNCs constituted only a small portion of total FDI flows. Moreover, the former were the drivers of China's export-processing regime in the 1990s, yielding an increasing share of export in GDP from around 12% in 1990 to 20% in 2000. Second, joint-ventures typically involved foreign firms and SOEs and were explicitly aimed at the acquisition of advanced technologies. Third, the share of wholly foreign owned enterprise relative to equity JVs increases from mid-1990s, due to the gradual enforcement of the Trade-Related Investment Measures linked with WTO accession.

Interestingly, foreign multinationals and JVs most often aim their production primarily to China's domestic market. In 2002, within the 10 industries with the highest share of FDI (accounting for around half of the output), two-thirds of their sales went to the domestic market (Brandt *et al.*, 2008). Moreover, the composition of the origin of FDI has shifted from Hong Kong, Macao, and Taiwan regions to Western countries and Japan. At the same time, MNCs' investments increasingly favored what Pavitt (1984) calls "scale-intensive sectors" (from automobiles to chemicals), "specialized suppliers" (such as machinery), and ICT.

In the third period (2004–) reform of the governance of SOEs went ahead, involving a higher liquidity of their shares and a greater separation between government and corporate management.

Possibly more interesting for the interpretation of the evidence that we shall present below, during this most recent period, in "pillar" industries, and especially the "scale-intensive" ones, SOEs and JVs kept a central role, notwithstanding some entering attempts by private domestic firms. And they indeed display a considerable dynamism in terms of technology acquisition and productivity growth. This is a dynamism which is shared across manufacturing by a good deal of private firms (especially in relative low-tech industries). Indeed, as we shall see in detail below the period witnesses the strengthening of the role of *domestic* firms of all types in the process of catching-up.

4. Data

The raw data set includes all industrial firms with sales above 5 million RMB covering period 1998–2007.[8] This data set comes from annual surveys of the "above-scale" industrial enterprises conducted by the National Bureau of Statistics of China.[9]

Out of that, we extracted manufacturing-only firms,[10] and we cleaned the data in order to eliminate visible recording errors, yielding what we call "China Micro Manufacturing" (CMM).[11]

8 Year 2004 is a census year and firm's value added of this year is not available in the data set, and thus, we do not use the 2004 survey in this article.

9 Industry is defined to include mining, manufacturing, and public utilities, according to NBS. Five million RMB is approximately US$ 600,000.

10 Manufacturing firms are those with Chinese Industrial Classification (CIC) code between 13 and 43.

11 We drop firms with missing, zero, or negative value-added; and also firms with a number of employees less than 8, since below that threshold they operate under another legal system (Brandt *et al.*, 2012). NBS has modified its

Table 1. Number of firms in original and modified data sets, respectively

Year	Number of obs (original data set)	Number of obs (CMM sample)	Deleted obs
1998	148,664	135,510	13,145 (9.70)
1999	146,078	134,004	12,074 (9.01)
2000	147,249	136,830	10,419 (7.61)
2001	155,665	147,612	8053 (5.46)
2002	165,801	157,015	8786 (5.60)
2003	181,013	174,932	6081 (3.48)
2005	250,975	243,906	7069 (2.90)
2006	278,667	271,726	6941 (2.55)
2007	312,304	306,327	5977 (1.95)

Note: Numbers in the brackets denote percentages of deleted observations with respect to original data set.
Source: Raw data set and CMM.

Table 1 shows the number of observations. Finally, we built a balanced CMM including only the firms that are in the sample for all years (Thus, excluding all firms dropping out at any point and all firms entering after the first year of the sample.) just to give an idea of the intensity of "churning" occurring over the period. The persistent firms are 25,557, that is 18.9% of the total in 1998 and 8.3% in 2007.

Here, we use the definition of "capital stock" originally provided by the data set, that is the sum of all vintages of capital still in use recorded at the nominal cost of the investments.

This work focuses on dynamics of labor productivity, measured as constant-price value added per employee, which we understand as a very plausible proxy of efficiency in different sectors (more on that below).[12] When appropriate, in the analysis we shall use relative productivities (normalized with sectoral averages).

$$\pi_i(t) = \log \Pi_i(t) - < \log \ \Pi_i(t) > \quad (1)$$

with $\Pi_i = \frac{VA_i}{N_i}$, $< \log \Pi_i(t) > \equiv \frac{\sum_{i \in sector j} \log \ \Pi_i(t)}{n_j(t)}$, $\Pi_i(t)$ labor productivity, $VA_i(t)$ real value added, $N_i(t)$ number of employees, of firm i at year t; $n_j(t)$ number of firms in sector j at year t.[13]

We further disaggregate firms by ownership and governance structures. According to the firm's registration status, we classify firms into seven ownership categories: SOEs; collective-owned enterprises (COEs), Hong Kong, Macao, and Taiwan-invested enterprises (HMTs); FIEs, including in turn foreign MNCs (FMNC), and JVs with a foreign share above 25%, SHEs; private-owned enterprises (POEs); and other domestic enterprises. As shown in Table 2, 23 registration categories have been aggregated into 7 larger ones, in line with the approach of Jefferson *et al*. (2003). Below, however, due to numerosity, we analyze only the first six categories.

Each firm is classified into a sector according to the four-digit Chinese Industry Classification (CIC) that resembles the old US SIC system.[14]

5. A striking productivity growth: the general picture

Table 3 shows the annual growth rate of labor productivity of incumbent firms during different subperiods in the CMM database, highlighting the dramatic growth of productivity in China's manufacturing. The overall productivity of incumbents grew at 9.98% during 1998–2007. All sectors display positive productivity growth rates, except petroleum refining, which had negative growth during the 1998–2002 period.

industrial classification after 2002. The data set used in this article has adjusted the industrial classification before 2003 into the new standard. Since CIC43 has emerged merely after 2002, we do not consider it here.

12 We undertook the same analysis in terms of TFP.

13 Value-added is deflated by four-digit sectoral output deflators, from Brandt *et al.* (2012).

14 In 2003, the classification system was revised to make room for further disaggregation for some sectors, while some other sectors were merged. To make the industry codes comparable across the entire period, we follow Brandt *et al.* (2012) which has constructed a harmonized classification. Our CMM data set spans over 29 two-digit sectors, 161 three-digit sectors, and 424 four-digit sectors.

Table 2. Aggregation of the 23 registration categories

Code	Ownership category		Code	Registration status
1	State-owned		110	State-owned enterprises
			141	State-owned jointly operated enterprises
			151	Wholly State-owned companies
2	Collective-owned		120	Collective-owned enterprises
			130	Shareholding cooperatives
			142	Collective jointly operated enterprises
3	Hong Kong, Macao, Taiwan-invested		210	Overseas joint ventures
			220	Overseas cooperatives
			230	Overseas wholly-owned enterprises
			240	Overseas shareholding limited companies
4	Foreign-invested		310	Foreign joint ventures
		Joint ventures	320	Foreign cooperatives
			340	Foreign shareholding limited companies
		Foreign MNCs	330	Foreign wholly-owned enterprises
5	Shareholding		159	Other limited liability companies
			160	Shareholding limited companies
6	Private		171	Private wholly-owned enterprises
			172	Private cooperatives enterprises
			173	Private limited liability companies
			174	Private shareholding companies
7	Other domestic (not included)		143	State-collective jointly operated enterprises
			149	Other jointly operated enterprises
			190	Other enterprises

Source: Jefferson *et al*. (2003), Annex I.

Further, note the remarkable differences in productivity growth across sectors, as such circumstantial evidence of significant inter-sectoral differences in *absorptive capacities* (Cohen and Levinthal, 1989) of "frontier," generally foreign, technologies, and of corresponding differences in the average catching-up rates.

Figure 1 offers three snapshots of the non-parametric kernel density distributions of labor productivity, together with the comparison with the corresponding Italian and French ones, as a vivid illustration of the overall technology gaps with two higher income countries.[15]

At a first glance the readers might find such a comparison as somewhat far-fetched if one has in mind of a "would production function," possibly multiplied by some country-specific scalar. After all, Chinese wages have been/are at least an order of magnitude lower than Italian and French ones. As a consequence, one would expect to see the three countries on very different positions on such production functions. But is it really the case? If it were so, one would also expect, first, major differences between China, on the one hand, and Italy and France, on the other, in *capital/output* ratios—the appropriate proxy for "capital intensities" when "production functions" differ. And of course one should expect strong correlations between labor productivities and capital/*labor* ratios within each country and within each sector.[16] Premise to the following: the proxies for "capital" are very noisy on Italian and French data and just more so on Chinese ones!

Remarkably, what the evidence suggests is rather at odds with the conventional wisdom. First, capital/output ratios also at sectoral levels do *not* differ very much between China and the two considered European countries (cf. Table A1): indeed they tend to be *higher* in China! Second, the *within-country*, *within-sector* micro correlations between labor productivities (VA/L) and capital/output ratios (K/VA), for whatever proxy for K is used, is robustly

15 Referees, compared to an earlier version, have asked us to add PPP estimates, of course, PPPs should not matter when estimating outputs of firms on sectors, but the profession is so inspired by an idea that the whole world is a general equilibrium that they probably thought that PPPs would change the picture, of course, it does not!

16 For intriguing historical evidence on this point, see Allen (2012).

Table 3. Annual growth rate of labor productivity over 1998–2007, and subperiods 1998–2002 and 2002–2007 among "continuing" firms (i.e. firms keeping in the same two-digit sector over the relevant period)

CIC	Sector	1998–2007	1998–2002	2002–2007
13	Food processing of agricultural products	11.25	8.55	13.46
14	Other foodstuff	8.87	5.73	11.22
15	Beverages	10.63	6.20	12.80
16	Tobacco	15.29	11.08	10.65
17	Textile	9.79	10.14	10.54
18	Garments, footwear etc.	7.84	4.84	10.57
19	Leather, fur, feather etc.	7.55	6.52	10.29
20	Processing of timber, manuf. of wood, bamboo etc.	11.87	7.61	14.43
21	Furniture	6.19	4.82	10.40
22	Paper and paper products	10.33	9.48	11.75
23	Printing, reproduction of recording media	8.92	7.54	8.17
24	Articles for culture, education and sports	8.39	7.06	10.03
25	Processing of petroleum, cokeries, nuclear fuel	3.77	−1.61	6.36
26	Raw chemical materials and chemical products	11.40	10.44	11.85
27	Pharmaceuticals	8.94	10.64	7.53
28	Chemical fibers	10.31	12.05	8.85
29	Rubber	8.80	7.01	9.39
30	Plastics	5.83	6.43	6.24
31	Non-metallic mineral products	12.76	9.86	14.71
32	Smelting and processing of ferrous metals	13.86	12.68	14.14
33	Smelting and processing of non-ferrous metals	12.45	13.73	12.64
34	Metal products	5.44	7.84	4.32
35	General purpose machinery	15.40	13.76	15.72
36	Special purpose machinery	16.23	13.09	15.13
37	Transport equipment	12.67	11.64	13.05
39	Electrical machinery and equipment	9.51	8.84	9.32
40	Communication equipments, computers etc.	5.64	8.37	3.30
41	Measuring instruments and machinery	9.62	9.46	9.57
42	Artwork and other	10.01	9.32	12.70
	Average	9.98	8.73	10.66

Source: Our elaboration on CMM.

negative in China (cf. Table A2) and is mildly negative in Italy and France (statistics available upon request). Putting it another way, labor and capital productivity are strongly *positively* correlated. Together, third, even within China, labor productivities and capital/*labor* ratios—as such a proxy of degrees of production mechanization/automation—are basically orthogonal (see Figure 2 for an illustration of a sector out of most).

Overall, the evidence suggests that very little action comes from "moving along isoquants" in response to relative prices.[17] Rather, "best practice" techniques involve a more efficient use of *both* labor and capital, and relatedly, catching-up fundamentally involves improvements on both dimensions. It is a world of complementarities rather than substitution, wherein technology-gaps and learning efforts are both captured by labor productivity differences, quite independently from relative prices, which TFP proxies might well yield a quite distorted picture of the development process. Indeed, given the inverse relation between labor productivities and capital/output ratios, labor productivities alone turn out to be a robust proxy for the *lower bound* of "true" efficiency distributions *within countries*, but also *across* countries, with the added advantage of avoiding any explicit or implicit hypotheses on interfactor substitutability and capital measurements.

17 In fact the empirical elasticities of substitutions implied by the negative micro relation between labor productivities and capital/output ratios (i.e. positive correlations between labor and capital productivities) are *positive in sign*: "isoquants" do not look like the standard isoquants but are more similar to rays out of the origin.

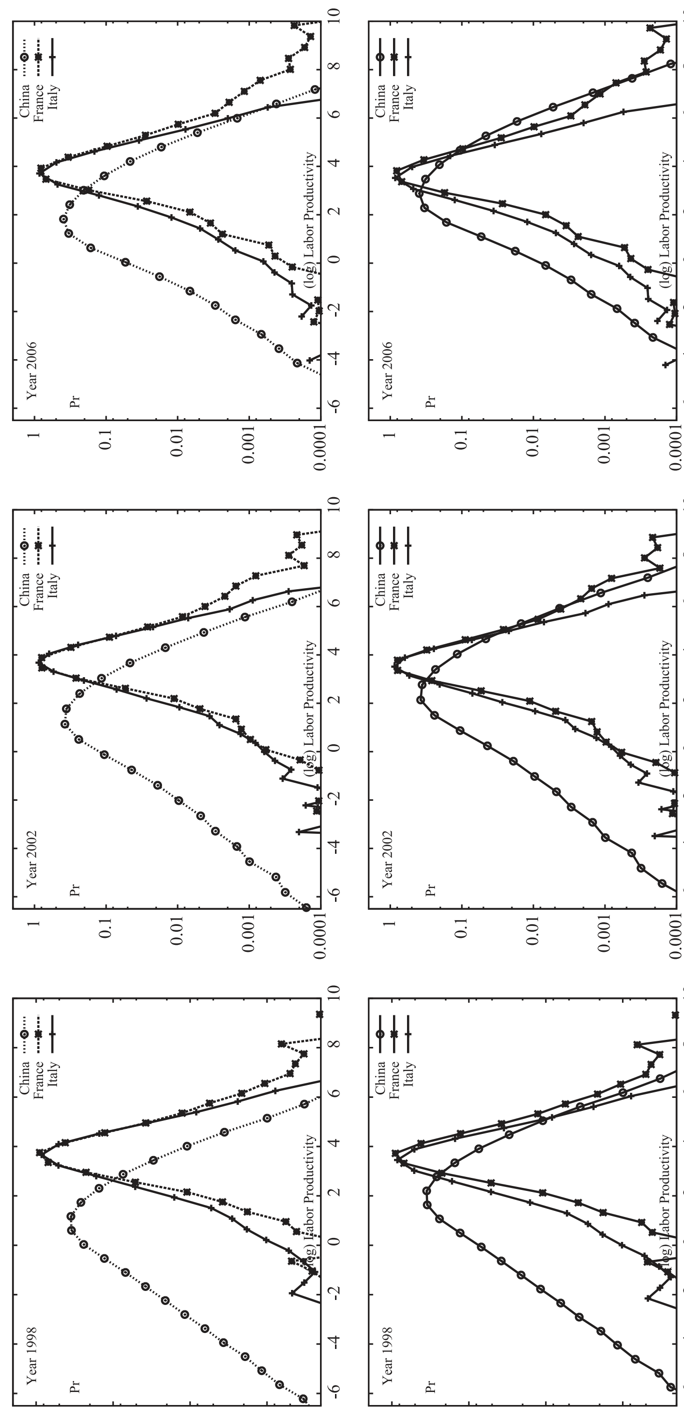

Figure 1. Empirical density of labor productivities, whole manufacturing of China, France, and Italy, years 1998, 2002, and 2006. Note: The first row—constant 2000 prices and exchange rates (IMF source); the second row—PPP adjusted price (World Bank source). Source: our elaboration on CMM, INSEE (on France) and ISTAT-Micro 3 (on Italy).

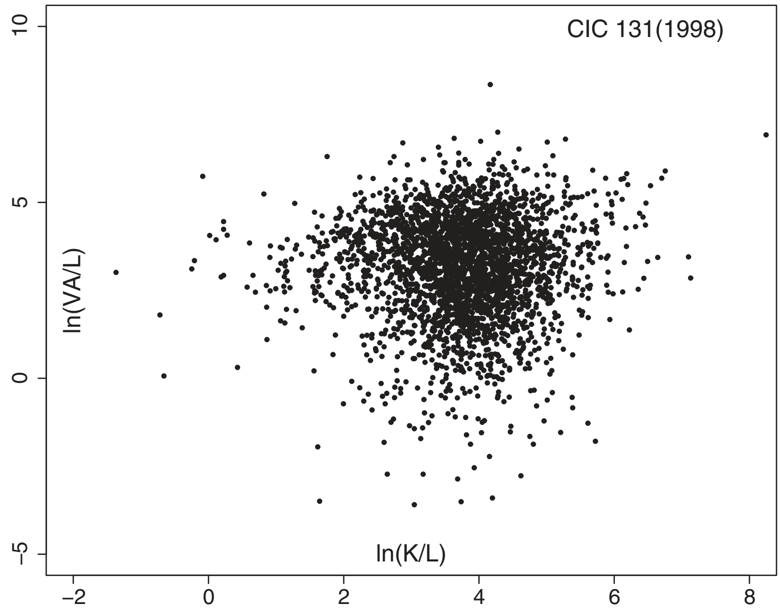

Figure 2. Scatterplot of *log*(*V A/L*) versus *log*(*K/L*) for Corn milling sector (CIC 131), year 1998. OLS regression: Coefficient = 0.038 (Standard error 0.029), $R^2 = 0.0006$, number of observations = 2838. Source: our elaboration on CMM.

Granted all that, let us now focus on the micro picture which the data offer and its dynamics. Start noting the different upper bounds of the three country distributions, as such an impressionistic proxy of different inter-country lags and leads (together of course with different sectoral compositions of output). Second, the width of the support of the distribution of China is much larger, revealing much greater technological asymmetries across Chinese firms.

The dynamics of catching-up in China's manufacturing productivity is indeed associated with (i) a rightward movement of the mean of the distributions; (ii) a corresponding rightward movement of the support; and (iii) as we shall analyze in more detail below, a shrinking of the support itself. Labor productivity distribution is asymmetric and left-skewed. The evolving pattern of the left-tail and that of the right-tail are different as well, as the magnitude of left-tail shift toward higher levels of productivity is very significant, compared with a relatively mild movement of right-tail.

Such dynamics matches what in the old development literature was called a "reduction of the dualistic structure economy" composed by a shrinking traditional/relatively backward part of manufacturing and an expanding "modern" one, which however is only just beginning to push "frontier technologies" further.

An important piece of evidence on *intra*-sectoral asymmetries in efficiency and their changes over time is the top to bottom ratio of labor productivities. Table 4 displays the ratio of the 9th decile over the 2nd decile for each sector from 1998 to 2007. The ratios decrease in most of the sectors, indicating a reduction of productivity dispersion, plausibly due both to learning by laggard firms and selection (exit) of worse performers. The ratios are generally lower in "traditional" ones (CIC 17–24 including textile, garments, leather, furniture, paper manufacturing, etc.) and higher in relatively technology-intensive sectors (e.g. transport equipment, electrical machinery, and communication equipment). The ratios drop more rapidly in the first part of the period under consideration which is also a period of retreat of SOEs from the so-called "competitive sectors." At the same time, the ratios in quite a few "heavy industries" such as petroleum refining, and non-ferrous metals sectors grows, hinting at some sort of persistent "dualism" within such industries (note that growing intra-sectoral asymmetries can and often go hand-in-hand with high *average* growth rates).

How much of the dynamics in overall productivity distribution is due to inter-sectoral relocation of production? Table 5 displays the time series of value-added shares of each two-digit sector in overall manufacturing. It is remarkable that relatively little structural change has occurred over the period under investigation. So, for example, the

Table 4. Ratio of the average labor productivity of the second highest decile over the second lowest one

CIC	Sector	1998	2002	2007
13	Food processing of agricultural products	15.62	11.35	10.02
14	Other Foodstuff	19.12	12.20	9.04
15	Beverages	14.89	11.82	9.06
16	Tobacco	17.05	22.95	26.44
17	Textile	8.61	7.01	6.07
18	Garments, footwear etc.	6.51	5.45	5.42
19	Leather, fur, feather etc.	7.80	7.17	6.80
20	Processing of timber, manuf. of wood, bamboo etc.	11.25	6.91	6.51
21	Furniture	9.29	7.15	6.93
22	Paper and paper products	7.44	6.16	6.27
23	Printing, reproduction of recording media	12.47	9.49	6.12
24	Articles for culture, education and sports	6.91	6.10	5.52
25	Processing of petroleum, cokeries, nuclear fuel	8.82	12.26	11.23
26	Raw chemical materials and chemical products	10.30	9.19	8.42
27	Pharmaceuticals	10.65	9.71	8.96
28	Chemical fibers	10.05	6.87	7.98
29	Rubber	6.56	7.49	7.42
30	Plastics	8.65	7.18	7.02
31	Non-metallic mineral products	8.32	7.91	8.23
32	Smelting and pressing of ferrous metals	9.57	8.58	8.40
33	Smelting and pressing of non-ferrous metals	9.70	8.43	12.72
34	Metal products	8.36	7.21	7.12
35	General purpose machinery	8.77	6.68	6.56
36	Special purpose machinery	12.24	9.59	7.25
37	Transport equipment	11.69	8.19	7.09
39	Electrical machinery and equipment	9.39	7.71	8.24
40	Communication equipment, computers etc.	13.52	11.08	8.36
41	Measuring instruments and machinery	12.38	9.00	8.70
42	Artwork and other	8.88	7.38	6.59

Source: Our elaboration on CMM.

shares of transport equipment, electrical machinery and equipment, and communication equipment, computers etc. are amongst the highest from the start of the period under consideration, and their total share just increases from 20.7% in 1998 to 22.5% in 2007. A sign indeed that China achieves quite early a "modern" industrial structure. Interestingly, this evidence seems to contradict Kuznets's view of increasing productivity due to structural change, i.e. movements from low-productivity sectors to high-productivity ones also within manufacturing. On the contrary, our evidence suggests that, unlike what happened in the 1980s (cf. Wang and Szirmai, 2008), the movement of the overall manufacturing means is mainly due to sector-specific dynamics.

Of course, the relative stability of sectoral shares at two-digit sectoral level, does not rule out much more turbulence at finer levels of disaggregation within each two-digit sector: indeed, there is very intensive "micro structural change." However, the evidence marks a difference with other episodes of industrialization and catching-up, in that China appears to be from the period of our observation already quite mature in terms of broad manufacturing structure. For example, when South Korea had the same real per capita income that China had in 1998, which was 1973 (Maddison's historical statistics www.ggdc.net/maddison/oriindex.htm), it had a share of around 22% of textile and clothing over total manufacturing (World Development Indicators database), compared to a 1998 Chinese share of 12%.

In the literature a quite common claim is that export and productivity growth go together (possibly with causality running in both directions). China does indeed display a dramatic rise in the share of export in total manufacturing output and coupled with a dramatic growth in productivity. However the latter is *not* associated with an increased frequency of exporting firms over the total; on the contrary, after a mild surge, the former's share in manufacturing

Table 5. Contribution of each two-digit sector to the total value added of manufacturing (percentages)

CIC	Sector	1998	2002	2007
13	Food processing of agricultural products	4.74	4.50	4.96
14	Other Foodstuff	2.07	1.99	1.99
15	Beverages	3.51	2.69	2.01
16	Tobacco	5.70	5.13	3.11
17	Textile	6.39	5.81	5.23
18	Garments, footwear etc.	3.02	2.76	2.41
19	Leather, fur, feather etc.	1.78	1.76	1.58
20	Processing of timber, manuf. of wood, bamboo etc.	0.82	0.86	1.16
21	Furniture	0.50	0.53	0.69
22	Paper and paper products	2.11	2.17	1.86
23	Printing, reproduction of recording media	1.21	1.11	0.74
24	Articles for culture, education and sports	0.92	0.77	0.60
25	Processing of petroleum, cokeries, nuclear fuel	3.56	3.79	3.52
26	Raw chemical materials and chemical products	7.18	6.96	7.78
27	Pharmaceuticals	2.95	3.29	2.45
28	Chemical fibers	1.19	0.91	0.86
29	Rubber	1.33	1.12	1.02
30	Plastics	2.35	2.47	2.28
31	Non-metallic mineral products	6.03	5.20	5.18
32	Smelting and pressing of ferrous metals	6.47	6.92	9.52
33	Smelting and pressing of non-ferrous metals	2.08	2.24	4.58
34	Metal products	2.98	2.86	3.21
35	General purpose machinery	4.75	4.51	5.46
36	Special purpose machinery	3.33	3.09	3.25
37	Transport equipment	7.41	8.54	7.54
39	Electrical machinery and equipment	5.94	6.12	6.47
40	Communication equipment, computers etc.	7.39	9.64	8.44
41	Measuring instruments and machinery	1.25	1.23	1.24
42	Artwork and other	1.05	0.99	0.86
	Total	100	100	100

Source: Our elaboration on CMM.

value added significantly falls (Figure 3). In fact, the final share in 2007 (48%) is lower than that at the beginning in 1998 (51%).

Figure 4 shows the labor productivity distributions of exporters and non-exporters for the years 1998 and 2007, in some selected sectors (chemical, electrical machinery, and communication equipment) which well illustrate a more general pattern. Note that in 1998 exporters have higher level of productivity and their support of distribution is narrower than that of non-exporters. However, a significant catch-up of non-exporters takes place, so that in 2007, exporters and non-exporters have similar productivity distributions and similar widths of support. (We refrain on purpose from making any causality statement.)

5.1 Learning vs. selection

An interesting assessment of the relative contribution to aggregate productivity growth arising from the reallocation of market shares between incumbents and the entry and exit of firms is provided by the decomposition method introduced by Bartelsman and Doms (2000).

The aggregate labor productivity of sector I at time t is denoted by equation

$$\prod_{I,t}=\sum_{i\in I} s_{i,t}\pi_{i,t} \tag{2}$$

where $s_{i,t}$ and $\pi_{i,t}$ represent the employment share and labor productivity of firm i within two-digit sector I. The variation of sectoral productivity can be decomposed into five components, of which the sum of

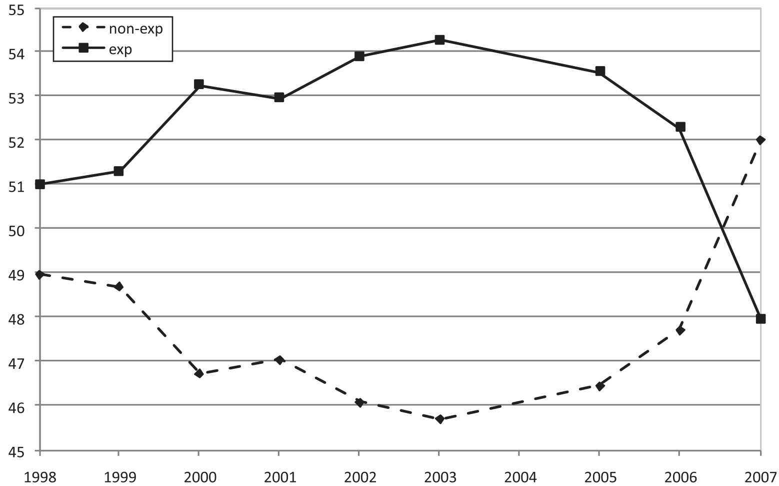

Figure 3. Annual percentage contribution of exporters and non-exporters to value added of manufacturing. Source: our elaboration on CMM.

the first three terms are the contribution of continuing firms, and the last two, of entering an exiting firms, respectively.

$$\Delta\Pi_{I,t} = \sum_{i\in C} s_{i,t-1}\Delta\pi_{i,t} + \sum_{i\in C}(\pi_{i,t-1} - \Pi_{I,t-1})\Delta s_{i,t} + \sum_{i\in C}\pi_{i,t}\Delta s_{i,t} + \sum_{i\in N} s_{i,t}(\pi_{i,t} - \Pi_{I,t-1}) + \sum_{i\in X} -s_{i,t-1}(\pi_{i,t-1} - \Pi_{I,t-1}). \quad (3)$$

The first term represents the *within* effect, i.e. within firm productivity changes weighted by initial labor shares. This term reflects productivity growth arising from the improvement of the productivity of installed production capacity (due to process of learning at firm level). The second term is a *between* effect—changing labor shares weighted by the deviation of initial firm productivity and initial industry productivity. This term reflects the contribution to productivity growth from the reallocation of market share from less productive to more productive firms (and vice versa). The third term is an *interaction* effect, capturing the covariations between firm productivities and shares. The fourth term represents the *entry* effect—a sum of a year-end labor share weighted deviation of productivity of entering firms and initial industry productivity. Finally, the fifth term is an *exit* effect—a sum of an initial-year labor share weighted difference between initial productivity of exiting firms and initial industry productivity.[18]

Given the high rates of input and output reallocations between incumbents, and via entry and exits, it is of great importance to investigate the contribution of micro dynamics to aggregate productivity growth. Tables A3 and A4 report the decomposition results for the whole manufacturing and for each two-digit sector using firm-level data set.

The within effect, i.e. intra-firm productivity growth, accounted for the largest proportion of manufacturing productivity growth (see the last rows of the tables), that is 47% (1998–2002) and 57% (2002–2007). Net entry, i.e. the overall effect of *genuine* entry and exit, also explained a substantial amount of growth: 19% (1998–2002) and 34%

18 Notice that, the between-firm, entry, and exit terms use the deviation between firm productivity and the industry average in the initial period. A continuously operating firm with an increasing share makes a positive contribution to aggregate productivity only if it initially has higher productivity than the industry average. Entering (exiting) firms contribute only if they have higher (lower) productivity than the initial average. This treatment of births and deaths ensures that the contribution to the aggregate does not arise because the entering firms are larger than exiting firms, but because of productivity differences.

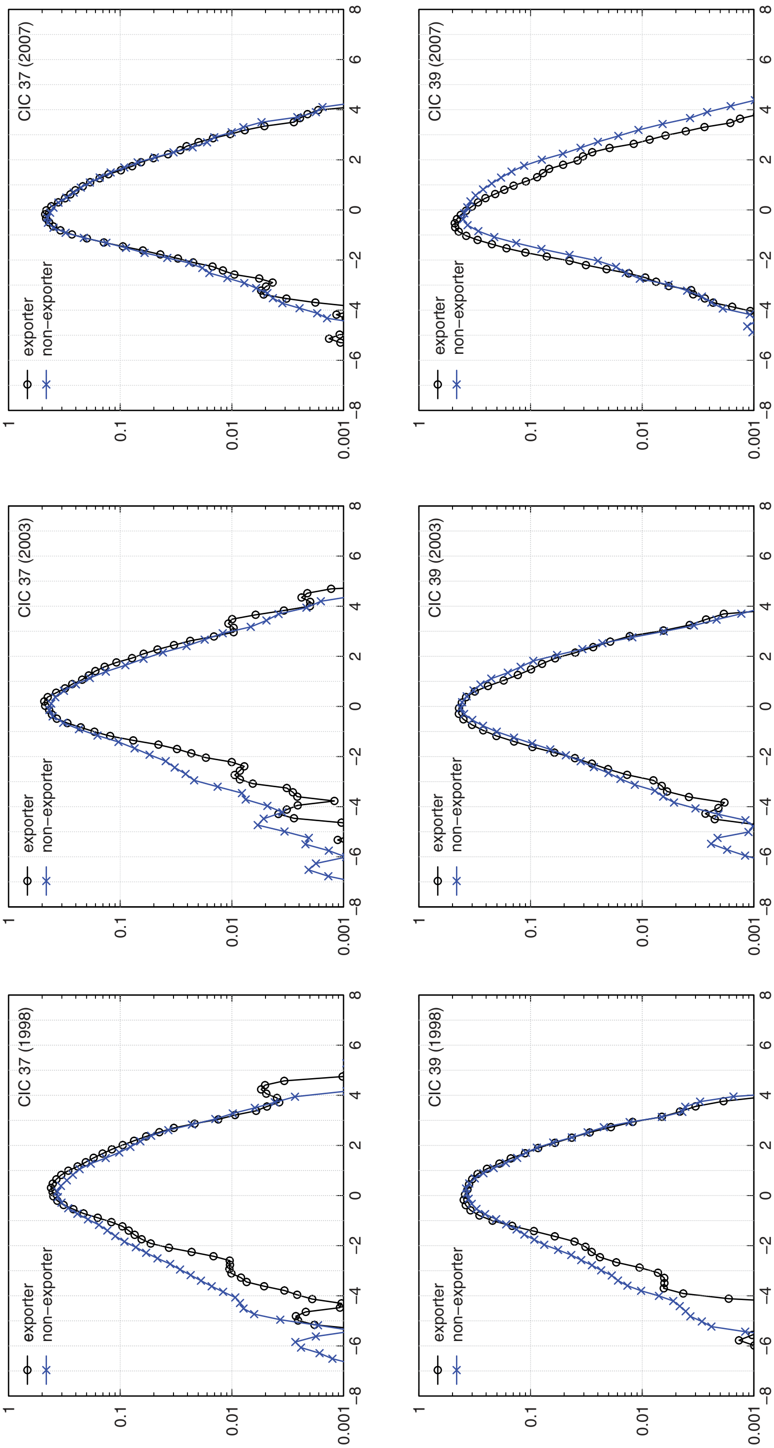

Figure 4. Empirical density of (log) labor productivity of exporters and non-exporters of transport equipment (CIC 37) and electrical machinery and equipment (CIC 39) sectors in selected years (1998, 2003, and 2007). Source: our elaboration on CMM.

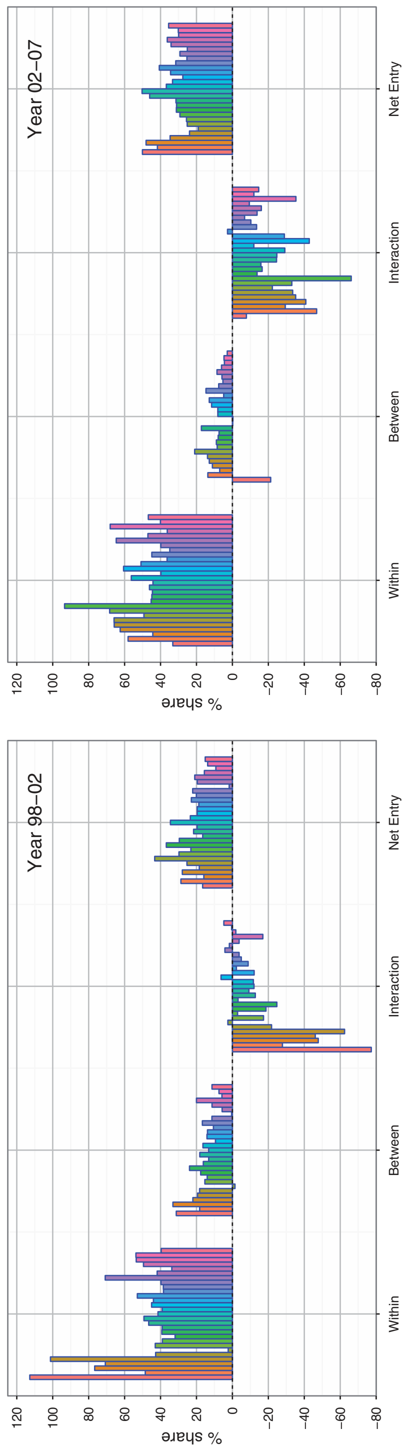

Figure 5. Decomposition by sectors cf. the corresponding Tables A3 and A4. Note: two-digit sectors are in ascending order (in terms of total productivity growth rate).

(2002–2007). At a finer level of disaggregation, within and net entry effects are the most important contributing factors to sectoral-level productivity growth (as also shown by Figure 5 displaying the relative contribution of formula 3). Remarkably, this property holds invariantly across all sectors. Such evidence sheds light on the prominence of both firm's idiosyncratic learning and "churning" via entry and exit. Conversely, the "between" effect contributed to a smaller fraction of sectoral-productivity growth. Note that the major role of the within effect and the positive contribution of net entry (and especially of its exit component) is a quite robust property of industrial dynamics also in developed countries: for a survey, see Foster *et al*. (2001).

6. The dynamics of labor productivity distributions

Let us now focus on the detailed properties of productivity distributions and their dynamics.

The nonparametric kernel densities (Figure 1) provide a general appreciation of the evolutionary patterns of labor productivity distributions. In order to account in more detail for such distributions and their dynamics, we resort to a family of theoretical distributions, Asymmetric Exponential Power (AEP) ones (Bottazzi and Secchi, 2011), which enables to properly account for the asymmetries and leptokurtosis of the distributions themselves.[19]

Note that by estimating an Exponential Power (EP) distribution, one implicitly undertakes robust maximum likelihood-based comparison of different distribution: indeed for a tail parameter $b=2$ on both tails of the distribution approximate a log-normal and for $b=1$ a symmetric Laplace (exponential) one (more details in Bottazzi and Secchi, 2011).[20]

6.1 A striking intra-sectoral heterogeneity

Let us study the behavior of normalized (log) labor productivity at a two-digit sectoral level.[21] We begin with the analysis of the *unbalanced* panel, thus investigating the overall properties of the evolving population of Chinese manufacturing firms, including entrants and exiters. Later we shall compare our results with the balanced panels of incumbents throughout our observation period.

Figure 6 displays the binned probability density, AEP fitted distribution[22] and, for sake of illustration, the Normal fit of normalized (log) labor productivity for selected sectors in years 1998, 2003, and 2007. Over all sectors, AEP estimates display significant deviations from (log-)Normal distributions, and even more so on the low-productivity side.

First, the width of the support of both empirical distributions and AEP fit is much larger than that implied by a Normal distribution with a good deal of the deviation due to the wide support of less-efficient firms.

Second, distributions are leptokurtic, with a very fat left tail. Figure 6 presents some sectoral examples while Tables 6 and 7 provide the MLE estimates of the AEP parameters.

Scale parameters a_l and a_r, capturing the left and right width of the support of AEP distributions, are shown in Table 6. In contrast with the properties of mature economies (see on Italy Dosi *et al*. (2012)[23]) for the majority of sectors, a_l monotonically decreases over time, indicating a shrinking process of the left-tail: this offers another

19 As discussion in Bottazzi and Secchi (2011) the AEP distribution is characterized by 5 parameters, two positive shape parameters b_l and b_r, describing the tail behavior in the upper and lower tail, respectively, two positive scale parameters a_l and a_r, measuring the width of left and right tail, respectively, and one mode parameter m. AEP density is

$$f_{AEP}(x;\mathbf{p}) = \frac{1}{C} e^{-\left(\frac{1}{b_l}\left|\frac{x-m}{a_l}\right|^{b_l}\theta(m-x)+\frac{1}{b_r}\left|\frac{x-m}{a_r}\right|^{b_r}\theta(x-m)\right)} \tag{4}$$

where $\mathbf{p}=(b_l, b_r, a_l, a_r, m)$, $\theta(x)$ is the Heaviside theta function and where the normalization constant reads $C=a_l\ A_0\ (b_l)+a_r\ A_0\ (b_r)$, with $A_k(x) = x^{\frac{k+1}{x}-1}\Gamma(\frac{k+1}{x})$. The AEP reduces to the Exponential Power distribution (Subbotin, 1923) when $a_l=a_r$ and $b_l=b_r$. Notice that the smaller the b's, the fatter the tails.

20 As such, the exercise is of a different kind from estimates of e.g. a Kolmogorov–Smirnov test concerning the diversity of two data-generating processes. Here we try to differentiate *families* of such processes.

21 For example evidence on distributions, see Bottazzi *et al*. (2002), Bottazzi and Secchi (2003), and Dosi and Grazzi (2006).

22 The five parameters are estimated by maximum likelihood method (MLE) following Bottazzi and Secchi (2011).

23 which finds a quite high stability of a_l and a_r over time.

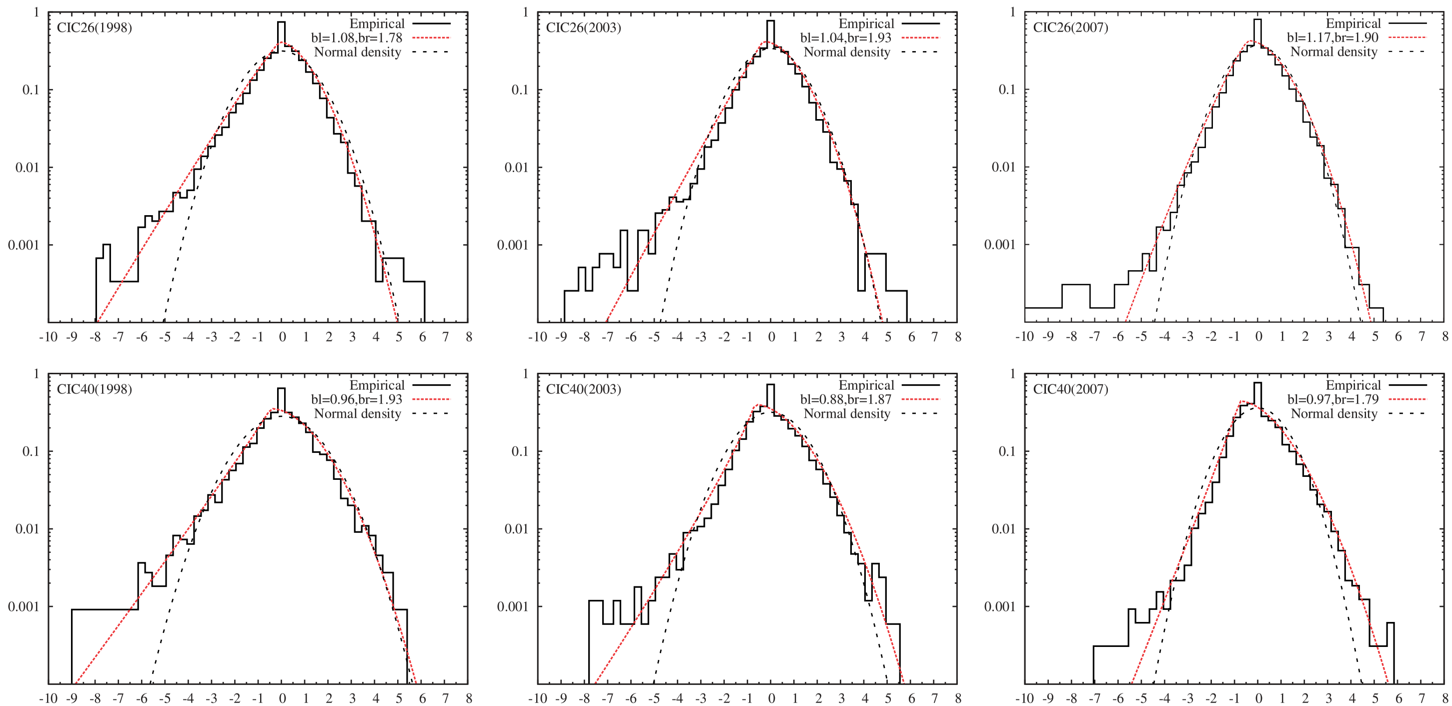

Figure 6. Empirical (log-) density of normalized (log) labor productivity for chemical (CIC26), first row; and communication equipment, computers, etc. (CIC40), second row; the AEP fit (solid smooth curve) and Normal fit (dotted curve) for year 1998, 2003, and 2007 respectively. Source: our elaboration on CMM.

Table 6. (Unbalanced panel) Estimated a_l, a_r parameters and standard errors (in parentheses) for the distribution of labor productivities, two-digit CIC sectors

	Unbalanced panel					
	a_l			a_r		
CIC	1998	2002	2007	1998	2002	2007
13	1.24 (0.03)	1.04 (0.02)	0.88 (0.02)	1.39 (0.05)	1.29 (0.04)	1.35 (0.03)
14	1.59 (0.07)	1.11 (0.04)	0.74 (0.03)	1.04 (0.07)	1.28 (0.06)	1.34 (0.05)
15	1.38 (0.06)	1.13 (0.04)	0.75 (0.03)	1.00 (0.07)	1.11 (0.06)	1.35 (0.05)
16	1.39 (0.31)	1.14 (0.24)	0.40 (0.12)	1.31 (0.38)	1.90 (0.37)	3.50 (0.29)
17	0.91 (0.02)	0.75 (0.01)	0.52 (0.01)	1.07 (0.03)	1.08 (0.02)	1.20 (0.01)
18	0.70 (0.02)	0.61 (0.01)	0.49 (0.01)	1.06 (0.03)	0.92 (0.02)	1.03 (0.02)
19	0.79 (0.03)	0.63 (0.02)	0.40 (0.01)	1.13 (0.04)	1.21 (0.03)	1.29 (0.02)
20	1.09 (0.04)	0.74 (0.03)	0.54 (0.02)	1.16 (0.07)	1.11 (0.04)	1.26 (0.03)
21	1.07 (0.07)	0.80 (0.03)	0.45 (0.02)	0.91 (0.08)	1.06 (0.06)	1.43 (0.03)
22	0.98 (0.03)	0.73 (0.02)	0.56 (0.01)	0.82 (0.04)	0.98 (0.03)	1.20 (0.02)
23	1.13 (0.06)	1.06 (0.04)	0.53 (0.02)	1.22 (0.07)	0.97 (0.05)	1.12 (0.03)
24	0.68 (0.03)	0.66 (0.03)	0.54 (0.02)	1.21 (0.05)	1.03 (0.05)	0.96 (0.03)
25	0.84 (0.06)	0.74 (0.05)	0.81 (0.04)	1.26 (0.10)	1.65 (0.09)	1.47 (0.07)
26	1.03 (0.02)	0.87 (0.02)	0.76 (0.01)	1.11 (0.03)	1.23 (0.03)	1.23 (0.02)
27	1.01 (0.05)	0.96 (0.04)	0.80 (0.04)	1.14 (0.06)	1.17 (0.05)	1.31 (0.06)
28	1.11 (0.11)	0.80 (0.06)	0.63 (0.05)	0.93 (0.13)	0.96 (0.08)	1.49 (0.08)
29	0.75 (0.03)	0.79 (0.04)	0.57 (0.03)	1.08 (0.05)	1.10 (0.06)	1.34 (0.05)
30	0.89 (0.03)	0.73 (0.02)	0.48 (0.01)	1.13 (0.04)	1.14 (0.03)	1.38 (0.02)
31	0.79 (0.01)	0.74 (0.01)	0.66 (0.01)	1.22 (0.02)	1.24 (0.02)	1.35 (0.02)
32	0.95 (0.03)	0.92 (0.03)	0.84 (0.03)	1.14 (0.05)	1.07 (0.05)	1.13 (0.04)
33	0.86 (0.03)	0.85 (0.04)	0.62 (0.02)	1.42 (0.06)	1.13 (0.06)	1.94 (0.04)
34	0.85 (0.02)	0.68 (0.01)	0.46 (0.01)	1.15 (0.03)	1.22 (0.02)	1.39 (0.02)
35	0.96 (0.02)	0.75 (0.01)	0.48 (0.01)	1.02 (0.03)	1.01 (0.02)	1.30 (0.01)
36	1.13 (0.04)	1.00 (0.02)	0.54 (0.01)	1.16 (0.05)	1.05 (0.04)	1.37 (0.02)
37	1.08 (0.03)	0.83 (0.02)	0.50 (0.01)	1.12 (0.04)	1.07 (0.03)	1.34 (0.02)
39	0.90 (0.02)	0.73 (0.02)	0.53 (0.01)	1.25 (0.04)	1.27 (0.03)	1.46 (0.02)
40	0.98 (0.03)	0.81 (0.02)	0.54 (0.01)	1.50 (0.05)	1.41 (0.04)	1.41 (0.02)
41	1.03 (0.05)	0.78 (0.03)	0.48 (0.02)	1.25 (0.07)	1.31 (0.05)	1.66 (0.03)
42	0.90 (0.05)	0.78 (0.03)	0.49 (0.02)	1.13 (0.07)	1.00 (0.04)	1.16 (0.03)

Source: Our elaboration on CMM.

circumstantial piece of evidence that labor productivities of less efficient firms tend to regress over time toward the mean. On the contrary, for the majority of sectors, their a_r increases over time, indicating that the labor productivities of more-efficient firms gradually diverge: indicating that some "frontier firms" forge ahead. Overall the support of sectoral labor productivity distributions shrinks over time for most sectors, except a few capital- and scale-intensive industries such as chemical fibers, rubber, nonmetallic mineral products, and nonferrous metals (CIC 25, 28, 29, 31, and 33).

Tail parameters b_l and b_r of the AEP distributions are shown in Table 7. The values of b_l are all around one, confirming the Laplace-type fat-tail property of the left-side distributions. Conversely, the values of b_r are not too far from 2, hinting at a near log-normality of the upper tail. In fact b_r in quite a few sector is *bigger* than 2: the "best practice" frontiers are quite steep.

Next, we split the whole panel among incumbents (firms which persist throughout our window of observation); "genuine entrants" (firms that are actually born in the year when one starts observing them), "entrant in the panel" (i.e. firms that were born before but only in a particular year enter the panel by overcoming the minimum sale

Table 7. (Unbalanced Panel) Estimated b_l, b_r parameters and standard errors (in parentheses) for the distribution of labour productivities, two-digit CIC sectors

	UNBALANCED PANEL					
	b_l			b_r		
CIC	1998	2002	2007	1998	2002	2007
13	1.18 (0.04)	1.02 (0.03)	1.27 (0.04)	2.47 (0.11)	2.36 (0.09)	2.41 (0.07)
14	1.45 (0.07)	1.09 (0.05)	1.20 (0.06)	1.74 (0.14)	2.19 (0.14)	2.22 (0.10)
15	1.32 (0.07)	1.09 (0.06)	1.09 (0.06)	1.61 (0.13)	1.77 (0.12)	2.24 (0.12)
16	1.56 (0.39)	1.25 (0.33)	0.67 (0.24)	2.30 (0.71)	2.75 (0.68)	6.85 (2.09)
17	1.05 (0.03)	0.99 (0.03)	0.99 (0.02)	1.77 (0.06)	1.88 (0.06)	2.10 (0.04)
18	0.86 (0.03)	0.93 (0.03)	0.96 (0.03)	1.75 (0.07)	1.61 (0.05)	1.68 (0.04)
19	0.90 (0.04)	0.85 (0.04)	0.89 (0.04)	1.80 (0.10)	1.83 (0.08)	1.71 (0.05)
20	1.02 (0.06)	0.94 (0.05)	1.07 (0.05)	2.03 (0.16)	2.00 (0.12)	2.16 (0.07)
21	1.23 (0.11)	0.89 (0.06)	0.79 (0.04)	1.50 (0.16)	1.97 (0.15)	2.28 (0.10)
22	1.15 (0.05)	0.97 (0.04)	0.91 (0.03)	1.44 (0.08)	1.82 (0.08)	2.09 (0.07)
23	1.31 (0.08)	1.19 (0.06)	0.95 (0.04)	1.94 (0.14)	1.68 (0.11)	1.73 (0.07)
24	0.79 (0.05)	1.03 (0.07)	1.08 (0.06)	2.01 (0.14)	1.84 (0.13)	1.58 (0.07)
25	1.09 (0.11)	0.95 (0.09)	1.07 (0.08)	2.21 (0.24)	2.31 (0.19)	2.10 (0.14)
26	1.08 (0.03)	1.04 (0.03)	1.17 (0.03)	1.77 (0.07)	1.98 (0.06)	1.90 (0.04)
27	1.22 (0.08)	1.10 (0.06)	1.36 (0.09)	1.68 (0.11)	1.98 (0.12)	2.39 (0.13)
28	1.19 (0.15)	0.99 (0.10)	1.07 (0.11)	1.74 (0.31)	1.53 (0.18)	2.89 (0.25)
29	0.85 (0.05)	0.92 (0.06)	1.12 (0.08)	2.00 (0.15)	2.01 (0.16)	2.27 (0.12)
30	1.03 (0.04)	0.94 (0.03)	0.94 (0.03)	1.95 (0.09)	1.95 (0.07)	2.16 (0.05)
31	0.96 (0.03)	1.01 (0.03)	1.08 (0.03)	2.05 (0.06)	2.14 (0.06)	2.22 (0.05)
32	1.02 (0.05)	1.03 (0.05)	1.29 (0.06)	1.78 (0.11)	1.84 (0.11)	1.85 (0.09)
33	0.85 (0.05)	1.10 (0.07)	0.97 (0.05)	2.37 (0.16)	1.85 (0.13)	2.78 (0.11)
34	0.94 (0.03)	0.84 (0.03)	0.92 (0.03)	1.83 (0.07)	1.96 (0.06)	2.10 (0.04)
35	1.04 (0.03)	0.92 (0.02)	0.88 (0.02)	1.69 (0.06)	1.68 (0.05)	2.07 (0.03)
36	1.17 (0.05)	1.02 (0.04)	0.86 (0.02)	1.88 (0.10)	1.75 (0.08)	2.11 (0.05)
37	1.09 (0.04)	0.95 (0.03)	0.85 (0.02)	1.66 (0.07)	1.61 (0.06)	1.95 (0.04)
39	1.03 (0.04)	0.91 (0.03)	0.96 (0.03)	2.11 (0.09)	2.23 (0.07)	2.12 (0.04)
40	0.96 (0.05)	0.92 (0.04)	0.97 (0.03)	1.93 (0.10)	1.75 (0.07)	1.79 (0.05)
41	0.93 (0.06)	0.83 (0.05)	0.75 (0.04)	1.87 (0.15)	1.83 (0.11)	2.37 (0.09)
42	1.21 (0.09)	1.14 (0.06)	1.11 (0.06)	1.79 (0.13)	1.59 (0.09)	1.67 (0.06)

Source: Our elaboration on CMM.

threshold), exiters (firms which die or are acquired), "others" (firms which for whatever reason fail to report in some years). Table 8 reports the frequencies of each type.[24]

Let us begin by comparing the foregoing properties of the distributions with those displayed by the balanced panel alone, comprising only the firms that are in the sample for all years.[25] Basically the comparison between the two ensembles of distributions flags out the distinct impact on the evolution of the productivities of firms' populations in each sector of entry and exit processes.

Tables 9 and 10 show the maximum likelihood estimators of AEP distributions for each two-digit sector.[26] The evidence shows a remarkable pairwise similarity between the distributions. In particular, the tails (proxied by the b_l

24 In Brandt *et al.* (2012) the definition of entrants is firms which in the year they are first observed indicate a birth year at most 2 years before. Empirical patterns are quite similar.

25 Note that the data set is able to track firms which persist even if changing governance forms and thus "institutional category": they continue to remain incumbents.

26 CIC 16 is not shown due to very few number of observations in the balanced panel.

Table 8. The number of firms and percentages (in parentheses) of incumbents, genuine entrants, entrants (above the threshold), exiters and "others"

	1998	1999	2000	2001	2002	2003	2005	2006	2007
Incumbents	25,557	25,557	25,557	25,557	25,557	25,557	25,557	25,557	25,557
	(18.9)	(19.1)	(18.7)	(17.3)	(16.3)	(14.6)	(10.5)	(9.4)	(8.3)
Genuine entrants	NA	686	729	2024	1484	3422	7331	8435	12,207
	(NA)	(0.5)	(0.5)	(1.4)	(0.9)	(2.0)	(3.0)	(3.1)	(4.0)
Entrants in panel	NA	6329 (4.7)	14,486	31,270	46,029	68,024	161,626	205,564	261,544
	(NA)		(10.6)	(21.2)	(29.3)	(38.9)	(66.3)	(75.7)	(85.4)
Exiters	102,934	96,317	91,582	84,497	79,807	73,367	43,923	26,188	NA
	(76.0)	(71.9)	(66.9)	(57.2)	(50.8)	(41.9)	(18.0)	(9.6)	(NA)
Others	7019	5115	4476	4264	4138	4562	5469	5982	7019
	(5.2)	(3.8)	(3.3)	(2.9)	(2.6)	(2.6)	(2.2)	(2.2)	(2.3)
Total	135,510	134,004	136,830	147,612	157,015	174,932	243,906	271,726	306,327
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Source: Our elaboration on CMM.

Table 9. (Balanced panel) Estimated a_l and a_r parameters and standard errors (in parentheses) for the distribution of labor productivities, two-digit CIC sectors

	Balanced Panel					
	a_l			a_r		
CIC	1998	2002	2007	1998	2002	2007
13	0.89 (0.08)	0.72 (0.05)	0.92 (0.12)	1.38 (0.12)	1.49 (0.09)	1.42 (0.16)
14	0.84 (0.13)	0.68 (0.07)	0.71 (0.08)	1.09 (0.17)	1.36 (0.12)	1.68 (0.15)
15	0.63 (0.07)	0.85 (0.12)	0.93 (0.09)	1.29 (0.12)	1.07 (0.14)	1.07 (0.13)
17	0.47 (0.02)	0.53 (0.03)	0.52 (0.03)	1.30 (0.05)	1.05 (0.05)	1.18 (0.05)
18	0.53 (0.03)	0.63 (0.04)	0.62 (0.05)	1.04 (0.04)	0.77 (0.05)	0.85 (0.05)
19	0.58 (0.05)	0.67 (0.10)	0.32 (0.04)	1.14 (0.07)	1.12 (0.12)	1.37 (0.08)
20	0.65 (0.08)	0.70 (0.11)	0.52 (0.07)	1.29 (0.15)	1.04 (0.15)	1.46 (0.12)
21	0.62 (0.10)	0.51 (0.08)	0.50 (0.08)	1.44 (0.19)	0.96 (0.13)	1.37 (0.11)
22	0.69 (0.06)	0.73 (0.08)	0.69 (0.05)	0.84 (0.07)	0.80 (0.08)	1.08 (0.08)
23	0.60 (0.06)	0.53 (0.04)	0.59 (0.05)	1.10 (0.09)	1.12 (0.07)	1.00 (0.08)
24	0.62 (0.06)	0.60 (0.10)	0.46 (0.06)	1.06 (0.09)	0.91 (0.13)	0.91 (0.10)
25	0.76 (0.13)	0.51 (0.17)	1.03 (0.21)	1.04 (0.18)	1.35 (0.23)	1.20 (0.23)
26	0.66 (0.03)	0.65 (0.04)	0.67 (0.03)	1.14 (0.05)	1.27 (0.06)	1.35 (0.06)
27	0.68 (0.07)	0.60 (0.06)	0.66 (0.07)	1.31 (0.12)	1.40 (0.11)	1.50 (0.13)
28	1.04 (0.21)	0.46 (0.12)	0.79 (0.61)	0.69 (0.14)	1.57 (0.17)	1.11 (0.46)
29	0.51 (0.09)	0.59 (0.18)	0.65 (0.11)	1.07 (0.14)	1.26 (0.26)	1.27 (0.17)
30	0.62 (0.04)	0.57 (0.04)	0.55 (0.05)	1.24 (0.07)	1.24 (0.08)	1.25 (0.08)
31	0.54 (0.02)	0.59 (0.04)	0.69 (0.03)	1.14 (0.04)	1.15 (0.06)	1.25 (0.06)
32	0.85 (0.08)	0.77 (0.08)	1.25 (0.23)	0.88 (0.10)	0.99 (0.11)	0.82 (0.19)
33	0.57 (0.07)	0.87 (0.12)	0.64 (0.08)	1.64 (0.11)	0.96 (0.16)	1.63 (0.15)
34	0.51 (0.03)	0.56 (0.04)	0.46 (0.03)	1.37 (0.06)	1.32 (0.07)	1.45 (0.07)
35	0.70 (0.04)	0.47 (0.02)	0.57 (0.03)	0.90 (0.05)	1.19 (0.04)	1.33 (0.05)
36	0.75 (0.05)	0.73 (0.06)	0.66 (0.04)	1.19 (0.08)	1.08 (0.08)	1.41 (0.07)
37	0.66 (0.04)	0.73 (0.05)	0.81 (0.06)	1.18 (0.06)	0.95 (0.06)	0.94 (0.07)
39	0.77 (0.06)	0.63 (0.05)	0.56 (0.04)	1.05 (0.08)	1.16 (0.07)	1.64 (0.07)
40	0.69 (0.05)	0.64 (0.06)	0.45 (0.03)	1.54 (0.08)	1.36 (0.09)	1.59 (0.07)
41	0.58 (0.06)	0.65 (0.10)	0.57 (0.05)	1.37 (0.12)	1.30 (0.15)	1.49 (0.10)
42	0.72 (0.07)	0.68 (0.08)	0.62 (0.09)	1.17 (0.12)	0.93 (0.09)	1.03 (0.11)

Source: Our elaboration on CMM.

Table 10. (Balanced panel) Estimated b_l and b_r parameters and standard errors (in parentheses) for the distribution of labor productivities, two-digit CIC sectors

	Balanced panel					
	b_l			b_r		
CIC	1998	2002	2007	1998	2002	2007
13	1.18 (0.14)	0.97 (0.10)	1.42 (0.21)	2.30 (0.26)	2.69 (0.26)	2.34 (0.30)
14	1.42 (0.26)	1.05 (0.16)	1.06 (0.18)	2.07 (0.37)	2.10 (0.28)	2.66 (0.37)
15	1.01 (0.17)	1.33 (0.24)	1.08 (0.16)	1.95 (0.28)	1.53 (0.26)	1.57 (0.25)
17	0.85 (0.07)	0.95 (0.07)	0.97 (0.08)	2.21 (0.14)	2.11 (0.15)	2.08 (0.14)
18	0.76 (0.05)	1.22 (0.12)	1.26 (0.13)	1.86 (0.14)	1.33 (0.12)	1.24 (0.11)
19	0.75 (0.08)	1.38 (0.26)	0.93 (0.16)	1.72 (0.18)	1.62 (0.22)	1.97 (0.21)
20	0.92 (0.18)	1.14 (0.24)	0.73 (0.13)	2.61 (0.51)	1.60 (0.31)	1.99 (0.31)
21	0.93 (0.23)	0.99 (0.23)	0.63 (0.11)	3.21 (0.77)	1.66 (0.34)	2.50 (0.45)
22	1.25 (0.16)	1.40 (0.19)	0.94 (0.10)	1.32 (0.15)	1.37 (0.17)	1.72 (0.18)
23	1.01 (0.14)	0.80 (0.09)	1.02 (0.14)	1.72 (0.21)	2.05 (0.23)	1.63 (0.20)
24	0.84 (0.11)	1.31 (0.27)	1.10 (0.21)	1.89 (0.27)	1.78 (0.31)	1.74 (0.26)
25	1.07 (0.26)	1.34 (0.54)	1.27 (0.34)	1.53 (0.36)	1.82 (0.43)	1.34 (0.34)
26	0.98 (0.07)	1.08 (0.09)	0.98 (0.07)	1.70 (0.11)	2.08 (0.15)	2.03 (0.13)
27	1.15 (0.16)	1.10 (0.16)	1.12 (0.17)	2.24 (0.27)	2.91 (0.35)	3.02 (0.39)
28	1.62 (0.47)	0.57 (0.14)	3.21 (2.51)	1.01 (0.30)	2.44 (0.60)	1.62 (0.71)
29	1.17 (0.26)	1.53 (0.53)	1.22 (0.27)	2.27 (0.41)	2.91 (0.71)	2.01 (0.35)
30	0.93 (0.09)	1.05 (0.12)	1.08 (0.13)	2.11 (0.19)	2.30 (0.22)	1.91 (0.17)
31	0.87 (0.05)	1.16 (0.10)	1.01 (0.07)	1.96 (0.12)	1.87 (0.13)	2.06 (0.14)
32	1.07 (0.15)	1.03 (0.15)	2.19 (0.47)	1.36 (0.21)	1.58 (0.25)	1.57 (0.41)
33	0.67 (0.10)	1.18 (0.22)	0.98 (0.18)	3.34 (0.53)	1.76 (0.37)	2.38 (0.36)
34	0.84 (0.08)	1.05 (0.11)	0.94 (0.11)	2.02 (0.15)	2.03 (0.17)	2.14 (0.17)
35	1.10 (0.08)	0.89 (0.06)	0.91 (0.06)	1.48 (0.10)	2.03 (0.12)	2.27 (0.14)
36	0.99 (0.09)	1.20 (0.13)	0.77 (0.06)	2.09 (0.20)	1.67 (0.17)	1.98 (0.16)
37	0.92 (0.07)	1.14 (0.10)	1.38 (0.14)	1.68 (0.13)	1.44 (0.12)	1.41 (0.13)
39	1.37 (0.14)	1.26 (0.13)	1.02 (0.10)	1.80 (0.17)	1.97 (0.16)	2.50 (0.18)
40	0.87 (0.09)	1.09 (0.13)	0.73 (0.07)	2.07 (0.19)	1.84 (0.18)	2.14 (0.17)
41	0.89 (0.14)	1.22 (0.25)	0.74 (0.10)	2.15 (0.30)	1.84 (0.29)	1.77 (0.20)
42	1.03 (0.15)	1.28 (0.21)	1.22 (0.22)	1.85 (0.26)	1.19 (0.15)	1.50 (0.22)

Source: Our elaboration on CMM.

and b_r parameters) are similarly fat-tailed. The only major significant difference concern the a_l parameters which in the unbalanced panel start large at the beginning of the period and shrink thereafter, while in the balanced one they tend to be relatively small from the beginning. That is, the shrinking of the width of the left part of the distribution—the less efficient one—is fundamentally due to some disappearance of the relatively less productive among the initial incumbents (and to some extent "churning," the entry and exit of new short-lived firms).

Figure 7 displays the average labor productivity by groups over the years. Note that the productivity of the incumbents is always the highest. Interestingly, after 2002, productivity is higher among exiters than entrants (this applies also at two-digit level) hinting at the marginality of a good deal of *de novo* entrants. Figure 8 shows the labor productivity distribution by type in two selected sectors (all two-digit sectors display qualitatively the same pattern). Not surprisingly the left tails of the distribution for exiters have large supports (many exiters are relatively low-efficiency firms). What is more puzzling is that the right tail is very close to that of incumbents. One of the reasons might be that "exit" may mean acquisition and not death. However, it may well be the case that firms actually die for reasons other than lack of technological efficiency, but e.g. due to financial fragility in presence of a myopic financial system (on the Italian evidence, see Bottazzi *et al.*, 2006). We leave these important questions to further research.

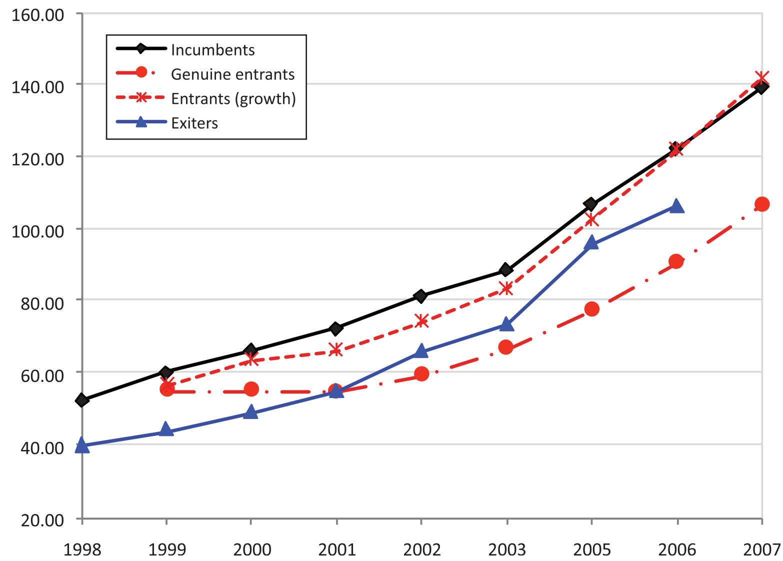

Figure 7. Average value added per employee of incumbents, entrants, and exiters (at 1998 constant price; 1000 yuan = 1). Source: our elaboration on CMM.

6.2 Growth rates of labor productivity

Let us look next at the properties of growth rates. Figure 9 displays the empirical distribution and EP fit of growth rates of labor productivity of selected sectors for periods 1998–2002 and 2003–2007.

They are all fat-tailed and symmetric. Such long-term "lumpiness" of productivity growth events clearly militates against any notion of productivity growth resulting from of a smooth process made by small independent improvements. Rather, it appears characterized by relatively frequent "big" idiosyncratic shocks (Dosi *et al.*, 2012; Dosi, 2007), plausibly of technological but also strategic and institutional nature.

Table 11 shows the autocorrelation coefficients for relative labor productivity in levels and first differences: the relative productivity levels are quite persistent over time, with only some relatively mild regression-to-the-mean tendency.[27]

7. The comparative evidence across ownership and governance forms

If we treat firms switching ownership categories as continuing firms (as shown in Table 12) apply formula 3 (cf. above, Section 5), we can decompose the total growth of manufacturing sector into the contribution of each ownership and further decompose the latter into the contribution of each effect. Using this method, the contributions of effects can be compared across different ownership types.[28]

Almost 50% of within effect can be attributed to SOEs only during 1998–2002 and both SOEs and SHEs between 2002 and 2007. The contribution of within effect of the ownership-switching group has been increased from 8.6% to 15.5%. The contribution of genuine entry effects doubled to 26% in the second subperiod. FIEs, SHEs and China's POEs are the most contributed groups.

Furthermore, at finer level of disaggregation, we replicate the same exercise for each two-digit sector (see Figures 10 and 11) and find similar evidence.

7.1 Aggregate evidence

Distributions and their dynamics are deeply affected by the organizational types of the micro entities. Let us consider them.

27 For the estimates we adopt the approach described in Chesher (1979).

28 For a highly complementary analysis on the micro patterns of *firm* growth by ownership types, see Duschl and Peng (2015), this issue.

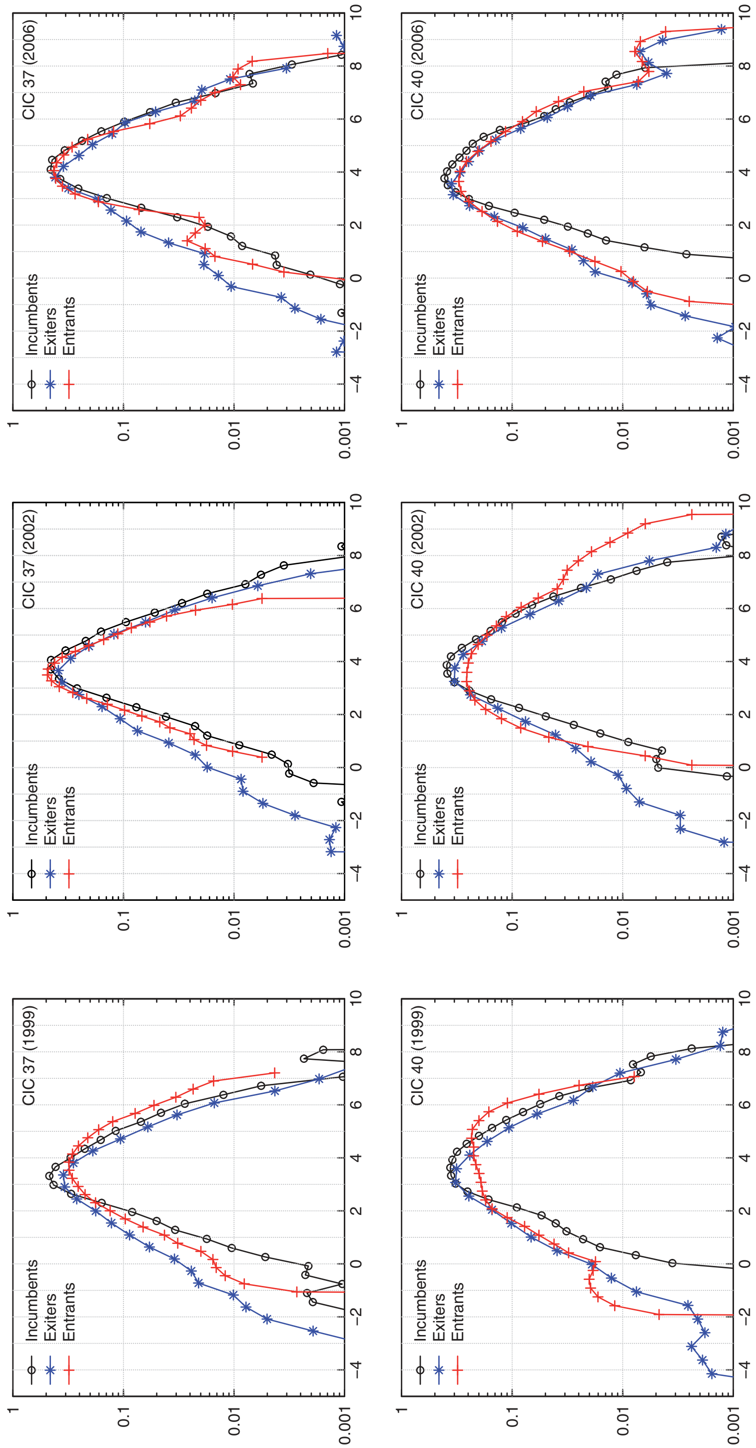

Figure 8. Empirical (log-) density of (log) labor productivity for transport equipment (CIC 37) and communication equipment, computers, etc. (CIC 40). Source: our elaboration on CMM.

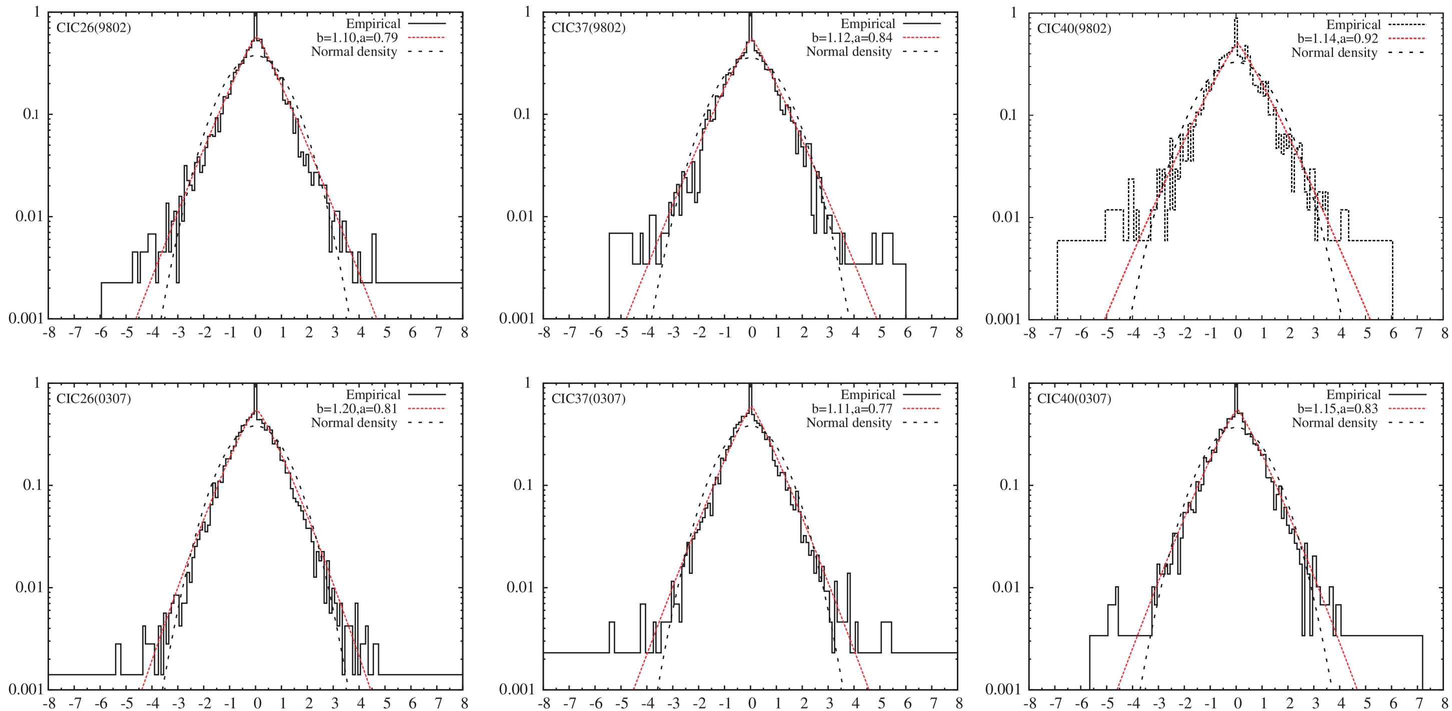

Figure 9. Empirical density of growth rates of normalized (log) labor productivity over 4 years interval, for chemical (CIC 26), transport equipment (CIC 37), and communication equipment, computers, etc. (CIC 40), with Exponential Power and Normal fits. The first row, 1998–2002; second row, 2003–2007. Source: our elaboration on CMM.

Table 11. AR(1) coefficients and robust standard errors (in parentheses) for normalized (log) labor productivity in levels and first differences

CIC	Sector	Levels	First differences
13	Food processing of agricultural products	0.844 (0.010)	−0.308 (0.024)
14	Other foodstuff	0.892 (0.014)	−0.267 (0.034)
15	Beverages	0.893 (0.015)	−0.302 (0.039)
16	Tobacco	0.982 (0.016)	−0.236 (0.077)
17	Textile	0.844 (0.009)	−0.286 (0.019)
18	Garments, footwear etc.	0.812 (0.011)	−0.255 (0.018)
19	Leather, fur, feather etc.	0.846 (0.017)	−0.304 (0.025)
20	Processing of timber, manuf. Of wood, bamboo etc.	0.844 (0.022)	−0.208 (0.040)
21	Furniture	0.829 (0.024)	−0.280 (0.043)
22	Paper and paper products	0.840 (0.013)	−0.247 (0.024)
23	Printing, reproduction of recording media	0.876 (0.012)	−0.333 (0.058)
24	Articles for culture, education and sports	0.828 (0.018)	−0.318 (0.030)
25	Processing of petroleum, cokeries, nuclear fuel	0.904 (0.025)	−0.241 (0.056)
26	Raw chemical materials and chemical products	0.895 (0.007)	−0.282 (0.014)
27	Pharmaceuticals	0.858 (0.011)	−0.280 (0.022)
28	Chemical fibers	0.825 (0.052)	−0.123 (0.051)
29	Rubber	0.891 (0.020)	−0.226 (0.039)
30	Plastics	0.845 (0.012)	−0.283 (0.022)
31	Non-metallic mineral products	0.888 (0.006)	−0.289 (0.015)
32	Smelting and processing of ferrous metals	0.823 (0.031)	−0.273 (0.045)
33	Smelting and processing of non-ferrous metals	0.865 (0.020)	−0.297 (0.037)
34	Metal products	0.883 (0.010)	−0.309 (0.025)
35	General purpose machinery	0.890 (0.007)	−0.246 (0.016)
36	Special purpose machinery	0.893 (0.012)	−0.236 (0.028)
37	Transport equipment	0.889 (0.010)	−0.245 (0.021)
39	Electrical machinery and equipment	0.874 (0.009)	−0.295 (0.020)
40	Communication equipments, computer etc.	0.890 (0.010)	−0.247 (0.024)
41	Measuring instruments and machinery	0.901 (0.017)	−0.359 (0.049)
42	Artwork and other	0.866 (0.018)	−0.258 (0.030)
	Aggregate	0.872 (0.002)	−0.279 (0.005)

Source: Elaboration on BCMM.

Let us start by noticing that over the period under consideration the Chinese industry underwent deep changes in its ownership and governance patterns. Figure 12 illustrates the fall of *fully* publicly owned firms. The share of SOEs and COEs drops from 66% in 1998 to around 7% in 2007 in terms of number of firms, and from 60% to 14% in terms of value added. On the contrary, one observes a surge of "shareholding" firms, as such a "capitalist" transformation of SOEs, and of private enterprises. SHEs increased from 7% in 1998 to 17.3% in 2007 in terms of numbers, and from 11% to 26.8% in terms of value added. Together, the share of domestic private enterprises has increased dramatically from 7.4% in 1998 to 54% in 2007 in terms of numbers and less dramatically from 3.2% to 26% as measured by value added.

The relative importance of public and private (domestic and foreign) forms of ownership however differs a lot across sectors. The "core" industries continue to be dominated by SOEs and/or by State-participated SHEs, even after the privatization process. For instance, in 2007, the value-added share of SOEs and SHEs was 67% for petroleum sector, 64% in nonferrous metals, 54% in ferrous metals. In transport equipment, the value added share of SOEs and shareholdings was 35%, while that of FIEs was 42%.[29] The activities dominated by privately owned companies are quite diverse, but mainly concentrated in "competitive sectors" as defined by the government policies, such as food

29 In transport equipment sector, FIEs are mainly joint ventures between foreign MNCs and the State and, in most cases, the Chinese side is the controlling shareholder.

Table 12. Decomposition of aggregate labor productivity by ownership types (% contribution to overall productivity growth)

Ownership	Total growth	Ownership keep			Ownership change			Exit	Entry		Total
		Within %	Between %	Inter %	Within %	Between %	Inter %	%	Real %	Growth %	%
	1998–2002										
SOE	0.95	18.09	2.15	−3.33	3.16	0.78	−0.78	6.21	0.46	4.29	31.03
Collective		5.22	1.83	−1.95	2.66	0.99	−0.65	0.92	0.59	2.84	12.45
HMT-invested		3.38	1.83	−0.76	0.84	0.37	−0.23	−0.45	1.59	2.76	9.33
Foreign-invested		6.64	2.94	0.31	0.82	0.18	−0.16	−1.07	2.86	6.44	18.96
Shareholding		3.67	1.16	−0.50	0.76	0.19	−0.08	0.37	5.41	9.53	20.52
Private		1.04	0.25	−0.12	0.19	0.12	−0.03	−0.02	2.48	3.24	7.15
Other domestic		0.14	0.05	−0.06	0.16	0.04	−0.02	0.05	0.09	0.11	0.55
Total		38.17	10.21	−6.41	8.59	2.68	−1.95	6.01	13.48	29.20	100.00
	2002–2007										
SOE	1.01	13.05	−0.01	−6.73	4.22	0.56	−1.84	2.97	2.23	2.61	17.04
Collective		2.21	0.71	−1.01	4.16	0.73	−1.73	2.07	0.50	0.99	8.63
HMT-invested		2.99	1.10	−2.02	0.70	0.22	−0.54	0.53	1.69	1.09	5.77
Foreign-invested		6.02	1.99	−3.77	0.59	0.17	−0.23	−0.52	7.49	6.42	18.16
Shareholding		10.87	2.27	−4.88	3.56	0.47	−1.23	1.17	5.64	8.03	25.90
Private		6.13	1.13	−2.19	2.01	0.31	−0.95	1.69	8.39	7.54	24.05
Other domestic		0.08	0.00	−0.05	0.23	0.08	−0.21	0.05	0.09	0.18	0.46
Total		41.36	7.18	−20.66	15.46	2.53	−6.72	7.97	26.04	26.85	100.00

Note: Treat firms switching their ownership categories as continuing firms.
Source: Our elaboration on CMM.

product, textile, nonmetallic minerals products, metal products. High and medium-high tech sectors (as classified by OECD taxonomy, with the caveat that in China, most of these sectors also contain a quite large labor-intensive export-processing part), such as communication equipment, computers, measuring instrument, etc. display a persistently high share of FIEs over the whole period, but also a significant presence of shareholding enterprises (often in the technological upper end of the industries).

Over the period, a good deal of the changes in the shares of different types of firms is due to a fast transformation in the forms of corporate governance of incumbents. Table 13 present, by governance type, the percentage of firms which maintain their institutional characteristics ("keep"), enter ("entry"), exit, move-in the type ("S-in"), and move to other types ("S-out"). The percentage share of "out" firms is the highest in publicly (both State and collective) owned enterprises in both periods. "Shareholding" and "domestic private" categories have highest share of entrants and they are also the main destinations of firms undertaking restructuring. (To repeat, "enter," "exit," etc. stand for institutional categories and *not* entry or exit into the industry.)

Figure 13 displays the trend in labor productivity by corporate type. FIEs (MNCs and JVs), not too surprisingly, keep the highest productivity levels, but, interestingly, display also the weaker growth rates. Conversely, Chinese firms, of all types—private, State-owned, and mixed ownership—all grow faster in an impressive catching-up processes. In 1998, SOEs had on average a quarter of the labor productivity of FIE and "shareholding" ones had a half. In 2007, SOE displayed around 70% and shareholding around 80% of the FIE average productivity.

Moreover, among Chinese firms, those which restructure (especially among the SOE) display the highest dynamics: see Table 14 covering the 10 largest sectors.

7.2 Micro-evidence

The foregoing evidence regards, the means of productivities by governance/ownership types. Let us now zoom-in onto the whole distributions.

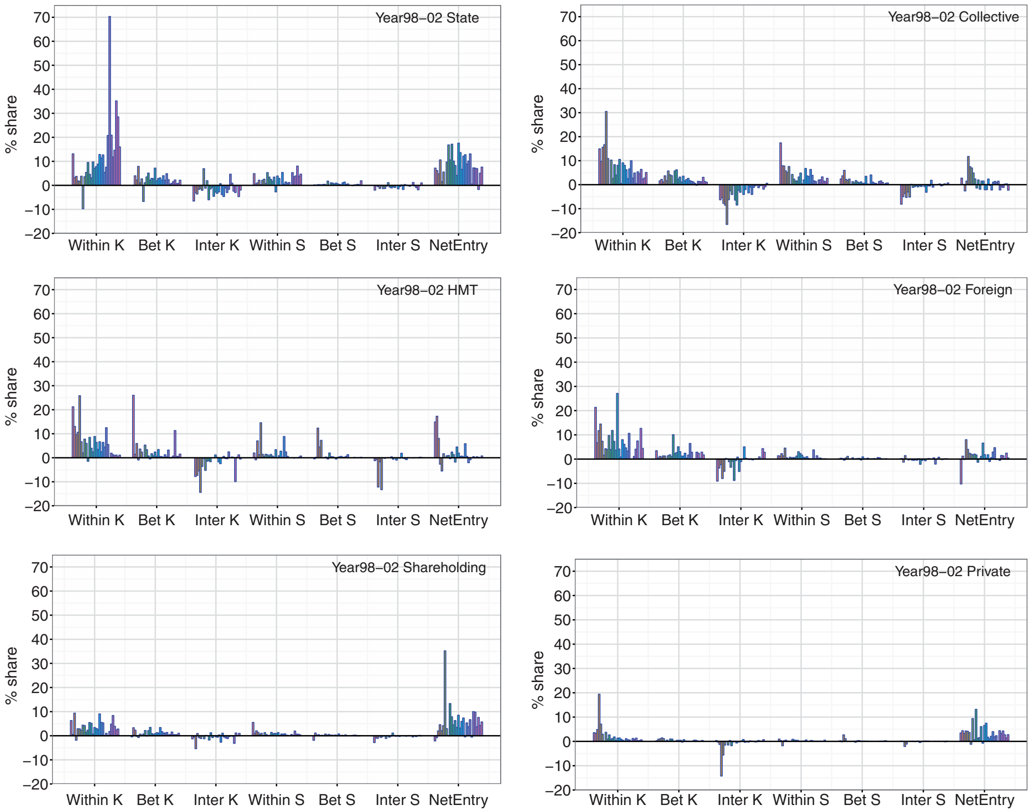

Figure 10. (1998–2002) Percentage contributions of within, between, interaction effects of both firms invariant in ownership type (denoted by "Within K," "Bet K," and "Inter K" respectively) and ownership-switching firms (denoted by "Within S," "Bet S," and "Inter S" respectively), and net entry effects (the sum of exit and greenfield entry effects) by two-digit sectors and by ownership types. Note: The sectors are in ascending order in terms of their overall productivity growth rates.

Figure 14 displays the kernel density plots in selected sectors and their evolutionary patterns by corporate types.[30] In addition to the different levels of labor productivity, notice that the empirical distribution of SOE is significantly different from that of the others, in terms of wider support, fatter left-tail, underling a catching-up process however characterized by an increasing dual structure, with a small group of SOEs lagging behind. Overall, the empirical densities of six ownership types converge over time.

In order to disentangle statistically the importance of the six types, we construct two panels (an unbalanced and a balanced one) containing the ML estimators of five parameters of AEP fits of annual labor productivity distribution by sectors and by ownership.[31] A two-way analysis of variance (ANOVA) with repeated yearly measures is employed to test the effects of ownership, time, and their interaction in a model such as

$$Y_{ijk} = \mu \ldots + \rho_{i(j)} + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \epsilon_{ijk} \qquad (5)$$

with Y_{ijk} the estimated AEP parameters a_l, a_r, b_l, b_r, and m respectively; α_j ownership effect, $j \in \{1, \ldots, 6\}$[32]; β_k year effect, $k \in \{1998, \ldots, 2007\}$; $(\alpha\beta)_{jk}$ interaction effect of ownership and year; $\rho_{i(j)}$ sector effects, $i \in \{1, \ldots, 25\}$; ϵ_{ijk} residual.

30 We only display four ownership types on each figure, neglecting COE and HMT.

31 This panel includes 1350 observations obtained by 6 ownerships × 25 CICs × 9 years. CIC 16, 25, 28 and 42 are excluded, due to the low number of observations. Likewise, the category "other domestic enterprises" is disregarded.

32 1–6 indicate SOEs, COEs, HMTs, FIEs, SHEs, and POEs.

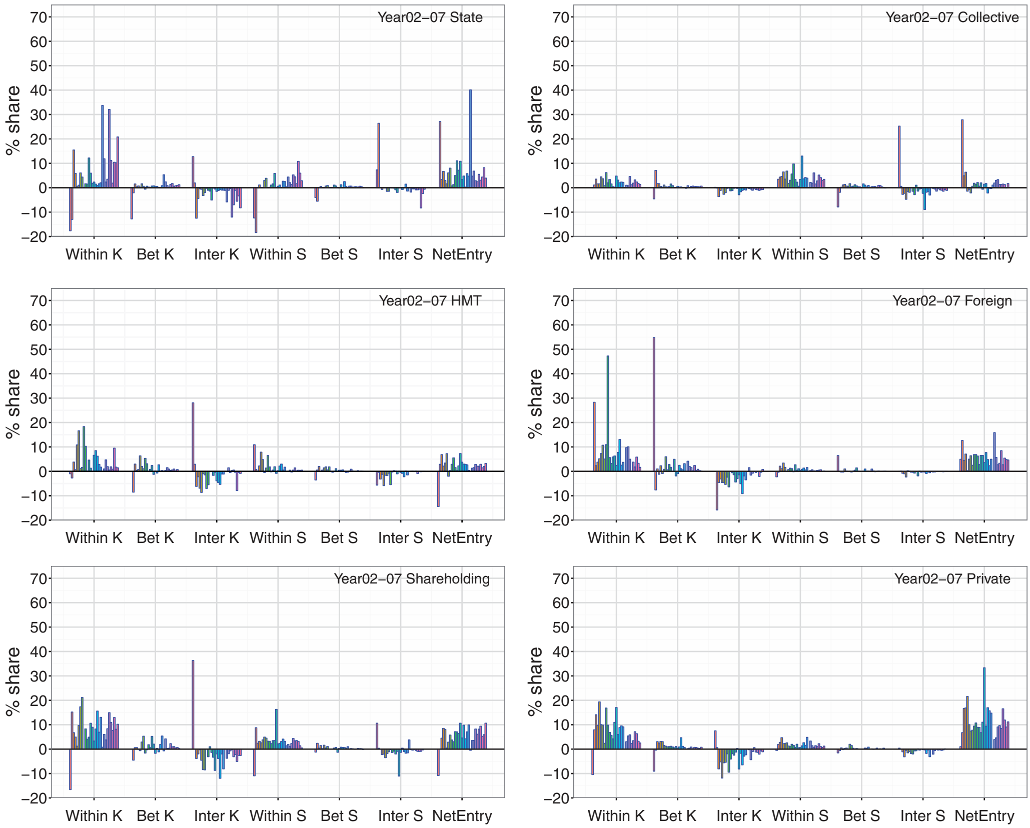

Figure 11. (2002–2007) Percentage contributions of within, between, interaction effects of both firms invariant in ownership type (denoted by "Within K," "Bet K," and "Inter K" respectively) and ownership-switching firms (denoted by "Within S," "Bet S." and "Inter S" respectively), and net entry effects (the sum of exit and greenfield entry effects) by two-digit sectors and by ownership types. Note: The sectors are in ascending order in terms of their overall productivity growth rates.

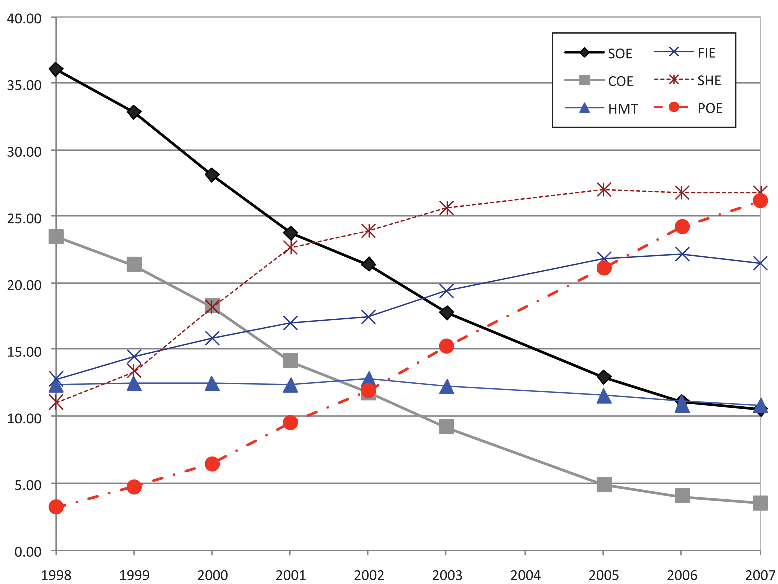

Figure 12. Annual percentage shares of ownership categories to total value added. Source: our elaboration on CMM.

Table 13. Dynamics of ownership distribution for 1998–2002 and 2002–2007: shares of ownership-keeping firms ("Keep"), exits ("Exit"), ownership-switching-out in percentage of firms in the initial year ("S-out") and shares of ownership-keeping firms ("Keep"), entrants ("Entry") and ownership-switching-in firms ("S-in") in the ending year

	Percentage of firms in initial year				Percentage of firms in final year			
Ownership	Keep	Exit	S-out	Total	Keep	Entry	S-in	Total
1998–2002								
SOE	31.94	60.23	7.83	100 (38,121)	63.77	34.38	1.86	100 (19,095)
COE	29.05	58.17	12.79	100 (52,099)	45.04	51.07	3.89	100 (33,599)
HMT	51.34	42.37	6.29	100 (14,410)	40.37	53.19	6.43	100 (18,324)
FOE	54.66	35.23	10.11	100 (9700)	38.20	56.12	5.67	100 (13,878)
SHE	38.10	48.91	12.99	100 (9447)	14.75	64.76	20.49	100 (24,393)
POE	34.66	58.86	6.48	100 (10,078)	7.52	81.99	10.49	100 (46,441)
ODE	23.50	52.87	23.63	100 (1655)	30.27	45.60	24.12	100 (1285)
Total	35.05	54.77	10.19	100 (135,510)	30.25	60.96	8.79	100 (157,015)
2002–2007								
SOE	18.27	72.14	9.59	100 (19,095)	59.66	33.61	6.73	100 (6316)
COE	18.26	58.51	23.23	100 (33,599)	45.40	48.01	6.60	100 (15,739)
HMT	50.16	38.54	11.30	100 (18,324)	36.99	57.01	6.01	100 (30,951)
FOE	59.70	32.14	8.16	100 (13,878)	31.58	60.40	8.03	100 (33,890)
SHE	37.09	44.17	18.74	100 (24,393)	22.56	62.75	14.69	100 (52,969)
POE	42.27	50.24	7.49	100 (46,441)	19.31	74.41	6.29	100 (165,027)
ODE	11.21	58.05	30.74	100 (1285)	11.43	65.37	23.21	100 (1435)
Total	35.62	50.82	13.56	100 (157,015)	25.15	66.84	8.01	100 (306,327)

Number of firms in brackets.
Source: Our elaboration on CMM.

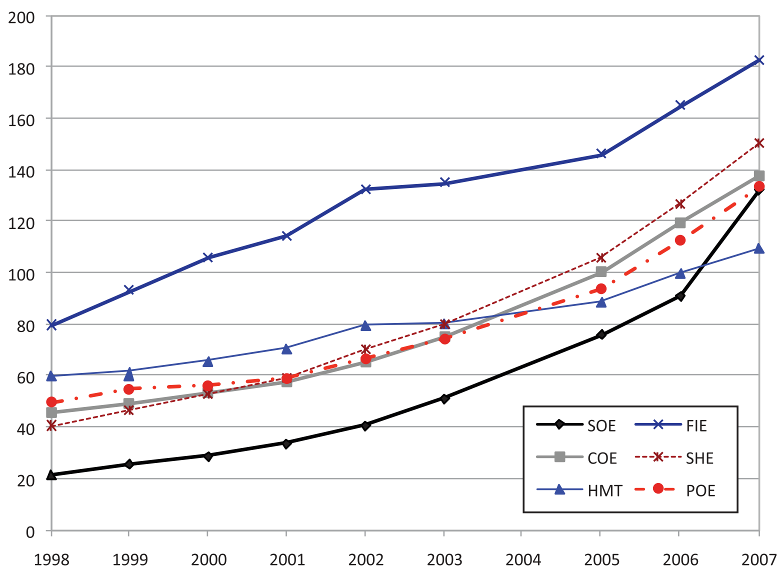

Figure 13. Average value added per employee by corporate categories (at 1998 constant price; 1000 yuan = 1). Source: our elaboration on CMM.

Table 14. Average growth rates of labor productivity, largest 10 sectors, firms keeping their ownership and switching-types

	SOE		COE		HMT		FIE		SHE		POE	
CIC	Keep	Switch	Keep	Switch	Keep	Switch	Keep	Switch	Keep	Switch	Keep	Switch
1998–2002												
13	4.95	14.54	8.65	11.14	10.14	10.13	9.08	5.66	8.09	10.48	8.18	9.55
17	8.75	12.69	10.02	11.93	6.42	16.33	4.64	9.38	8.56	14.28	12.75	13.24
26	8.55	15.17	8.68	10.86	6.60	7.15	12.73	6.51	13.71	8.41	11.85	8.70
31	8.25	13.42	8.82	10.26	8.38	10.31	9.66	7.03	8.67	11.52	12.45	11.79
32	15.91	22.76	8.70	14.53	7.67	0.56	6.97	27.71	9.19	8.72	13.35	14.70
33	16.39	20.07	10.30	11.68	16.53	27.44	3.66	25.04	14.23	15.83	12.47	13.07
35	12.27	19.93	12.56	12.55	10.16	7.75	15.73	14.15	12.81	15.65	10.37	9.00
37	11.87	20.50	8.72	9.48	3.46	10.58	13.54	7.76	15.65	13.42	12.17	10.28
39	9.33	9.84	7.19	7.56	6.79	9.50	9.37	7.68	7.67	10.07	16.54	13.39
40	11.54	12.35	7.93	7.11	6.24	5.05	7.87	6.23	8.77	18.20	7.47	−6.04
2002–2007												
13	12.56	16.23	12.41	12.91	4.91	9.24	7.88	11.99	10.38	13.20	16.10	16.77
17	8.48	13.23	9.53	11.16	4.89	7.55	6.84	8.26	9.48	12.89	12.05	11.30
26	14.03	16.66	8.91	11.42	6.12	5.89	7.57	11.55	11.94	12.85	13.26	11.25
31	12.44	13.77	13.97	15.65	5.84	8.64	7.59	10.42	11.80	15.42	16.54	16.70
32	13.70	21.02	12.34	10.56	1.66	14.42	3.13	18.88	17.00	18.84	13.11	12.77
33	11.89	15.07	11.61	11.58	12.05	14.54	10.18	16.98	10.82	7.06	12.35	15.36
35	14.47	22.62	13.17	16.04	8.54	10.51	10.35	13.08	16.20	15.77	15.34	14.37
37	16.26	18.35	11.67	14.57	6.52	10.71	7.03	2.86	11.84	12.44	14.19	11.53
39	6.78	16.23	8.41	11.47	3.55	5.77	6.16	4.81	8.84	12.32	10.20	13.97
40	−0.40	8.27	−0.46	11.13	1.48	4.57	2.05	1.76	1.31	7.98	6.53	6.76

Source: Our elaboration on CMM.

Let us first consider the unbalanced panel. Remarkably, ownership effect turns out indeed to be highly significant for all five parameters.

The differences across distributions conditional on ownership and their evolving patterns are detected adopting *post hoc* Tukey simultaneous pairwise comparison techniques.[33] The average values of AEP parameters over sectors and years for each ownership category are shown in Table 15.[34]

In particular, first, corporate types exert a statistically significant influence on the value of a_l (the width of the less efficient part of the distribution), with SOEs having the largest and domestic private the smallest ones. Conversely, FIEs display the largest contribution to the upper-tail (a_r) and both domestic private firms and SOEs the smallest one.

Concerning the b-values (recall that they relate to the properties of the tail), they appear quite similar across ownership types with respect to the (quite fat) lower tail, while Chinese firms of all types but especially SOEs in the upper echelons of productivity are more heterogeneous (display a fatter tail) than foreign ventures.

Third, also time effects are significant for a_l and a_r. The *post hoc* Tuckey pairwise comparison of mean values of parameters over years shows that in the final years 2005–2007 the a_l are significantly smaller than those of 1998–2003. Conversely, a_r of years 2006–2007 are significantly greater than those of 1998–2002. (Indeed, we detect a regime change reflected by productivity distributions, around year 2003).

Fourth, the Ownership and Year interaction effect is significant, meaning that the evolving patterns of labor productivity distributions differ across different ownership types.

33 The Tukey's hsd test statistic is $q\sqrt{MSE/_n}$, where MSE is the mean square error computed following the analysis of variance, n is the sample size per group and q is the studentized range critical value.

34 The *post hoc* Tukey pairwise comparison of mean differences of six ownership-groups is available upon request.

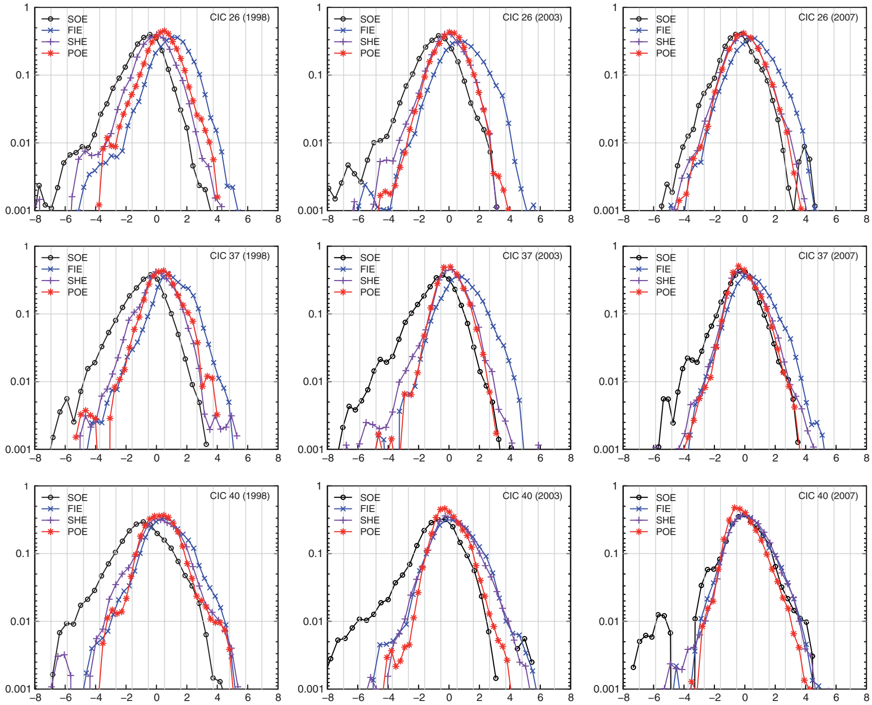

Figure 14. Empirical density of normalized (log) labor productivity of four ownership categories (SOEs, FIEs, SHEs, and private enterprises) for chemical (CIC 26), transport equipment (CIC 37) and communication equipment, computers, etc. (CIC 40), for years 1998, 2003, and 2007. Source: our elaboration on CMM.

Table 15. (Unbalanced Panel) Average value of parameters of AEP fits for each ownership category

Order	a_l	Ownership	a_r	Ownership	b_l	Ownership	b_r	Ownership
Smallest	0.622	Private	1.057	SOE	1.039	Shareholding	1.835	SOE
	0.713	Collective	1.112	Private	1.047	Collective	1.984	Private
	0.744	HMT-invested	1.152	Shareholding	1.104	Private	1.999	Shareholding
	0.746	Shareholding	1.169	Collective	1.120	HMT-invested	1.999	Collective
	0.805	Foreign-invested	1.202	HMT-invested	1.124	SOE	2.061	HMT-invested
Largest	1.212	SOE	1.336	Foreign-invested	1.162	Foreign-invested	2.238	Foreign-invested

Source: *post hoc* Tukey Pairwise comparison of ownership effects.

Table 16. (Balanced Panel) Median value of parameters of AEP fits for each ownership category

Order	a_l	Ownership	a_r	Ownership
Smallest	0.585 (0.748)	Private	0.779 (0.881)	SOE
	0.611 (0.675)	Shareholding	0.922 (0.974)	Private
	0.650 (0.733)	Collective	1.000 (1.067)	Collective
	0.661 (0.792)	HMT-invested	1.021 (1.143)	Foreign-invested
	0.812 (0.887)	SOE	1.058 (1.060)	Shareholding
Largest	0.823 (0.958)	Foreign-invested	1.148 (1.192)	HMT-invested

Note: mean values are reported in parentheses.
Source: *post hoc* Tukey Pairwise comparison of ownership effects.

Finally, we use a similar method (one-way ANOVA with repeated measures in year and *post hoc* Tukey pairwise comparison) to test the year effect on parameters for each ownership type separately. In particular, the estimates, available on request from the author, show a significant time effect on the (shrinking process of the) left tail of State-owned, Shareholding and private Chinese firms highlighting yet another piece of evidence on the dynamism of domestic firms of all types. Together we find a significant time effect on the (expanding) contribution to the support of the right tail by Chinese domestic POEs.

Again, it is interesting to compare this evidence with the balanced panel.[35] First, ownership effects continue to be significant for the a_l and a_r values. Interestingly, however, according to *post hoc* Tukey pairwise comparisons, the a_l parameters of SOEs and FIEs are significantly larger than SHEs, COEs, and domestic POEs (see Table 16). That is, both incumbent SOE and incumbent foreign investors appear to be more "dualistic" than other types of domestic Chinese firms. Second, the time effect is significant only on a_r (but not on a_l) for the parameter estimates based on balanced panel: that is, incumbent firms do not seem to display any time-dependent movement concerning the firms in the lower relative productivity brackets (Note however that the phenomenon is subject to a major selection bias: a lot of low productivity firms have actually died over the period). Third, the interaction effect is still significant, even if the levels of significance are lower than in the unbalanced panel.

In a nutshell, the statistical analysis corroborates the foregoing interpretation of patterns of Chinese industrial learning and catching-up. At the beginning of our window of observation domestic firms display relatively higher degrees of heterogeneity, with a high density on the "inefficient" side and a low one on the "efficient" one (especially regarding fully private firms).

The dynamic however displays different patterns according to ownership/governance types, highlighting a generalized catching-up of all types of Chinese firms (but based on different mechanisms), and, at the same time, no time effect on both tails of FIEs on either sets of estimates (balanced and unbalanced panels). First, year effects are statistically significant on the expanding process of the right-tail of China's domestic POEs on both sets of estimates. Second, the shrinking process of the left-tail (of SOEs, SHEs and China's domestic POEs) is only significant based on unbalanced panel: basically, that means also that a lot of weeding out of lower efficiency firms took place together with learning.

8. Conclusion

In this work, we investigated the microeconomic patterns underling the impressive growth of labor productivity in Chinese manufacturing over the most recent decade for which data are available.

The evidence suggests that the major driver of such dynamic rests in a fast catching-up by *Chinese* firms of different governance and ownership structures. The dispersion in productivities, still extremely high in the late 90s, significantly shrinks due to exit, but also more importantly, organizational change involving deep transformations in governance and together technological learning.

In all that, firms which initially were State-owned play a very important role. Most of them modify their structure gaining the shape of management-run "capitalist" firms. And many of them (the "shareholding" ones) become State-private JVs. Together, newly born private domestic firms gain importance even if mostly in industries characterized by relatively low technological sophistication. Interestingly, aggregate manufacturing productivity growth does not appear to be influenced by "structural change" at the coarse-grained level of two-digit industries: China seems to have achieved quite early a "mature" composition of industrial sectors.

Finally, our evidence suggests that FMNCs and JVs do often display initial above-average productivities, but they are also the group of firms with a relatively lower rate of productivity growth.

Indeed, the overall picture suggests a fast process of restructuring and learning rooted in the deep transformation of domestic (often ex-State owned) enterprises. Fundamentally, the story underlying the impressive catching up of Chinese manufacturing is much more one of *creative restructuring* and accumulation of absorptive capabilities by domestic firms, rather than sheer "creative destruction" and even less so by an MNC-led drive. In fact, the Chinese patterns of industrialization and catching-up are well in tune with a view of the development process driven by

35 Given the smaller number of firms in the balanced panel, tails (i.e. the *b*'s estimates) are quite unstable even if always fat-tailed. Hence, we discuss here only the *a*'s values.

processes of *capability accumulation* (Cimoli *et al*., 2009), diverse across firms but generalized across the whole industry, wherein domestic firms play a paramount role.

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Appendix

Comparative capital intensities and decompositions of labor productivity growth

Table A1. The median of capital intensity (capital/output ratios) by sector

NACE	Sector	China 1998	Italy	France	China 2002	Italy	France	China 2006	Italy	France[a]
173	Finishing of textiles	2.772	1.971	1.863	0.732	0.755	0.694	1.228	1.512	1.546
175	Carpets, rugs and other textiles	1.672	1.327	0.789	0.752	0.775	0.688	0.891	0.987	1.055
182	Wearing apparel	1.052	0.785	0.620	0.268	0.276	0.226	0.318	0.318	0.336
193	Footwear	1.062	0.885	0.529	0.29	0.331	0.288	0.488	0.631	0.645
203	Wood products for construction	1.477	0.954	0.629	0.728	0.734	0.763	0.773	0.744	0.736
212	Articles of paper and paperboard	1.475	1.367	1.123	0.824	0.901	0.988	1.025	1.206	1.217
221	Publishing	3.873	5.250	5.716	0.259	0.19	0.117	0.229	0.204	0.192
222	Printing	2.559	2.456	2.084	0.508	0.566	0.562	0.7	0.797	0.792
241	Production of basic chemicals	2.547	1.784	1.049	0.977	1.045	1.153	2.081	2.443	2.811
243	Paints, varnishes, inks mastics	1.312	1.086	0.852	0.584	0.544	0.57	0.946	0.936	1.052
244	Pharma., med. chemicals, botanical prod	1.707	1.514	1.508	0.57	0.623	0.656	0.666	0.83	0.837
246	Other chemical products	1.436	1.167	0.707	0.588	0.628	0.636	0.973	1.004	1.072
251	Rubber products	1.587	1.479	0.974	0.514	0.588	0.495	0.951	1.088	1.03
252	Plastic products	1.614	1.394	1.055	0.714	0.795	0.818	0.969	0.991	1.035
261	Glass and glass products	1.696	1.442	1.079	0.579	0.594	0.742	0.996	1.169	1.198
266	Concrete, plaster and cement	2.084	1.643	1.676	0.93	0.847	0.965	1.365	1.399	1.253
275	Casting of metals	1.113	0.937	0.698	0.669	0.815	0.734	0.886	1.127	1.128
281	Structural metal products	1.290	1.176	0.870	0.433	0.481	0.455	0.547	0.505	0.569
284	Forging, pressing, stamping, of metal	1.981	1.289	0.820	0.574	0.695	0.618	0.77	0.913	0.967
285	Treatment and coating of metals	1.113	0.980	0.923	0.452	0.515	0.467	0.673	0.762	0.803
286	Cutlery, tools and general hardware	1.554	1.068	0.940	0.471	0.584	0.559	0.734	0.861	0.892
287	Other fabricated metal products	1.337	1.018	0.788	0.586	0.626	0.566	0.818	0.921	0.871
291	Machinery for prod. use of mech. power	2.041	1.524	1.012	0.48	0.491	0.408	0.674	0.76	0.714
292	Other general purpose machinery	1.756	1.321	0.905	0.323	0.315	0.272	0.372	0.364	0.361
294	Machine Tools	2.530	1.669	0.961	0.343	0.391	0.289	0.425	0.465	0.466
295	Other special purpose machinery	2.177	1.486	0.977	0.358	0.337	0.332	0.52	0.585	0.614
311	Electric motors, generators and transform	1.570	1.200	0.767	0.369	0.452	0.397	0.51	0.526	0.501
312	Manuf. of electricity distrib, control equip	1.409	1.127	0.781	0.335	0.453	0.352	0.64	0.648	0.553
316	Electrical equipment not e/where class	1.163	0.863	0.671	0.299	0.288	0.275	0.498	0.516	0.497
343	Parts for motor vehicles and their engines	1.781	1.336	1.094	0.526	0.63	0.534	1.088	1.311	1.185
361	Furniture	1.293	1.092	0.798	0.593	0.61	0.564	0.633	0.674	0.722
366	Manufacturing n.e.c.	0.793	0.830	0.808	0.467	0.485	0.405	0.576	0.669	0.781
	Mean	1.713	1.419	1.127	0.534	0.574	0.550	0.780	0.871	0.888
	Median	1.578	1.305	0.914	0.520	0.586	0.561	0.717	0.814	0.820

Note: [a]In the last column, the France data is year 2004.

Source: CMM, INSEE (on France), and ISTAT-Micro 3 (on Italy).

Table A2. China: OLS regression results of $ln(VA/L) = \alpha + \beta ln(K/VA) + \epsilon$, with robustic standard errors

NACE	Sector	Coef 1998	SE	R^2	Coef 2002	SE	R^2	Coef 2006	SE	R^2
151	Production, process and preserv. Of meat	−0.608	0.019	0.587	−0.519	0.020	0.475	−0.541	0.047	0.420
155	Dairy products	−0.620	0.049	0.553	−0.533	0.043	0.382	−0.656	0.080	0.451
158	Prod. Of other food	−0.674	0.015	0.538	−0.561	0.016	0.438	−0.402	0.033	0.259
159	Beverages	−0.590	0.019	0.440	−0.487	0.021	0.332	−0.464	0.043	0.240
173	Finishing of textiles	−0.551	0.042	0.451	−0.467	0.026	0.397	−0.458	0.088	0.323
175	Carpets, rugs and other textiles	−0.457	0.024	0.309	−0.316	0.022	0.168	−0.315	0.054	0.213
177	Knitted and crocheted articles	−0.460	0.022	0.335	−0.289	0.018	0.163	−0.292	0.060	0.143
182	Wearing apparel	−0.465	0.013	0.339	−0.377	0.011	0.258	−0.332	0.039	0.183
192	Luggage, handbags, saddlery and harness	−0.369	0.046	0.240	−0.292	0.034	0.161	−0.265	0.116	0.132
193	Footwear	−0.510	0.032	0.407	−0.354	0.022	0.269	−0.323	0.036	0.327
203	Wood products for construction	−0.549	0.023	0.504	−0.409	0.026	0.320	−0.333	0.091	0.147
205	Other wood prod.	−0.404	0.069	0.283	−0.254	0.052	0.138	−0.233	0.139	0.151
211	Pulp, paper and paperboard	−0.548	0.024	0.425	−0.404	0.023	0.275	−0.298	0.095	0.144
212	Articles of paper and paperboard	−0.508	0.026	0.338	−0.386	0.022	0.237	−0.379	0.092	0.219
221	Publishing	−0.594	0.259	0.315	−0.352	0.209	0.138	0.298	0.665	0.235
222	Printing	−0.631	0.021	0.405	−0.569	0.023	0.359	−0.324	0.072	0.151
241	Production of basic chemicals	−0.629	0.016	0.525	−0.468	0.017	0.345	−0.380	0.034	0.239
243	Paints, varnishes, inks mastics	−0.514	0.025	0.372	−0.492	0.022	0.327	−0.506	0.039	0.290
244	Pharma., med. chemicals, botanical prod	−0.585	0.019	0.415	−0.554	0.018	0.381	−0.582	0.025	0.427
245	Soap and detergents perfumes and toilet prep	−0.563	0.033	0.392	−0.518	0.028	0.382	−0.400	0.059	0.211
246	Other chemical products	−0.578	0.026	0.432	−0.455	0.022	0.290	−0.400	0.040	0.184
251	Rubber products	−0.461	0.036	0.316	−0.473	0.028	0.322	−0.339	0.061	0.178
252	Plastic products	−0.470	0.014	0.309	−0.375	0.013	0.223	−0.352	0.035	0.173
261	Glass and glass products	−0.441	0.028	0.295	−0.304	0.026	0.165	−0.313	0.054	0.133
262	Ceramic, refractory not, not for construction	−0.569	0.032	0.412	−0.433	0.027	0.242	−0.280	0.056	0.103
263	Ceramic goods for construction	−0.383	0.022	0.239	−0.339	0.023	0.182	−0.306	0.060	0.147
266	Concrete, plaster and cement	−0.506	0.023	0.355	−0.433	0.027	0.259	−0.331	0.076	0.148
267	Cutting, shaping and finishing of stone	−0.469	0.032	0.396	−0.390	0.031	0.272	−0.456	0.092	0.318
275	Casting of metals	−0.553	0.020	0.473	−0.442	0.020	0.340	−0.496	0.078	0.295
281	Structural metal products	−0.506	0.032	0.370	−0.491	0.025	0.335	−0.424	0.052	0.231
283	Steam generators, except central heating	−0.650	0.048	0.556	−0.563	0.042	0.458	−0.612	0.089	0.458
284	Forging, pressing, stamping, of metal	−0.633	0.048	0.526	−0.438	0.057	0.348	−0.501	0.079	0.374
285	Treatment and coating of metals	−0.470	0.047	0.316	−0.406	0.039	0.220	−0.150	0.209	0.016
286	Cutlery, tools and general hardware	−0.583	0.033	0.468	−0.462	0.034	0.342	−0.400	0.080	0.238
287	Other fabricated metal products	−0.438	0.019	0.285	−0.391	0.017	0.259	−0.370	0.045	0.170
291	Machinery for prod. use of mech. power	−0.610	0.019	0.506	−0.524	0.019	0.411	−0.467	0.030	0.295
292	Other general purpose machinery	−0.601	0.020	0.465	−0.468	0.017	0.345	−0.435	0.030	0.248
293	Agricultural and forestry machinery	−0.682	0.021	0.658	−0.639	0.026	0.610	−0.502	0.073	0.409
294	Machine Tools	−0.607	0.037	0.504	−0.539	0.026	0.441	−0.333	0.056	0.179
295	Other special purpose machinery	−0.660	0.014	0.578	−0.539	0.014	0.460	−0.452	0.026	0.358
297	Domestic appliances not e/where class	−0.491	0.031	0.356	−0.418	0.022	0.319	−0.328	0.045	0.154
311	Electric motors, generators and transform	−0.524	0.024	0.380	−0.468	0.018	0.360	−0.414	0.028	0.250
312	Manuf. of electricity distrib, control equip	−0.601	0.035	0.447	−0.502	0.037	0.374	−0.471	0.041	0.343
316	Electrical equipment not e/where class	−0.577	0.081	0.387	−0.331	0.073	0.192	−0.473	0.099	0.344
321	Elect valves tubes, other elect components	−0.491	0.025	0.349	−0.334	0.023	0.187	−0.286	0.027	0.128
322	TV radio, Telephone app.	−0.711	0.085	0.581	−0.543	0.062	0.542	−0.412	0.074	0.224
331	Medical surgical equip, orthopedic appliances	−0.647	0.056	0.512	−0.561	0.047	0.407	−0.409	0.054	0.277
332	Measuring, checking, testing navigating app.	−0.538	0.038	0.443	−0.482	0.031	0.386	−0.401	0.031	0.291
333	Industrial process control equipment	−0.601	0.078	0.449	−0.486	0.062	0.363	−0.412	0.053	0.262
342	Motor vehicles(bodies), trailers semi-trailers	−0.679	0.085	0.603	−0.634	0.076	0.525	−0.743	0.170	0.527
343	Parts for motor vehicles and their engines	−0.582	0.024	0.409	−0.422	0.021	0.261	−0.435	0.029	0.239
361	Furniture	−0.500	0.021	0.403	−0.459	0.024	0.388	−0.363	0.050	0.221
366	Manufacturing n.e.c.	−0.405	0.051	0.299	−0.369	0.048	0.239	−0.267	0.130	0.107
	Mean	−0.548		0.420	−0.447		0.321	−0.387		0.244
	Median	−0.553		0.409	−0.459		0.332	−0.400		0.235

Source: our elaboration on CMM.

Table A3. Decomposition of sectoral-level labor productivity growth 1998–2002

CIC	Sector	Π_0 level 1998–2002	Total growth	Within %	Between %	Int. %	Exit %	Entry Genuine %	Entry Growth %	Total %
13	Food processing of agricultural products	40.90	0.83	41.43	13.22	−12.02	9.55	24.95	22.86	100.00
14	Other foodstuff	35.01	0.76	39.26	23.88	−24.74	12.40	17.15	32.05	100.00
15	Beverages	49.93	0.73	38.98	14.03	−2.88	12.12	11.00	26.75	100.00
16	Tobacco	311.85	1.05	70.79	0.47	4.18	3.25	−1.45	22.76	100.00
17	Textile	18.76	0.89	39.12	16.41	−11.68	7.69	15.73	32.73	100.00
18	Garments, footwear, etc.	23.44	0.30	48.50	18.22	−27.84	14.05	14.63	32.45	100.00
19	Leather, fur, feather, etc.	25.99	0.35	76.65	33.11	−47.78	6.95	8.96	22.11	100.00
20	Processing of timber, manuf. of wood, bamboo	25.73	0.74	31.91	17.67	−18.68	8.19	28.61	32.30	100.00
21	Furniture	31.73	0.37	70.72	22.01	−46.11	7.59	20.29	25.49	100.00
22	Paper and paper products	27.35	1.02	38.36	10.57	−8.76	8.49	14.36	36.97	100.00
23	Printing, reproduction of recording media	29.84	1.03	39.77	11.41	−3.72	9.31	12.80	30.43	100.00
24	Articles for culture, education and sport activity	25.33	0.22	112.76	31.25	−77.28	5.37	11.20	16.70	100.00
25	Processing of petroleum, cokeries, nuclear fuel	63.83	0.70	2.36	−1.44	2.54	5.43	37.81	53.29	100.00
26	Raw chemical materials and chemical products	30.71	1.18	33.72	11.35	−3.73	3.16	17.81	37.69	100.00
27	Pharmaceuticals	44.94	0.95	43.96	14.17	−12.10	6.81	12.79	34.38	100.00
28	Chemical fibers	38.39	0.99	52.92	13.88	−2.22	6.20	12.50	16.72	100.00
29	Rubber	27.79	0.95	44.98	9.43	6.34	10.15	9.47	19.63	100.00
30	Plastics	35.18	0.63	42.73	18.27	−21.79	8.81	16.49	35.50	100.00
31	Non-metallic mineral products	21.47	0.79	46.60	13.22	−12.75	2.79	18.82	31.32	100.00
32	Smelting and pressing of ferrous metals	34.55	1.31	53.53	5.83	−1.91	−1.41	10.62	33.34	100.00
33	Smelting and pressing of non-ferrous metals	31.31	1.11	41.89	5.74	1.71	−1.05	20.59	31.12	100.00
34	Metal products	30.89	0.70	42.95	15.34	−17.32	8.93	20.82	29.28	100.00
35	General purpose machinery	22.45	1.26	49.48	20.00	−16.94	2.75	12.86	31.85	100.00
36	Special purpose machinery	18.36	1.58	39.64	11.37	4.77	0.20	14.94	29.07	100.00
37	Transport equipment	35.27	1.47	53.70	7.48	0.45	3.45	10.33	24.58	100.00
39	Electrical machinery and equipment	40.43	0.78	39.10	16.21	−3.15	6.41	10.12	31.31	100.00
40	Communication equipment, computers, etc.	70.10	0.81	49.23	18.16	−9.18	5.68	13.99	22.12	100.00
41	Measuring instruments and machinery	29.10	1.03	38.45	16.73	−4.95	0.10	19.96	29.70	100.00
42	Artwork and other	22.07	0.53	101.26	19.40	−62.42	5.51	12.94	23.32	100.00
	Whole manufacturing	32.47	0.95	46.77	12.89	−8.36	6.01	13.48	29.21	100.00

Note: Percentage shares of within, between, interaction, exit, and entry effects. Labor productivity unit: 1000 yuan at 1998 constant price.
Source: Our elaboration on CMM.

Table A4. Decomposition of sectoral-level labor productivity growth 2002–2007

CIC	Sector	Π_0 level	Total growth	Within %	Between %	Int. %	Exit %	Entry		Total %
								Genuine %	Growth %	
		2002–2007								
13	Food processing of agricultural products	75.14	1.21	50.89	12.90	−28.92	2.92	31.50	30.71	100.00
14	Other foodstuff	61.27	1.12	56.28	8.12	−29.17	8.63	28.16	27.98	100.00
15	Beverages	85.90	1.02	44.52	17.28	−15.87	10.61	20.82	22.64	100.00
16	Tobacco	640.54	1.26	36.36	4.86	2.73	14.97	25.73	15.36	100.00
17	Textile	34.90	1.20	39.80	8.13	−11.94	6.38	26.95	30.68	100.00
18	Garments, footwear, etc.	30.51	0.80	93.41	8.94	−66.12	3.55	25.66	34.57	100.00
19	Leather, fur, feather, etc.	34.87	0.61	65.79	12.88	−35.20	−5.00	28.87	32.65	100.00
20	Processing of timber, wood, bamboo, etc.	44.93	1.09	44.22	−0.30	−24.73	4.45	45.84	30.53	100.00
21	Furniture	42.85	0.56	62.46	11.14	−40.86	−3.24	37.92	32.58	100.00
22	Paper and paper products	54.77	1.47	39.84	5.28	−6.78	9.33	19.88	32.45	100.00
23	Printing, reproduction of recording media	57.95	0.91	44.84	7.44	−16.55	9.25	21.84	33.18	100.00
24	Articles for culture, education and sport activity	30.66	0.76	68.33	8.48	−33.07	3.72	21.85	30.69	100.00
25	Processing of petroleum, cokeries, nuclear fuel	111.11	0.15	33.18	−21.30	−7.79	45.57	4.51	45.83	100.00
26	Raw chemical materials and chemical products	67.93	1.59	47.03	8.60	−16.10	5.68	28.48	26.31	100.00
27	Pharmaceuticals	87.49	0.72	49.24	21.01	−22.24	9.64	15.53	26.82	100.00
28	Chemical fibers	75.59	1.05	46.17	−0.14	−24.55	17.25	28.81	32.47	100.00
29	Rubber	54.27	0.90	45.25	7.94	−13.73	12.78	18.43	29.34	100.00
30	Plastics	56.20	0.52	58.07	13.68	−46.88	11.40	30.34	33.39	100.00
31	Non–metallic mineral products	37.83	1.87	36.26	6.07	−9.40	3.52	32.74	30.80	100.00
32	Smelting and pressing of ferrous metals	81.36	1.58	64.67	5.83	−13.73	3.81	21.30	18.13	100.00
33	Smelting and pressing of non-ferrous metals	65.87	2.26	46.81	2.88	−14.64	1.30	34.21	29.43	100.00
34	Metal products	51.64	0.52	44.31	7.08	−29.40	10.29	37.77	29.96	100.00
35	General purpose machinery	49.67	1.94	68.02	4.46	−35.35	3.56	26.39	32.92	100.00
36	Special purpose machinery	45.35	2.20	40.05	4.69	−11.96	4.72	25.41	37.09	100.00
37	Transport equipment	87.62	1.35	44.85	14.72	−13.46	6.84	24.70	22.35	100.00
39	Electrical machinery and equipment	72.27	0.63	65.87	13.87	−33.54	2.00	17.05	34.76	100.00
40	Communication equipment, computers, etc.	128.91	−0.08	−112.75	−36.69	221.29	−104.21	13.45	118.91	100.00
41	Measuring instruments and machinery	51.94	1.42	34.86	7.64	−10.27	7.95	17.36	42.46	100.00
42	Artwork and other	33.97	1.20	60.58	11.59	−42.78	0.91	26.70	43.00	100.00
	Whole manufacturing	63.27	1.01	56.81	9.72	−27.39	7.97	26.04	26.85	100.00

Note: Percentage shares of within, between, interaction, exit, and entry effects. Labor productivity unit: 1000 yuan at 1998 constant price.
Source: Our elaboration on CMM.