

Ownership, Performance, and Innovation in China's Large and Medium-Size Industrial Enterprise Sector¹

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Abstract

China's 22,000 large and medium-size enterprises stand at the pinnacle of Chinese industry. While they account for less than a fraction of a percent of China's nearly 8 million industrial enterprises, they collectively account for one-third of the nation's total industrial output. Using a panel of these enterprise data for 1994-1999, we find a rapidly diversifying ownership structure in which the role of the state is steadily retreating. At the same time, we find considerable variation in measures of performance across ownership types and see emerging within Chinese industry evidence of high-intensity R&D performers that exhibit substantial innovation capabilities.

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1. Introduction

China's industrial sector consists of nearly 8 million enterprises. A relatively small number of these enterprises – approximately 22,000 that are classified as “medium-size” and “large-size” – accounts for approximately one-third of China's industrial output and nearly two thirds of the economy's total industrial assets. This collection of enterprises, whose performance is carefully tracked by China's National Bureau of Statistics (NBS), at once includes China's most successful companies – those that have grown and sustained their status at the pinnacle of China's industrial enterprise sector – as well as many of its most troubled enterprises. As the focus of decades of central planning and administered allocations of subsidized capital, skilled labor, and raw materials, some of these large and medium-size state-owned enterprises continue to impede China's transition to an advanced market economy

In this paper, we use this well-documented population of China's large and medium-size enterprises (LMEs) to construct a statistical profile of change in the composition and performance of these important enterprises. This profile documents patterns of ownership change in China's LMEs during the latter half of the 1990s, while also documenting the correspondence between ownership and performance measured by productivity, profitability, export activity, and innovation.

By 1994, the earliest year of our data set, China's enterprise system had already engaged in a decade of formal reform. Although China's 1985 industrial census

classified enterprises according to 16 ownership classifications, in that year 95.5 percent of China's 8,320 large and medium-size industrial enterprises were classified as state-owned. Of the remaining 374 enterprises, all but 36 were either collective-owned or joint state-collective owned enterprises; among these remaining 36 enterprises, 35 belonged to the category of "foreign capital" (Industrial Census, 1985, p. 10). The shareholding experiment had not yet begun, and private enterprise was not yet recognized.

During the latter half of the 1990s, many SOEs entered a period of accelerated reform. In 1997, Premier Zhu Rongji put China's loss-making SOEs on a strict three-year schedule during which they were instructed to implement a "modern enterprise system" and convert losses to surpluses. Two quantitative changes are most visible during the latter 1990s – a rapid decline in the number of state-owned enterprises and declining employment levels within surviving SOEs.

During the later half of the 1990s, SOE employment fell precipitously. The policy of furloughs (*xiagang*), introduced in 1996, had by the end of the decade led to the layoff of approximately 6 million of 44 million workers in the industrial SOE workforce (Rawski, 2002). Between 1997 and 1999, even as output growth flagged, measured in constant prices labor productivity among the LMEs surged by more than 35 percent (see Table 6).

For many industrial SOEs, restructuring resulted via merger or acquisition, the conversion of ownership status, or in outright liquidation. The number of registered state owned enterprises in 1999 was 61,300, less than one half the reform period peak of 127,600 in 1996 (NBS, 2000, p. 407). While the outright sale of state-owned enterprises was largely limited to smaller scale enterprises, as reflected in the motto "retain the large

and release the small” (*juada fangxiao*), a substantial number of large and medium-size enterprises also exited from the ranks of state industry. As shown in Table 3, by 1999, just half of the registered LMEs were state-owned, down from 68 percent in 1994. Also by that year, the number of ownership classifications had grown to 21 categories from 16 a decade earlier; in 1999 that number further expanded to 23 classifications. During the same 5-year period, the number of large and medium-size industrial enterprises classified as foreign or overseas (Hong Kong, Macao, or Taiwan), shareholding, or private ballooned from less than 3,000 to more than 7,300.

Against this background, we investigate the following three questions relating to the evolution of China’s large and medium-size industrial enterprises during 1994-1999:

- Measured by formal classification and by asset mix, how has ownership composition changed? Can we identify the relative contributions of entry, exit, and ownership conversion to changes in the ownership pattern of China’s LMEs?
- Can we identify systematic differences in performance by ownership? Is there any correspondence between measures of ownership – both affiliation and asset mix – and various measures of performance, including levels and growth of productivity, profitability, and export orientation?
- Do patterns of innovation activity vary by ownership? Does the intensity of inputs to the innovation process (i.e., technical innovation expenditures and personnel) and innovation outputs (i.e., new products and patents) vary by ownership?

While measures of productivity, profitability, and export orientation measure current economic performance, we interpret measures of innovative activity as broad predictors of future performance.

We do not in this paper use econometric methods to examine in depth specific issues; indeed, each of the three areas of investigation above warrants a separate, more in depth analysis. Our purpose is to document patterns of ownership change in Chinese industry and to investigate associations among ownership reform, enterprise performance, and innovation within this important population of large and medium-size enterprises. In doing so, we also hope to bring into clearer view the rather extraordinary set of enterprise data that is regularly maintained by China's National Bureau of Statistics.

Classifying large and medium-size enterprises: China's National Bureau of Statistics (NBS) regularly monitors the statistical performance of China's large and medium-size industrial enterprises. The NBS establishes the requirements for an enterprise belonging to this select group of enterprises.² There is no uniform set of size classifications that spans all industry types; rather, different criteria are used for different industries. Within each two-digit industry classification, size is sometimes delineated at a still finer level of detail, either at the three or four-digit level. Each enterprise is evaluated against the relevant industry measure, which is generally one of two types – a physical measure of annual production capacity (*nianchan nengli*) or a value measure of fixed production assets (*shengchanyong gudingzechanyuanzhi*).

Examples of physical measures of production capacity include tons (e.g. ferrous and non-ferrous metallurgical industries), cubic meters (e.g. natural gas), kilowatts (e.g.

electric power generation), and spindles (e.g. textiles). Virtually all size criteria that are not specified in physical terms are specified in terms of fixed production assets (e.g. the aviation industry, other types of non-ferrous metallurgical enterprises, and the electronics industry). The classification criteria may vary within similar product types. The machinery industry, for example, is one of several industries that use both production capacity and productive assets to define size. Within the machinery industry, certain sub-categories, such as petrochemical equipment, use 10,000 tons of annual production capacity to rank size while other machine manufacturing industries, such as textile machinery, classify size according to the yuan value of fixed production assets.³

Share in total aggregates. Table 1 shows that in 1994, China's large and medium-size enterprises accounted for nearly one-half of total industrial sales, a share that by 1999 had fallen to approximately one-third. The fact that as a share of total industry, LMEs in both 1994 and 1999 claim both a higher share of assets than sales and a lower share of employment than sales reflects, not surprisingly, the relative capital-intensity of China's large and medium-enterprise sector. Relative to total industry, the capital intensity of this sector, measured in terms of the ratio of assets to sales rose significantly during the latter half of the 1990s.

In 1999, large-size enterprises account for approximately 7,765 of the 22,000 large and medium-size enterprises. Although representing just 35 percent of the LMEs, the combined sales of these large enterprises account for over three-quarters of total LME sales, 69 percent of total LME employment, and four-fifths of LME assets. That large-

² "Criteria for defining large- and medium-size enterprises," National Bureau of Statistics (2000).

³ Within this classification scheme, for each industry, there are five, not three, classifications. That is, in addition to small size, large size is divided into "large one" and "large two"; likewise, medium is divided into "medium one" and medium two."

size enterprises account for approximately one-third of the total number of LMEs and three-quarters of sales indicates that the sales volume of the typical large-size LME is nearly six times that of the typical medium-size LME. We further see that over time the LME population appears to become more tilted toward large-size enterprises, as their share of LME sales rises from 70 to 77 percent and their share of LME assets rises from 72 to 80 percent.

Table 2, which shows the share of LME sales in individual industries, indicates (in column 2) that LME sales as a share of total sales remained relatively stable during 1994 to 1999 having declined by only slightly more than one percentage point. The disparity between this marginal decline and the rather large decline shown in Table 1 arises from different measures of total industry. Whereas the small decline in total sales shown in Table 2 is measured relative to the sales of independent accounting units only (i.e. *duli hesuan danwei*), the larger decline shown in Table 1 is measured relative to a comprehensive measure of industrial sales. This comprehensive measure includes the sales of individual enterprises and other smaller enterprise, some of which are classified principally as non-independent accounting units that belong to a wide range of ownership types, including cooperative and individual-run enterprise. The decline in the share of LMEs in total industrial sales, therefore, arose largely from the rapid increase in the sales of fringe enterprises, i.e. smaller non-independent accounting units.⁴

Industry composition. China's large and medium-size industrial enterprise data set spans 39 two-digit industries, 185 three-digit industries, and 552 four-digit industries. Table 2 shows the ten largest two-digit industrial classifications, the share of LME sales

⁴Independent accounting (*duli hesuan*) enterprises are those which "are financially independent and compile their own balance sheets." (NBS, 1998, p. 487).

within each of these industries, and within the LME category the share of sales accounted for by state-owned enterprises. Among the approximately 22,000 LMEs, SOEs accounted for nearly 72 percent of sales in 1994 but just 55 percent in 1999. In each of the ten major industries, the SOE share of sales fell during the latter half of the 1990s by substantial amounts in all but electric power, but even there the decline was not trivial. In seven of the ten industries, state-owned industrial production declined by more than 40 percent. Whether measured by numbers of enterprises or share of sales, we find during the later half of the 1990s a pervasive retreat in the relative standing of SOEs among China's LMEs.

2. Ownership reform

For the purpose of comparing categories of ownership and tracking ownership reform between 1994 and 1999, we use the concordance shown in Annex I, which aligns the 1998 system of ownership classification with the preexisting system. This aggregation of 23 categories into seven categories - state-owned enterprises, collective-owned enterprises, Hong-Kong, Macao, and Taiwan-owned enterprises (also HKTs or overseas-owned enterprises), foreign-owned enterprises, shareholding enterprises, and other domestic enterprises - closely tracks the classification system currently used in the China Statistical Yearbook.⁵

Ownership distribution. As shown in Table 3, the ownership distribution of China's large and medium-size enterprises was by 1994 considerably more diverse than it

⁵ The exceptions are that (i) the concordance excludes "individual-owned enterprises" (none of which qualify as large or medium-size enterprises), (ii) it distinguishes between foreign owned and Hong Kong, Macao, and Taiwan-owned enterprises, and (iii) it breaks out private-ownership from the category of

had been in 1985 when over 95 percent of the LMEs were classified as state owned. By 1994, just two-thirds of the LMEs were registered as state enterprises; by 1999, the SOE share fell to one half. While the total number of LMEs during this five-year period remained relatively unchanged, the number of state-owned enterprises fell from 15,533 to just over 11,000

Table 3 also shows that, during 1994-99, the shareholding sector exhibited the largest increase in the number of enterprises. While the numbers of shareholding, foreign, and overseas-owned enterprises were similar in 1994 – all in the vicinity of 1,000 – the growth of shareholding enterprises during the latter 1990s easily outpaced the growth of the foreign and overseas sectors. Contrasted with somewhat less than a doubling of enterprises in the overseas and foreign sectors, the number of shareholding LMEs quadrupled. This surge in shareholding enterprises coincided with the government’s promotion of the shareholding experiment, the hallmark of China’s enterprise reform program during the latter 1990s.

Perhaps the most surprising revelation among the ownership data is the decline in the collective-owned enterprise sector, in which the number of LMEs fell from 4,068 in 1994 to 3,408 in 1999. While not as pronounced as the 28 percent decline in the number of SOEs, the 16 percent decline in the number of collective enterprises is nonetheless striking. By 1999, the shareholding sector, which in 1994 accounted for less than one-quarter the number of enterprises as the collective sector, had grown to displace the collective sector as the second largest ownership category among China’s LMEs. The latter half of the 1990s, therefore, was characterized by steady erosion in the number of

“enterprises of other type of ownership.” (NBS, 2000, p. 407). For a definition of certain of the relevant ownership categories, see “Explanatory Notes on Main Statistical Indicators, NBS, 2000, p. 464).

enterprises representing traditional forms of public ownership. While the erosion in the number of SOEs might have been anticipated, the contemporaneous retreat in the number of collective-owned enterprise, which had been heralded as a notable institutional innovation in China's emerging corporate landscape,⁶ was not so widely anticipated.

Exit and entry. The profile described above portrays the net change in the ownership distribution of the LME population during 1994-99. It does not reveal *gross* flows, that is, Table 3 does not provide separate figures for total entries and exits. By comparison, Table 4 does provide a rough gauge of annual entries and exits. These gross flows provide an overall measure of the stability – or dynamism – of each ownership group in the LME population. Table 4 shows that of the 22,111 firms reporting in 1999, 46.2 percent reported the same enterprise identification number in 1994; by the end of the decade, over half of the enterprises reported identification numbers that were not observed in 1994.

The measures of stability differ by ownership type; at 70.1 percent, stability is highest for SOEs and considerably lower for each of the other six ownership types. The zero entry for private ownership indicates that among the 316 private firms that reported LME status in 1999, none were present in 1994. Each of the seven private LMEs that did report in 1994 had exited by 1999. The balance of this subsection attempts to interpret these statistical measures of entry and exit.

In principle, the number of firms in an ownership category may change due to one of two events. The first is the entry or exit of a firm that retains its prior ownership status. For example, a small-size foreign firm may graduate to middle-size status and thereby enter the population of LMEs. Alternatively, the number of enterprises counted

⁶ See for example, Weitzman and Xu (1994).

in an ownership type may change as a result of a change in ownership. An example of this form of change is the conversion a LME state-owned enterprise to a LME foreign joint venture, which results in one more firm in the foreign category and one less in the count of state-owned enterprises.

According to the NBS, ownership change requires the affected enterprise to re-register with a new enterprise identification number. If this principle were consistently followed, we could not use enterprise IDs to track the ownership conversions of individual enterprises. In particular, we could not distinguish between an ownership conversion and an exit from or entry to the general population of LMEs. For example, the appearance of a new enterprise in the shareholding category could not be distinguished as a converted state-owned LME or a pre-existing shareholding enterprise that graduated through growth to large or medium-size status. Likewise the “exit” of an enterprise, say from the SOE category, may have resulted from the conversion of the enterprise to another ownership form or from its downgrading to a small-size enterprise or its outright liquidation.

In practice, we find numerous enterprises that changed their ownership status while retaining their enterprise ID. For example, Su (2002) finds that of the 9,377 enterprises that exited the SOE category during 1995-99, 3,492, i.e. 37 percent, retained their original identification.⁷ In light of the fact that notwithstanding the official anticipation that enterprises engaging in ownership change their ID, we are able to ascertain that 37 percent of the exiting firms exited as a result of verifiable ownership

⁷ Our investigation in which we used year-to-year data to match a sample of the converted enterprise that did change their ID indicates that when enterprises do change their ID pursuant to an ownership change, relative to enterprises that retain their ID, they are more likely to have also implemented a change in their industry classification and/or location designation.

change, it may well be that a very substantial proportion of the firms that exited did so pursuant to ownership change rather than having diminished in size so as to no longer be eligible for the LME population. Notwithstanding the substantial decline in the number of SOEs during 1995-99, state industry nonetheless accounted for the plurality – nearly one-third – of all new entrants (i.e. enterprises with new identification numbers) and two-thirds of the exits. The stability ratios, shown in Table 4, indicate the proportion of enterprises within each ownership classification that reported the same identification number in both 1994 and 1999. According to the stability ratios shown in the last column, the proportions firms reporting in 1999 that entered after 1994 (computed as 100 minus the stability ratio) in the SOE, collective, and shareholding sectors were approximately 34, 55, and 88 percent, respectively. These numbers reveal a surprising dynamism of ownership and/or size within the population of China's large and medium-size enterprises.

Across ownership types, the proportions of enterprises present in 1994 that exited during subsequent years were uniformly high. At 62 percent, the collective sector exhibited the highest exit rate, followed by 55 percent in the shareholding sector, 53 percent in state industry, 52 percent in the overseas-funded classification, and 48 percent exiting the foreign-funded classification. Given the prominence of the shareholding experiment during the latter half of the 1990s, the high rate of exit from the shareholding sector is surprising. This finding raises an intriguing research question: what happened to the exceptionally large proportion of shareholding enterprises that exited during 1995-99 – were they further restructured or did they shrink in size?

Share of state assets. Many of China's enterprises include assets that are held by a combination of owners, both private and public, state and local governments, domestic and foreign. Within each of the seven listed ownership types, Table 5 shows the share of total assets that are owned by the state. What is striking about this table is that, with the exception of foreign wholly owned enterprises and private cooperative enterprises, the state's ownership share is at once greater than zero for 21 of the 23 ownership forms and less than 100 percent for each of the three state-owned classifications. For the full set of LMEs, the average share of state-owned assets fell from 69.0 percent in 1994 to just 51.1 percent in 1999.

Combining the results in Tables 3 and 5 together yields a rather striking insight. Table 3 shows that by 1999, the number of SOEs had fallen to barely more than one-half of the total; Table 5 shows that the share of state-owned capital in total assets controlled by LMEs had also fallen to just over one half. At these rates of reduction, we would expect that sometime during 2000, China's state government lost its once dominant control of the largest and most successful enterprises at the core of Chinese industry.

This mix of state and non-state capital across a large number of ownership classifications reflects the underlying process of ownership reform in China. In all classifications of ownership, enterprises are experiencing significant transformations in their asset structure as they are being sold, acquired, and merged with enterprises from other forms of ownership. Even as the proportion of state-owned assets within the category of "state-owned" enterprises fell from 94 percent in 1994 to 85 percent in 1999, state ownership has become more pervasive, and more uniformly spread, across a wide range of ownership forms.

Although in the aggregate, state ownership assets dominate SOEs, among the eleven thousand enterprises listed as “state-owned” in 1999 the state held minority shares in 1,417 of these enterprises. Outside the state sector, the state retains a quarter or more ownership in five of 20 categories that are generally characterized as “non-state”. Among the 11,550 non-state enterprises, in 1999, 1,935 report shares in which the state’s share exceeded 50 percent. These data indicate that among China’s LMEs, the distinction between state and non-state ownership is becoming increasingly blurred. Ownership reform among China’s LMEs is a process in which state-owned capital, originally the exclusive preserve of state-owned industry, has migrated outside the traditional state sector into virtually all new forms of enterprise ownership.⁸

The last column of Table 5 shows the rising share of foreign direct investment in China’s LMEs, a share that nearly doubled from 1995 to 1999. While the private sector now incorporates a small share of investment from both the foreign sector and Hong Kong, Taiwan, and Macao (HMT), the decline in the FDI share in the HMT sector, shown in Table 5, indicates that most of the rising share of FDI appears to have originated in the foreign sector.

Overall, from 1994 to 1999 the combined capital stock of China’s LMEs grew at an annual rate of 10.5 percent.⁹ During this same period, the growth of state-owned assets was just 4.8 percent, less than one-half of the overall rate of capital formation. At 14.6 percent, the pace of accumulation of FDI greatly exceeded that of state-owned capital. These data, aggregated from the individual enterprise data, suggest a strikingly

⁸Table 5 also suggests that certain ownership categories can be interpreted flexibly. These include “wholly State-owned companies for which we compute the state’s ownership share to be 79.5% ; also the state appears to hold assets in 3 or the 4 categories of “private” ownership. We have no explanation for these

different story than the common account, which suggests that most new capital formation is state owned. Our data show that even within the population of China's largest enterprises, which includes the key state-owned enterprises, most new investment is owned by non-state sources.

3. Efficiency

Table 6 shows levels of labor productivity and capital productivity and a combined measure of multi-factor productivity. We calculate these productivity measures for each of the seven ownership categories shown in Tables 3 through 5. In addition, we divide the state-owned category into three sub-groupings by share of assets owned by the state (S): $S = 100\%$, $100\% > S \geq 50\%$, and $S < 50\%$. Output (Q) is measured as constant price (1990) gross value of industrial output, labor (L) is total year-end employment, and fixed assets (K) are measured as the net value of fixed assets. We calculate relative levels of multi-factor productivity using the following formula¹⁰:

$$\text{MFP} = (\text{Q/K})^{0.377} (\text{Q/L})^{0.623}, \quad (1)$$

Our calculations, not shown here, indicate relatively stable value added ratios over time within each ownership category; we therefore expect that changes in measures

curiosities. The possibilities are (a) reporting error, (b) a flexible classification system, and/or (c) lags in reclassifying restructured enterprises.

⁹ From 1995-99, the rate was 10.2%.

¹⁰ The output elasticities in this formula were obtained from estimates of a Cobb-Douglas production function, which included dummies for the 2-digit industries, ownership, and time. Estimates were obtained with the restriction of constant returns to scale.

of multi-factor productivity closely approximate the growth of total factor productivity, a broader productivity measure.

Across all ownership categories, beginning in 1995, we see year-to-year gains in labor productivity, with annual rates of increase ranging from just eight percent in the shareholding sector to over 30 percent in the private sector. By contrast, capital productivity declines or stagnates from 1995 to 1998, a period of macroeconomic retrenchment in China; it rises from 1998-99, but in no category does capital regain the level of productivity it had enjoyed in 1995.

Table 6 exhibits a wide range of levels of multi-factor productivity (MFP) in 1999, ranging from state industry at 1.69 to the foreign sector at 4.25. Measured in terms of annual rates of growth of MFP, the private sector outstrips all other sectors. However, with only seven firms in 1995 and a high rate of entry in the private sector, growth is driven more by the characteristics of the new entrants than by the performance of a stable sample of firms. Among the other categories, the state and shareholding enterprises demonstrate the slowest rates of MFP growth – about 2 percent – while the foreign sector turns in the highest rate of growth. Regardless of the sector, however, with the exception of the private group, few show little overall productivity growth through 1998. Virtually all of the improvement corresponds with the beginning of macroeconomic recovery in 1999.

In Table 6, we find a striking association between efficiency and shares of asset ownership in state industry. Whether measured in terms of levels or rates of growth of MFP, among the population of state-owned LMEs, we see a clear inverse relationship between the share of state asset ownership and productivity performance. These results

suggest that SOE reform, at least measured in terms of the diversification of asset ownership, has been somewhat successful: highly-reformed SOEs ($S < 50\%$) outperform moderately-reformed SOEs ($50 < S < 100\%$), and moderately-reformed SOEs outperform the least-reformed SOEs ($S = 100\%$).

We can also use our results to make some general observations about the growing category of shareholding enterprises. In their paper, Jefferson, Rawski, Wang, and Zheng (JRWZ, 2000) find over the period 1993-96 striking declines in both capital and total factor productivity in the shareholding sector – declines that are substantially greater than those reported for the state sector. Our LME data for the shareholding sector continues to show lagging labor productivity growth in the shareholding sector; it does, however, indicate that during the latter half of the 1990s capital productivity in this sector declined at a rate that was not significantly out of line with the overall LME population. Overall, however, both levels and the rate of growth of MFP in the shareholding sector lagged behind comparable measures of enterprise performance for other non-state categories. We do see, however, that levels of MFP in the shareholding sector exceeded the comparable measures for all forms of state-owned enterprise – minority, majority, and wholly owned state enterprises. As JRWZ emphasize, given the problem of selection bias in the conversion of enterprises from categories of traditional ownership, it is difficult to evaluate the pure ownership-effect of China's experiment in shareholding governance. Table 6 shows that regardless of which of the three categories of state-ownership from enterprises are being converted, the conversion of SOEs with substantially lower levels of MFP to shareholding status is likely to depress average levels of measured MFP in the shareholding sector. The year-to-year conversion of

SOEs, with relatively low levels of productivity may account for the relatively low rate of growth of MFP of the shareholding aggregate as shown in Table 6.

4. Financial and Export Performance

Measures of enterprise efficiency and competitiveness include profitability and export orientation. While we anticipate substantial correspondence between these measures and productivity, as shown in Table 7, due to changes in macroeconomic conditions and differences in market power and possible reporting error, the correspondence is not exact.

Profitability. China's LMEs report a variety of profit measures. These include total profit; they also report product sales profit (*chanpin xiaoxiu lirun*), which is the conventional economic measure of the difference between price and average unit cost multiplied by the number of units sold. Our data show substantial differences between total profit and profit sales profit. While during 1995-99, the former is generally negative, the latter measure is generally positive. The difference arises from obligations that are not directly related to manufacturing activities in the current period. These include "non-main-operation profit" (*qita yewu lirun*), taxes, unemployment insurance fees, and other charges. Because the product sales profit more directly reflects the relative manufacturing efficiency of the reporting enterprises, Table 7 reports and compares these figures.

One conclusion that can be drawn from Table 7 is that during 1995-99, profit rates fell across the board. For all ownership categories, except for the other domestic

sector where the rates in 1999 and 1995 were identical, rates generally fell during the period. As with productivity, during 1998-99, we see some recovery, or slowing of decline.

In light of the shareholding sector's relatively weak productivity performance, it is surprising to see that sector turn in the most robust profit performance. In every year, its profit rate equals or exceeds that of all other ownership categories. Curiously, we also see in 1999 that shareholding profitability is followed by profit rates reported by highly reformed and moderately reformed state-owned enterprises. With the exception of the other domestic sector, profit rates in collective, overseas, foreign, private, and SOEs in which $S=100\%$ lag behind those of shareholding enterprises, as well as those of the highly and moderately-reformed state-owned enterprises.

One clue to this somewhat unexpected pattern appears in the bottom part of Table 7. We see from this table, apart from within state industry, a generally negative association between export orientation and profitability. These negative associations may result from concentration ratios that are higher for industries in which SOEs continue to dominate, such as electric power and smelting (see Table 2), relative to those in which foreign and HMT capital is concentrated, such as the electronic and electric equipment industries. Comparatively high sales profit rates in sectors of state industry and in the shareholding sector, consisting of many converted SOEs may, therefore, result from the relatively protected status of SOEs.

Before leaving the topic of ownership and profitability, we note that, other than the other domestic category, the only category that enjoyed a *rise* in profitability during 1996-99 was the highly reformed state-owned enterprises. The pattern of increase

closely follows that of MFP shown in Table 7. While rising productivity and profitability within the category of highly reformed SOEs may be indicative of the salutary effect of diminished shares of state asset ownership, they may also reflect selection bias – the tendency for non-state asset ownership to increase for the highest quality SOEs. In order for selection bias to explain the relative gains in the performance of the highly reformed SOEs, however, the quality of SOEs converted to highly reformed status would have to rise year-on-year. Alternatively, the number of high quality SOEs that convert to highly reformed status would have to increase year-on-year. While both of these conditions seem unlikely, we have no hard evidence to support the hypothesis that diminished shares of state ownership improve performance over the alternative hypothesis of selection bias.

Export orientation. Export data, limited to 1998 and 1999, show that LMEs sell approximately 11 percent of their sales abroad. Not surprisingly, the overseas and foreign sectors export two to five times as much of their total sales as their domestic enterprise counterparts. The least export-oriented enterprises are those that are 100 percent state-owned; export-orientation appears to rise monotonically with the decline in the state's capital share. Within the non-state domestic-owned sector, collectives are the most export oriented. Shareholding enterprises are the least export-oriented, which probably reflects their tendency to be converted from the ranks of state industry.

5. R&D Effort

A central purpose of this survey is to measure and compare the innovation effort of China's enterprises. While measures of efficiency, such as the measures of

productivity, profitability, and export-orientation examined above, provide an indication of current levels of performance, comparative measures of innovative activity, both inputs to and outputs from the R&D process, may presage future performance.

Although the data reported in Tables 1 through 7 are relatively complete, one feature of the data set becomes problematic for the R&D input and output data, for which reporting is more uneven. When the NBS and its local subsidiary offices receive forms from individual enterprises, some of the requested data have not been reported by the enterprise. Rather than mark these as missing observations, the statistical authorities often, but not always, convert missing observations to zeros. The effect of this practice is relatively benign for regularly reported measures, such as those appearing in Tables 1 through 7, since the vast majority of the reported observations are non-zero and we know that zero observation for a firm's capital stock is very likely to have resulted from the true figure not having been reported. But this is not the case for the R&D data for which substantial proportions of the reported observations are zero and the true value may be zero. The result is that, for a large number of observations, we cannot distinguish between zeros that represent a true zero level of R&D activity and zeros that have been created by the statistical authorities, because no figures have been recorded by the enterprises.

To allow for a more complete evaluation of the data, in Tables 8, 10, and 12 through 15, we exhibit two numbers: one is for enterprises that report non-zero levels of activity (i.e. hereafter called "R&D performers"). The other, reported in brackets, includes both R&D performers and non-performers – those for which the recorded observation is zero. In Tables 8 through 11, we measure R&D effort in two ways:

expenditure as a proportion of sales and R&D personnel as a proportion of the total work force. Our expenditure measure is more broadly defined than the typical measure of R&D used by the OECD and in most of the R&D literature relating to the advanced industrial economies. We use the NBS measure, which includes a broader set of innovation activity, including quality improvements of existing products and process innovation, such as the installation of foreign equipment. Our data suggest that, within our population of LMEs, this broader measure – technical development (*jishu kaifa*) expenditure – is approximately three times as large as the conventional R&D measure. In the discussion that follows, we continue to designate technical development as R&D.

Ratio of R&D expenditure to sales. For the full population of large and medium-size enterprises, the data show relatively low rates of R&D intensity. Table 8 reveals from 1995 to 1999 only a small, sustained increase in R&D intensity for the R&D performers – from 2 percent of sales in 1995 to 2.2 percent of sales in 1999. For the full sample inclusive of non-performers, we see a one-time increase in 1995-96, which is sustained throughout the subsequent years. In the most recent year, overall R&D intensity is 0.7 percent of total sales.

We draw several conclusions from the data in Table 8. First for the R&D performers only, the measures of R&D intensity in 1999 are similar across ownership types. With the exception of the private and other domestic sectors in which the numbers are notably unstable, the intensities in 1999 all fall in the range of 0.021-0.025. Among all enterprises, R&D performers and non-performers, the range spans 0.004 to 0.009. These latter figures, inclusive of firms not reporting positive levels of R&D expenditure, show that collective-owned enterprises, overseas firms, and foreign firms are the least

R&D-intensive ownership groups. While the R&D performers in these ownership groups perform at levels that are similar to performers in other groups, the incidence of non-performers within these groups is relatively high.

To evaluate the overall trend in R&D intensity, we compare the distribution of expenditure across various ranges for 1995 and 1999. Table 9 shows several results. First, the number, and proportion, of LMEs not reporting positive levels of activity declined from 1995-1999. Across every range of positive activity, the number of performing firms rose. The largest proportional increases were for the high R&D intensity ranges. Most notably, the number of enterprises for which R&D activity exceeded three percent of sales nearly doubled to 1,076, approximately 5 percent of the total LME population. Moreover, the mean ratio for these firms was over 10 percent.

Ratio of R&D personnel to total employment. Compared with the expenditure measure, the R&D personnel/total employment ratio shows a significant and continuous increase in R&D intensity. In Table 10, the share of R&D personnel in total employment rises from 5.2 percent in 1995 to 8.2 percent in 1999. Moreover, we can see from the comparatively small gap between the R&D personnel ratio for performers and the ratio for all enterprises that the proportion of non-performers is substantially smaller for the personnel measure of R&D intensity than it was using the expenditure measure. Since R&D personnel require expenditures, such as compensation, it is likely that firms more often fail to report R&D expenditure, which may explicitly appear in the budget of only those enterprises with formal R&D units.

In Table 10, we see notable increases in R&D intensity for enterprises in all categories of ownership, although the increase for 100 percent state-owned SOEs,

particularly for the performing group, is the least impressive. The overseas and foreign LMEs present particularly interesting cases. Although R&D intensity for all of the LMEs in each of these ownership categories does not substantially differ from that of the full population of LMEs, the intensities for the R&D performers in these categories in 1999 stands above 10 percent. This pattern suggests that while a smaller proportion of overseas and foreign-owned enterprises conduct (or at least report) R&D, those that do are high-intensity R&D performers.

Unlike the distribution of R&D expenditure intensity, which moves unambiguously toward a more intensive pattern of R&D, the distribution of R&D personnel/employment ratio is not so pronounced. On the one hand, it shows a rising number, and proportion, of non-performers, while, at the other tail of the distribution, we see a substantial increase in both the number of high-intensity performers and the average intensity of R&D personnel. While the overall picture is one of growing R&D intensity in China's important large and medium-size enterprise sector, the different measures of this change – R&D expenditure/sales and R&D personnel/employment – require further analysis and reconciliation. The data seem to indicate that at the upper end of the distributions shown in Tables 9 and 11, R&D expenditure has risen to match the rising intensity of R&D personnel. There may be emerging a core of high R&D performers. Overall, however, the continuous rise in the intensity of R&D personnel is not reflected in comparable increases in the intensity of R&D expenditure.

6. Innovation Performance

Measuring the output of innovation effort is a well-known challenge. Our data set contains numerous measures of innovation output. We, in particular, examine the ratio of new product sales/total sales and patent applications.

New product sales. Countries that measure counts or sales of new products often use different criteria for the innovations that qualify as “new products”. Even within national economies and national bureaucracies, the relevant criteria may differ. The criteria used by the Social, Population, and Technology Department of the NBS for measuring the variable “new product sales” is defined below:

Products included in the category of “new product sales” are those, which are new in relation to the reporting firm’s prior product mix. Products that involve the use of new principles, incorporate design improvements, utilize new materials, or embody new techniques constitute new products; existing products that are used for new functions or expand capabilities (e.g. production or speed) also constitute new products. Changes in a product’s shape or minor changes in functionality do not constitute new products.¹¹ The duration of new products varies from one to four years, depending on the nature of the product.

Table 12 shows for LME R&D performers a significant increase in the proportion of new product sales, growing to 24.5 percent in 1999, up by one-third from 1995. At the same time, the relatively slow rise in the share of new product sales for the full population suggests that the proportion of LMEs that are not producing new products also grew over the period 1995-99. With the exception of the other domestic category, this pattern holds for each of the ownership classifications. For the overseas and foreign

categories, we see a pattern similar to that of R&D personnel intensity. While for all LMEs in these two ownership categories, the proportions of new product sales are not consistently larger than those of other ownership categories, if we limit the comparison to performing enterprises, alone, the proportions for the overseas and foreign categories stand out relative to other ownership categories. It appears that while a relatively small proportion of all overseas and foreign-owned LMEs report new product sales, many of the high-performing new product innovators lie within these two ownership categories.

Table 13 shows the ranking of the industries that in 1999 were most prolific in their sale of new products as a share of total industry sales. Within the electronic and telecommunications equipment industry, which outperform the other industries by a substantial margin, the share of new product sales consistently stood above 22 percent for all firms and above 40 percent for those reporting new product sales. Not surprisingly, the top five new product producers were all equipment producers.

While the medical and pharmaceutical products industry ranked among the top ten in new product sales intensity, we might have expected it to rank higher than nine. However, having reported an increase of nearly 50 percent in its new product sales during 1995 to 1999, this industry, along with the cultural, education, and sporting goods industry, has emerged as the fastest growing on the list in the intensity of new product sales.

Patent applications. In distinguishing between new product sales and patent applications as measures of R&D output, we can reasonably assume that new products are the outcome of R&D with an applied orientation; patent applications are more likely

¹¹ Email correspondence from Yu Xiaoguan, NBS, Department of Industrial and Transportation Statistics, February 6, 2001.

to emerge from R&D with more of a basic research orientation. It should not be surprising, therefore, to see a much larger share of “non-performers” who are not producing patent applications. Table 14 shows that in 1999, during which the performers produced an average of 5.45 applications per firm, the average for all of the LMEs was just 0.35. This sizeable disparity implies that only 6.5 percent of LMEs in that year produced patent applications.

The aggregate data – both that for just the performers as well as that for all LMEs – display a distinct trend of rising numbers of patent applications during 1995-1999. One or more firms that report, in a single year, more than 100 patent applications, however, substantially inflate some of these figures. Because it is the judgement of NBS staff, which know the data and, in some cases, the firms involved, that these are reliable counts; we include these observations in our calculations.

Table 14 shows that all ownership categories display increasing numbers of patent applications for their R&D performers as well as for their full populations of LMEs. Collectives show the highest intensity of patenting activity; they also include among their ranks four – half of the total number – of Chinese industry’s most prolific patent innovators. We see, therefore, that this upward swing in patent activity is consistent with trends revealed in other measures of innovative activity. Measures of R&D effort – R&D expenditure and personnel – and R&D outcomes – new products sales and patent applications – all show in varying degrees increasing intensity in China’s large and medium-size enterprise system.

Table 15, which identifies the high-frequency patentees, shows less than complete correspondence between frequency of patent applications and new product sales

intensity. The four equipment-producing industries that appear at the top of the new product list are also among the high-frequency patent applicants, although only the electrical equipment industry is among the top five patent applicants. Among the patent applicants, the petroleum and gas industry leads by a wide margin, presumably with an emphasis on process innovations rather than new product innovations. The spread between that industry with more than 12 patents per firm on average and the last on the list, medical and pharmaceutical products, with less than a half a patent per firm suggests a high concentration of patenting activity within China's manufacturing sector.

7. Conclusions

Using a rich set of panel data spanning China's 22,000 large and medium-size enterprises, we present a statistical description and analytical overview of this important sector of Chinese industry. Over the five-year period 1994-1999, a number of comparisons and changes stand out. The first is the dynamic ownership composition of the population of large and medium-size enterprises. While state ownership continued to dominate this pinnacle of China's industrial enterprise in 1994, accounting for more than two-thirds of the enterprises and total assets of China's LMEs, by 1999, the state's share of both enterprises and total assets had declined to just one half. Sometime during 2000, the role of state ownership in China's large and medium-size enterprise sector was eclipsed by foreign and overseas, local government, and private ownership. Moreover, the effective control of formally state-owned enterprises was becoming increasingly

ambiguous as the state no longer held a majority of the assets in at least 1,400 so-called state-owned enterprises.

State asset ownership is becoming spread over an increasingly wide-range of ownership categories. The high rate of entry and exit across ownership types, particularly exit from state industry, explains this accumulation of state-owned assets outside state industry. Against the background of increasingly diversely owned asset structures, the conventional categories of ownership are becoming increasingly less meaningful.

For state-owned enterprises, patterns of asset ownership are associated with performance. Differences in both levels and rates of growth of productivity vary substantially; SOEs with the highest concentrations of state assets perform at the low end, while those with low concentrations of state-owned assets perform at the high end. Nonetheless, even among SOEs reporting minority state ownership, productivity levels lie below those of all other ownership categories. The productivity of shareholding enterprises, whose level lies below all other categories of ownership except state industry, exhibits the lowest rate of growth during the latter half of the 1990s. However, because the shareholding sector also exhibits the highest proportions of new entrants and exits, rather than representing a pure ownership effect, its lackluster performance may reflect patterns of firm migration in which low productivity firms enter and high productivity firms exit the shareholding sector.

During the latter half of the 1990s, in just five years, we find that R&D activity, both inputs and outputs, is becoming more intensive. Overall, R&D intensity, measured in terms of expenditures and personnel, rose from 1995-99. The increase in the sheer

number of high-intensity performers was most impressive. Likewise, during 1995-99, the incidence of new product sales intensity rose, although, again, most of the increase arose from a relatively few number of enterprises, which substantially increasing their intensity of new product sales. Patent application intensity also rose, nearly doubling over the period 1995-99. In particular, we note the emergence of high-performing patent producers. In 1995, no enterprises reported applying for more than 100 patents; the following year the number rose to three; by 1999, it had risen to eight. Rapid increases in R&D and new product intensity among high-end performers and the emergence of high-frequency patentees may harbingers an emerging core of high-end R&D performers. Although we see the growth of high intensity R&D performers and along with some increase in the number of R&D performers, we have yet to see a broad-based takeoff of R&D activity.

China's population of large and medium-size industrial enterprises offers rich statistical insight into the evolution of the pinnacle of Chinese industry. Through this annual documentation of China's twenty thousand enterprises, we see a rapidly diversifying ownership structure in which the role of the state is steadily retreating. At the same time, we see emerging within Chinese industry evidence of high-intensity R&D performers that exhibit substantial innovation capabilities.

Table 1
Shares of LMEs in total industry (%)¹

Measure	1994		1999	
	L&M	Of which: large	L&M	Of which: large
Sales	47.3	33.1	33.7	26.0
Employment	33.7	20.2	24.2	16.8
Assets	59.7	43.2	64.6	51.8

¹Independent accounting units plus the gross value of industrial output of urban cooperative industry, rural cooperative industry, urban individual-run industry, and rural individual run industry at or below the village level.

Sources: Yearbook, 1995, pp. 376, 382, 386, 387 and 407. *Labor Statistics Yearbook* 1995, p. 7; the data for 1999 was compiled by staff of the NBS.

Table 2
Industry composition, 1994 and 1999 (%)¹

Industry	Share of total industry sales*		Share of LME sales*		SOE share of LME sales		FOR/HKT share of LME sales	
	1994	1999	1994	1999	1994	1999	1994	1999
Total industry	100	100	60.1	58.9	71.5	55.2	11.1	20.2
1. Textiles	8.6	5.9	57.1	49.9	65.7	34.3	7.1	12.5
2. Smelting	7.8	5.8	87.3	78.9	85.1	57.6	2.2	3.6
3. Transport equipment	6.3	6.4	75.9	75.4	67.8	43.1	16.9	30.1
4. Chemical	6.2	6.5	60.1	59.6	77.8	41.9	7.2	38.9
5. Electric power	6.0	7.9	78.3	78.0	85.7	73.1	10.8	9.6
6. Non-ferrous metal	5.7	4.4	37.4	38.7	64.0	34.3	10.4	14.7
7. Food processing	4.8	4.6	38.3	39.3	65.6	36.2	20.2	25.4
8. Electric equipment	4.4	5.3	60.4	45.2	35.5	16.5	18.1	26.9
9. Ordinary machinery	4.4	3.5	56.8	54.8	65.5	43.6	12.4	21.2
10. Electronic and telecom	4.1	8.0	69.1	61.8	39.5	22.5	46.0	63.6

¹For independent accounting units only.

Table 3
LME ownership distribution (%)

Ownership type	1994		1999	
State-owned	15,533	[67.9]	11,184	[50.6]
Collective-owned	4,068	[17.8]	3,408	[15.4]
Hong-Kong, Macao, Taiwan	967	[4.2]	1,567	[7.1]
Foreign	1,041	[4.6]	1,966	[8.9]
Shareholding	961	[4.2]	3,478	[15.7]
Private	7	[0.0]	316	[1.4]
Other domestic*	293	[1.3]	192	[0.9]
Total	22,870	[100.0]	22,111	[100.0]

Table 4
Entry and exit across categories of ownership (%)

Ownership type	Stable ¹		Exits ²		Entrants ³		Stability ⁴
State-owned	7,372	[70.1]	8,161	[65.6]	3,812	[32.6]	65.9%
Collective-owned	1,534	[14.7]	2,534	[20.4]	1,874	[16.0]	45.0
Hong-Kong, Macao, Taiwan	467	[4.5]	500	[4.0]	1,100	[9.4]	29.8
Foreign	546	[5.2]	495	[4.0]	1,420	[12.2]	27.8
Shareholding	429	[4.1]	532	[4.3]	3,049	[26.1]	12.3
Private	0	[0.0]	7	[0.0]	316	[2.7]	0.0
Other domestic	57	[0.5]	236	[1.9]	135	[1.2]	18.0
Total	10405	[100.1]	12448	[100.2]	11689	[100.2]	47.1
Share of total (in relevant year)	46.2%	[1999]	64.4%	[1994]	53.8%	[1999]	

¹ Stable: enterprises that used the same enterprise I.D. in both 1994 and 1999, implying no exit, entry, or ownership change; [% of the total LME stable enterprises].

² Exits: enterprises that were present in 1994 but exited or changed ownership thereafter; [such enterprises as a % of total LME exits].

³ Entrants: enterprises for which there were no comparable I.D.s reported in 1994, implying new entry or ownership change; [% of total LME entrants].

⁴ Stability: % of enterprises within this ownership category in 1994 for which ownership and size status was unchanged in 1999.

Table 5
Share of state and foreign-owned assets in total assets, 1999 (%)

Code	Ownership	Number	State %	FOR/HKT %
total	All ownership types	21,573 [22,331] ¹	51.1 [69.0] ¹	10.8 [5.5] ²
State-owned		10,750 [15,267]	85.0 [94.3]	0.9 [0.9]
110	State-owned enterprises	10,023	85.6	0.8
141	State owned jointly operated enterprises	91	49.3	0.9
151	Wholly state-owned companies	636	79.5	1.8
Collective-owned		3,375 [4,006]	3.4 [11.2]	2.9 [3.3]
120	Collective-owned enterprises	2,638	2.3	3.2
130	Shareholding cooperatives	710	7.4	2.0
142	Collective jointly operated enterprises	27	2.9	1.5
Hong Kong, Macao, and Taiwan		1,552 [919]	17.0 [0.0]	51.3 [60.7]
210	Overseas joint ventures	1,102	20.3	42.4
220	Overseas cooperatives	161	17.8	52.1
230	Overseas wholly-owned enterprises	238	0.3	95.8
240	Overseas shareholding limited companies	51	20.6	36.3
Foreign		1,957 [919]	12.7 [0.0]	64.8 [56.5]
310	Foreign joint ventures	1,384	16.4	54.5
320	Foreign cooperatives	104	12.1	66.1
330	Foreign wholly-owned enterprises	440	0.0	98.5
340	Foreign shareholding limited companies	29	30.1	41.5
Shareholding		3,441 [946]	34.7 [48.0]	1.8 [3.0]
159	Other limited liability companies	1,686	33.3	1.5
160	Shareholding limited companies	1,755	36.0	2.1
Private		312 [4]	3.0 [0.0]	1.8 [0.0]
171	Private wholly-owned enterprises	107	4.7	0.7
172	Private cooperative enterprises	16	0.0	2.2
173	Private limited liability companies	168	1.9	2.6
174	Private shareholding companies	21	4.7	0.0
Other domestic		186 [270]	29.3 [38.6]	1.7 [1.7]
143	State-collective jointly operated enterprises	128	26.7	0.8
149	Other jointly operated enterprises	21	4.7	2.5
190	Other enterprises	37	52.5	4.3

¹ figures in brackets are for 1994; ² figures in brackets are for 1995

³ both state share and FOR/HKT share are recorded within the range [0,100]

Table 6
Efficiency measures, 1995-1999

Measure	1995	1996	1997	1998	1999	Growth ¹
Number	22,892	24,202	24,292	23,766	22,589	n.a.
Q/L: all	17.56	21.24	23.32	25.93	34.46	16.85
SOEs: all, Of which:	13.24	15.05	16.20	17.88	21.83	12.50
S = 100%	n.a.	14.58	15.32	16.35	19.86	10.30
50<S<100%	n.a.	18.89	21.73	23.63	29.20	14.18
S < 50%	n.a.	17.94	20.85	22.15	27.08	13.73
Collectives	20.70	26.11	27.26	28.82	34.10	12.48
Overseas	39.53	46.07	49.33	50.23	62.28	11.36
Foreign	45.01	50.52	55.46	61.70	83.86	15.56
Shareholding	25.03	27.10	27.45	28.02	34.44	7.97
Private	13.09	57.53	44.53	28.35	44.01	30.31
Other domestic	22.25	25.72	25.96	22.26	38.34	13.60
Q/K:all	0.53	0.49	0.48	0.45	0.52	-0.48
SOEs: all, of which:	0.43	0.37	0.36	0.34	0.36	-4.44
S = 100%	n.a.	0.35	0.33	0.31	0.33	-1.96
50<S<100%	n.a.	0.36	0.34	0.32	0.34	-1.91
S<50%	n.a.	0.51	0.54	0.45	0.51	0
Collectives	0.74	0.77	0.70	0.64	0.73	-0.34
Overseas	0.74	0.67	0.66	0.58	0.68	-2.11
Foreign	0.72	0.69	0.70	0.59	0.70	-0.70
Shareholding	0.64	0.63	0.59	0.57	0.60	-1.61
Private	0.39	0.95	0.57	0.57	0.81	18.27
Other domestic	0.67	0.63	0.59	0.47	0.62	-1.94
MFP²: all	1.98	2.03	2.08	2.07	2.53	6.06
SOEs: all, of which:	1.57	1.50	1.51	1.51	1.69	1.86 (4.05)
S = 100%	n.a.	1.43	1.40	1.38	1.55	(2.66)
50<S<100%	n.a.	1.60	1.63	1.62	1.82	(4.29)
S<50%	n.a.	1.95	2.14	1.96	2.28	(5.17)
Collectives	2.60	2.91	2.78	2.69	3.11	4.49
Overseas	3.32	3.30	3.36	3.12	3.73	2.97
Foreign	3.42	4.48	3.64	3.41	4.25	5.43
Shareholding	2.55	2.60	2.51	2.48	2.76	2.00
Private	1.47	4.46	2.95	2.49	3.65	28.81
Other domestic	2.51	2.55	2.46	2.01	2.94	3.92

¹Growth rates are exponential rates of growth for 1995-99 or, if 1995 = n.a., then rates, shown in parentheses, are computed for 1996-99. ²The MFP series is formed by normalizing the 1995 observations to 100 and applying equation (1) in the text.

Table 7
Profit and export performance

Measure	1995	1996	1997	1998	1999
Profit/sales ¹ : all	0.145	0.127	0.118	0.106	0.116
SOEs:all, of which:	0.149	0.132	0.120	0.101	0.114
S = 100%	n.a.	0.132	0.118	0.097	0.109
50<S<100%	n.a.	0.137	0.128	0.114	0.125
S< 50%	n.a.	0.124	0.134	0.116	0.132
Collectives	0.137	0.130	0.124	0.114	0.106
Overseas	0.116	0.088	0.092	0.086	0.090
Foreign	0.119	0.073	0.066	0.092	0.112
Shareholding	0.184	0.165	0.153	0.142	0.143
Private	0.184	0.139	0.134	0.103	0.117
Other domestic	0.129	0.108	0.109	0.099	0.129
Export/sales : ² all	n.a.	n.a.	n.a.	0.107	0.112
SOEs:all, of which:	n.a.	n.a.	n.a.	0.068	0.065
S = 100%	n.a.	n.a.	n.a.	0.059	0.057
50<S<100%	n.a.	n.a.	n.a.	0.064	0.063
S<50%	n.a.	n.a.	n.a.	0.108	0.085
Collectives	n.a.	n.a.	n.a.	0.137	0.134
Overseas	n.a.	n.a.	n.a.	0.243	0.230
Foreign	n.a.	n.a.	n.a.	0.261	0.289
Shareholding	n.a.	n.a.	n.a.	0.091	0.091
Private	n.a.	n.a.	n.a.	0.097	0.097
Other domestic	n.a.	n.a.	n.a.	0.110	0.121

¹ Measured as sales profit; omits all missing observations and all observations that lie outside the range -1 to 1.

² Omits all observation outside the range [0,1].

Table 8
R&D effort: R&D expenditure/sales ratio

Measure	1995	1996	1997	1998	1999
R&D/sales ¹ : all	0.020 ² [0.004] ³	0.028 [0.007]	0.027 [0.007]	0.022 [0.006]	0.022 [0.007]
SOEs: all	0.020	0.027	0.028	0.024	0.024
Of which:	[0.004]	[0.00]	[0.008]	[0.007]	[0.008]
S = 100%	n.a.	0.027 [0.007]	0.029 [0.008]	0.025 [0.007]	0.025 [0.008]
50<S<100%	n.a.	0.031 [0.010]	0.020 [0.007]	0.024 [0.007]	0.024 [0.009]
S<50%	n.a.	0.022 [0.007]	0.029 [0.009]	0.015 [0.003]	0.021 [0.009]
Collectives	0.022 0.003]	0.030 0.005]	0.024 0.005]	0.014 0.003]	0.022 0.004]
Overseas	0.008 [0.001]	0.022 [0.004]	0.025 [0.006]	0.024 [0.005]	0.025 [0.006]
Foreign	0.018 [0.003]	0.031 [0.005]	0.023 [0.004]	0.032 [0.007]	0.022 [0.004]
Shareholding	0.016 [0.005]	0.026 [0.009]	0.023 [0.008]	0.019 [0.007]	0.021 [0.007]
Private	0.008 [0.003]	0.075 [0.015]	0.006 [0.001]	0.027 [0.004]	0.049 [0.008]
Other domestic	0.022 [0.003]	0.024 [0.006]	0.059 [0.013]	0.018 [0.005]	0.053 [0.016]

¹ Omits those observations, which lie outside the range [0,2].

² Includes only observations for which values are greater than zero.

³ Figures in parentheses include observations for which values equal zero.

Table 9
Distribution of R&D/sales (r), all enterprises (%)¹

Year	0	0<r≤ 0.25	0.25<r≤0.5	0.5<r≤1	1<r≤3	r>3
1995	0.00 [16,559] ²	0.111 [1,375]	0.364 [657]	0.719 [668]	1.719 [820]	10.549 [544]
1999	0.00 [14,951]	0.105 [1,917]	0.368 [894]	0.723 [1,031]	1.802 [1,371]	10.077 [1,076]

¹ Observations that lie outside the range [0,2] have been omitted.

² The number of observations is recorded in parentheses.

Table 10
R&D effort: R&D personnel/total employment ratio

measure	1995	1996	1997	1998	1999
R&D personnel/ employment: ¹ all	0.052 ² [0.032] ³	0.068 [0.035]	0.073 [0.035]	0.076 [0.037]	0.082 [0.043]
SOEs: all, Of which:	0.049 [0.033]	0.065 [0.036]	0.068 [0.037]	0.073 [0.038]	0.078 [0.043]
S = 100%	n.a.	0.065 [0.035]	0.068 [0.035]	0.069 [0.034]	0.074 [0.037]
50<S<100%	n.a.	0.059 [0.037]	0.068 [0.042]	0.070 [0.036]	0.083 [0.049]
S<50%	n.a.	0.072 [0.041]	0.070 [0.042]	0.088 [0.057]	0.079 [0.066]
Collectives	0.052 [0.026]	0.067 [0.028]	0.070 [0.027]	0.067 [0.029]	0.079 [0.034]
Overseas	0.061 [0.027]	0.087 [0.031]	0.095 [0.035]	0.095 [0.034]	0.108 [0.041]
Foreign	0.081 [0.037]	0.105 [0.036]	0.115 [0.036]	0.115 [0.039]	0.121 [0.040]
Shareholding	0.059 [0.047]	0.075 [0.048]	0.078 [0.047]	0.079 [0.047]	0.087 [0.051]
Private	0.010 [0.003]	0.062 [0.013]	0.070 [0.014]	0.074 [0.025]	0.085 [0.027]
Other domestic	0.054 [0.032]	0.080 [0.039]	0.087 [0.037]	0.078 [0.037]	0.092 [0.044]

¹ Omits those observations which lie outside the range [0,1]

² Includes only observations which values are greater than zero.

³ Figures in parentheses include observations for which values equal zero.

Table 11
Distribution of R&D personnel/employment (p), all enterprises (%)¹

Year	0	0<d≤1	1<p≤3	3<p≤5	5<p≤10	p>10
1995	0 [7,716] ²	0.60 [2,281]	1.90 [4,256]	3.91 [2,296]	7.08 [2,390]	18.15 [1,734]
1999	0 [10,639]	0.63 [918]	1.96 [2,635]	3.95 [1,893]	7.19 [2,546]	21.24 [2,808]

¹ Observations that lie outside the range [0,1] have been omitted.

² The number of observations is recorded in parentheses.

Table 12
R&D outcomes: new product sales/total sales

Measure	1995	1996	1997	1998	1999
New product sales/sales:¹ all	0.185 [0.078]	0.199 [0.069]	0.200 [0.064]	0.277 [0.074]	0.245 [0.082]
SOEs: all	0.173 [0.077]	0.184 [0.067]	0.183 [0.062]	0.204 [0.067]	0.215 [0.075]
Of which:					
S = 100%	n.a.	0.177 [0.061]	0.173 [0.054]	0.198 [0.059]	0.200 [0.063]
50<S<100%	n.a.	0.191 [0.090]	0.186 [0.082]	0.200 [0.063]	0.214 [0.092]
S<50%	n.a.	0.233 [0.104]	0.247 [0.115]	0.227 [0.100]	0.245 [0.130]
Collectives	0.201 [0.068]	0.197 [0.060]	0.196 [0.053]	0.231 [0.067]	0.245 [0.076]
Overseas	0.246 [0.078]	0.263 [0.061]	0.267 [0.069]	0.299 [0.075]	0.310 [0.082]
Foreign	0.316 [0.107]	0.351 [0.087]	0.378 [0.089]	0.413 [0.111]	0.407 [0.101]
Shareholding	0.170 [0.106]	0.207 [0.105]	0.194 [0.086]	0.215 [0.091]	0.247 [0.100]
Private	0 [n.a.]	0.049 [0.010]	0.085 [0.005]	0.237 [0.048]	0.265 [0.063]
Other domestic	0.254 [0.114]	0.260 [0.102]	0.220 [0.069]	0.264 [0.106]	0.238 [0.090]

¹Omits observations that lie outside the range [0,1].

Table 13
New product sales/total sales: top 10 industries¹

industry	1995	1996	1997	1998	1999
1. (41) electronic and telecommunications equipment	0.329 [0.226]	0.403 [0.241]	0.524 [0.290]	0.401 [0.224]	0.414 [0.222]
2. (40) electric equipment machinery	0.239 [0.151]	0.545 [0.306]	0.285 [0.148]	0.293 [0.151]	0.322 [0.175]
3. (42) instruments and office machinery	0.235 [0.179]	0.219 [0.148]	0.312 [0.190]	0.246 [0.152]	0.274 [0.171]
4. (36) special purpose equipment	0.208 [0.142]	0.230 [0.136]	0.228 [0.126]	0.243 [0.137]	0.271 [0.156]
5. (37) transport equipment	0.230 [0.148]	0.319 [0.172]	0.286 [0.147]	0.289 [0.156]	0.279 [0.146]
6. (24) cultural education, and sports goods	0.252 [0.107]	0.231 [0.083]	0.273 [0.103]	0.323 [0.133]	0.373 [0.140]
7. (35) ordinary machinery	0.209 [0.150]	0.200 [0.123]	0.267 [0.155]	0.224 [0.124]	0.224 [0.131]
8. (21) furniture manufacturing	0.259 [0.094]	0.497 [0.179]	0.453 [0.176]	0.309 [0.111]	0.341 [0.122]
9. (27) medical and pharmaceutical products	0.166 [0.098]	0.195 [0.095]	0.207 [0.095]	0.206 [0.099]	0.242 [0.119]
10. (29) rubber products	0.160 [0.098]	0.192 [0.101]	0.170 [0.079]	0.176 [0.089]	0.189 [0.096]

¹ranking based on 1999 reporting; figures in brackets include firms reporting zero.

Table 14
R&D outcomes: patent applications

measure	1995	1996	1997	1998	1999
Patent applications: all ¹	3.03 [0.183]	3.46 (3) ² [0.205]	4.48 (6) [0.245]	4.74 (5) [0.268]	5.45 (8) [0.354]
SOEs: all Of which:	3.04 [0.201]	2.99 (1) [0.178]	3.33 (1) [0.183]	3.59 (1) [0.204]	4.442 (3) [0.283]
S = 100%	n.a.	2.87 (1) [0.162]	3.14 (1) [0.159]	3.42 (1) [0.170]	4.22 (1) [0.225]
50<S<100%	n.a.	4.01 [0.366]	4.27 [0.400]	3.48 [0.193]	5.77 (2) [0.571]
S<50%	n.a.	1.93 [0.104]	3.06 [0.164]	4.57 [0.327]	3.90 [0.380]
Collectives	3.20 [0.137]	4.18 (2) [0.260]	7.27 (2) [0.365]	6.23 (2) [0.318]	9.06 (4) [0.530]
Overseas	3.18 [0.140]	4.25 [0.178]	4.08 [0.159]	4.46 [0.248]	5.58 [0.307]
Foreign	2.59 [0.105]	4.26 [0.182]	3.78 [0.131]	4.87 [0.164]	6.29 [0.239]
Shareholding	2.84 [0.345]	3.80 [0.413]	6.90 (3) [0.616]	6.77 (1) [0.564]	4.83 (1) [0.484]
Private	0 [n.a.]	0 [n.a.]	4.00 [0.114]	1.40 [0.040]	7.31 [0.384]
Other domestic	3.18 [0.128]	2.00 [0.104]	2.87 [0.149]	13.50 (1) [0.643]	4.33 [0.148]

¹ Omits observations that lie outside the range [0,1].

² Numbers in parentheses (#) are numbers of firms reporting 100 or more patent applications in the relevant year.

Table 15
Patent applications: top 10 Industries¹

industry	1995	1996	1997	1998	1999
1. (7) petroleum and natural gas	16.78 (2.58)	20.81 [13.88]	24.42 [16.60]	22.19 [12.68]	30.92 [12.57]
2. (24) cultural, education, and sports equipment	4.00 (0.21)	16.08 [1.77]	24.77 [2.98]	7.00 [0.83]	17.35 [2.68]
3. (40) electric equipment and machinery	4.22 (0.41)	5.77 [0.63]	8.70 [0.89]	10.79 [0.99]	12.75 [1.52]
4. (25) petroleum processing and recoking	4.86 (1.13)	7.28 [1.63]	6.74 [1.11]	6.68 [1.18]	7.84 [1.25]
5. (32) smelting and processing of ferrous metals	6.58 (0.86)	7.19 [0.81]	6.51 [0.69]	6.27 [0.73]	9.13 [0.96]
6. (41) electronic and telecommunications equip	2.41 (0.19)	2.95 [0.28]	4.55 [0.30]	7.22 [0.65]	10.15 [0.96]
7. (36) special purposes equipment mfg.	2.32 (0.26)	2.74 [0.30]	2.63 [0.30]	3.03 [0.40]	4.13 [0.69]
8. (42) instrument, meters, and office machinery	2.63 (0.35)	2.37 [0.28]	2.64 [0.30]	3.84 [0.40]	2.90 [0.43]
9. (14) food production	2.68 (0.10)	6.71 [0.17]	7.47 [0.23]	8.15 [0.30]	7.66 [0.42]
10. (27) medical and pharmaceutical prod.	3.41 (0.45)	2.91 [0.25]	3.78 [0.37]	3.65 [0.39]	3.27 [0.40]

¹ranking based on 1999 reporting; figures in [] include firms reporting zero.

Annex I

Concordance of Ownership Classifications, 1994-1999

1994		1999	
Code	Ownership category	Code	Ownership category
State-owned			
11	State-owned enterprises	110	State-owned enterprises
12	State owned jointly operated enterprises	141	State owned jointly operated enterprises
11	Wholly state-owned companies	151	Wholly state-owned companies
Collective-owned			
21	Collective-owned enterprises	120	Collective-owned enterprises
		130	Shareholding cooperatives
22	Collective jointly operated enterprises	142	Collective jointly operated enterprises
Hong Kong, Macao, Taiwan-owned			
81	Overseas joint ventures	210	Overseas joint ventures
82	Overseas cooperatives	220	Overseas cooperatives
83	Overseas wholly-owned enterprises	230	Overseas wholly-owned enterprises
		240	Overseas shareholding limited companies
Foreign-owned			
71	Foreign joint ventures	310	Foreign joint ventures
72	Foreign cooperatives	320	Foreign cooperatives
73	Foreign wholly-owned enterprises	330	Foreign wholly-owned enterprises
		340	Foreign shareholding limited companies
Shareholding			
62	Limited liability company	159	Other limited liability companies
61	Shareholding limited companies	160	Shareholding limited companies
Private			
31	Private wholly-owned enterprises	171	Private wholly-owned enterprises
32	Private cooperative enterprises	172	Private cooperative enterprises
33	Private limited liability companies	173	Private limited liability companies
		174	Private shareholding companies
Other domestic			
51	State-collective jointly operated enterprises	143	State-collective jointly operated enterprises
		149	Other jointly operated enterprises
52	State-private jointly operated enterprises		
53	Collective-private jointly operated enter.		
54	State-collective-private jointly operated enter.		
9	Other enterprises	190	Other enterprises

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