Recent Productivity Trends in China: Evidence from Macro- and Firm-Level Data

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Using macro- and micro-level data, this article examines China's productivity growth slowdown after 2007. The authors find that strong investment in infrastructure and housing led to lower returns to capital. Firm-level evidence suggests that limited market entry and exit and a lack of resource allocation to more productive firms were associated with slower manufacturing total factor productivity (TFP) growth. Earlier reforms had led to convergence in productivity between state-owned and private manufacturing companies, but this process stalled after 2007. China's growth potential remains high, but its long-term prospects depend on reversing the decline in TFP growth.

China's economy grew by 10 per cent annually in the 1978–2007 period, with productivity contributing significantly to this expansion. Productivity improvements within sectors as well as gains from the reallocation of resources between sectors—from agriculture to more productive modern industry and services—and between ownership groups—from inefficient state-owned enterprises (SOEs) to dynamic private firms—

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were especially important. However, China has experienced a marked deceleration in growth since the 2007–08 global financial crisis, to 6.0% in 2019.

This study examines the characteristics of China's productivity growth slowdown using both macro- and micro-level data. First, a standard growth accounting exercise suggests that the slowdown was, to a large extent, due to weaker TFP growth. Aggregate TFP growth slowed from 3.1 per cent per year in the 2000–09 period to 1.1 per cent in the 2010–19 period. Further evidence shows that the efficiency with which capital is used has declined. Capital stock estimates by sector show that strong investment in infrastructure and housing in response to the global financial crisis was associated with an increase in the capital-output ratios in these sectors, indicating lower returns to capital. Given that public infrastructure was no longer a major constraint on growth, government investment was subject to diminishing returns.

The second contribution of this study is to update previous firm-level studies of manufacturing sector productivity and to provide evidence of the productivity effects of China's SOE reforms. The authors conclude that, while within-firm TFP growth has remained resilient, limited market entry and exit, and a lack of resource allocation to more productive firms have been associated with slower manufacturing TFP growth since 2008. Furthermore, there was considerable convergence in productivity between SOEs and private companies in manufacturing after market reforms in the 1990s, although SOEs remained less efficient than private firms in their use of capital. However, the relative performance of manufacturing SOEs deteriorated as relative leverage rose after the global financial crisis. Overall, the process of SOEs catching up to private sector efficiency stalled after 2007.

Nevertheless, from the perspective of international convergence, China's growth potential remains significant. As per capita income and productivity are still far below those in advanced countries, there is significant room for catch-up growth. But China's long-term growth prospects depend on reversing the recent decline in TFP growth. This article concludes with some policy recommendations to ensure that China realises its potential for strong growth in light of recent external developments and domestic reforms.

LITERATURE REVIEW

The role of productivity in the growth experience of Asian economies has been debated in the literature for many years. In a 1991 lecture entitled "Making a Miracle", Lucas viewed these growth miracles as productivity miracles.[1] However, Young's findings in a 1995 article, "The Tyranny of Numbers", on growth accounting show the opposite: high Asian growth rates were mainly due to factor accumulation, with unusually low productivity growth.[2]

[1] Robert E. Lucas, Jr., "Making a Miracle", *Econometrica* 61, no. 2 (1993): 251–72.

[2] Alwyn Young, "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience", *The Quarterly Journal of Economics* 110, no. 3 (1995): 641–80.

Using growth accounting, this study finds that annual TFP growth in China averaged 3.0 per cent over the 1980–2009 period, generating 40 per cent of growth in output per worker. Bosworth and Collins, Perkins and Rawski, and Zhu obtain similar results,[3] while calculation of the TFP share of growth in other studies worked out to be somewhat lower.[4] In a 2012 article, Tian and Yu reported the findings of their meta-analysis of 150 papers and found that the mean aggregate TFP growth was about two per cent a year after 1978, accounting for about a fifth of GDP (gross domestic product) growth.[5] As other authors have done,[6] the present study also shows that, after three decades of productivity-driven growth, China has experienced a notable decline in TFP growth in recent years.

The second part of this article uses the Industrial Enterprise Survey of all large industrial firms collected by China's National Bureau of Statistics (NBS) to update through 2013 the firm-level productivity estimates for the 1998–2007 period, as given in Brandt et al., to compare manufacturing firm performance before and after the global financial crisis.[7] Brandt et al. find that the net new entry of firms accounted for more than two-thirds of manufacturing TFP growth before the global financial crisis, while the exit of firms and reallocation of inputs to more productive firms were limited. The updated results show that TFP growth in manufacturing decelerated after 2008, with market entry contributing to a much reduced productivity growth in recent years.

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[3] Barry Bosworth and Susan M. Collins, "Accounting for Growth: Comparing China and India", *Journal of Economic Perspectives* 22, no. 1 (2008): 45–66; Dwight H. Perkins and Thomas G. Rawski, "Forecasting China's Economic Growth to 2025", in *China's Great Economic Transformation*, ed. Loren Brandt and Thomas G. Rawski (Cambridge: Cambridge University Press, 2008), pp. 829–86; Zhu Xiaodong, "Understanding China's Growth: Past, Present, and Future", *Journal of Economic Perspectives* 26, no. 4 (2012): 103–24.

[4] Gregory Chow and Lin An-loh, "Accounting for Economic Growth in Taiwan and Mainland China: A Comparative Analysis", *Journal of Comparative Economics* 30, no. 3 (2002): 507–30; Robert C. Feenstra, Robert Inklaar and Marcel P. Timmer, "The Next Generation of the Penn World Table", *American Economic Review* 105, no. 10 (2015): 3150–82; Woo Wing Thye, "Chinese Economic Growth: Sources and Prospects", Working Paper no. 96–08, Department of Economics, University of California, Davis; Harry X. Wu, "Accounting for China's Growth in 1952–2008: China's Growth Performance Debate Revisited with a Newly Constructed Data Set", Discussion Papers 11003, 2011, Research Institute of Economy, Trade and Industry (RIETI [Japan]); Alwyn Young, "Gold into Base Metals: Productivity Growth in the People's Republic of China during the Reform Period", *Journal of Political Economy* 111, no. 1 (2003): 1220–61.

[5] Tian Xu and Yu Xiaohua, "The Enigmas of TFP in China: A Meta-Analysis", *China Economic Review* 23, no. 2 (2012): 396–414.

[6] Wei Shang-Jin, Xie Zhuan and Zhang Xiaobo, "From 'Made in China' to 'Innovated in China': Necessity, Prospect, and Challenges", *Journal of Economic Perspectives* 31, no. 1 (2017): 49–70; Harry X. Wu, "In Quest of Institutional Interpretation of TFP Change—the Case of China", *Man and the Economy* 6, no. 2 (2019): 1–22.

[7] Loren Brandt, Johannes Van Biesebroeck and Zhang Yifan, "Creative Accounting or Creative Destruction", *Journal of Development Economics* 97, no. 2 (2012): 339–51. Firm-level data that are representative of the service sector are not available. Hence, there is a significant shortcoming in the authors' analysis, given the growing importance of the service sector in China's economy.

This study next explores the differences in returns to factors of production as well as the differences in TFP levels of firms across types of ownership and across China's provinces. Several earlier studies have compared the performance of state-owned and private enterprises in the pre-crisis years. Using survey data based on a stratified random sample of 12,400 firms in the 2002–04 period, Dollar and Wei find large gaps in the returns to capital—between SOEs and private firms, between regions and between sectors.[8] Hsieh and Song use the NBS Industrial Enterprise Survey data for the 1998–2007 period to show that TFP and the average product of labour of SOEs converged to those of private firms, while the SOE average product of capital remained significantly lower than that of private enterprises.[9] In a 2009 article, Hsieh and Klenow find sizeable gaps in the marginal products of labour and capital across plants within the same narrowly defined sector in China compared with the United States.[10]

PRODUCTIVITY TRENDS AT THE MACROECONOMIC LEVEL

In the standard growth accounting framework, growth in output per worker can be allocated into contributions from changes in physical capital, employment, human capital (the education and skills of the labour force), and a residual, TFP.[11] TFP measures gains in economic efficiency (the quantity of output produced with a given quantity of inputs), including those driven by technological progress.

The data on output (real GDP), employment and the labour share of income (i.e. labour compensation divided by GDP) are from the NBS. The capital stock estimates are from Herd[12] and the human capital variable is from Penn World Table (PWT) 10.0.[13]

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[8] David Dollar and Wei Shang-Jin, "Das (Wasted) Kapital: Firm Ownership and Investment Efficiency in China", IMF Working Paper 07/09 (2007).

[9] Hsieh Chang-Tai and Zheng (Michael) Song, "Grasp the Large, Let Go of the Small: The Transformation of the State Sector in China", Brookings Papers on Economic Activity (Spring 2015): 295–346.

[10] Hsieh Chang-Tai and Peter J. Klenow, "Misallocation and Manufacturing TFP in China and India", *The Quarterly Journal of Economics* CXXIV, no. 4 (2009): 1403–48.

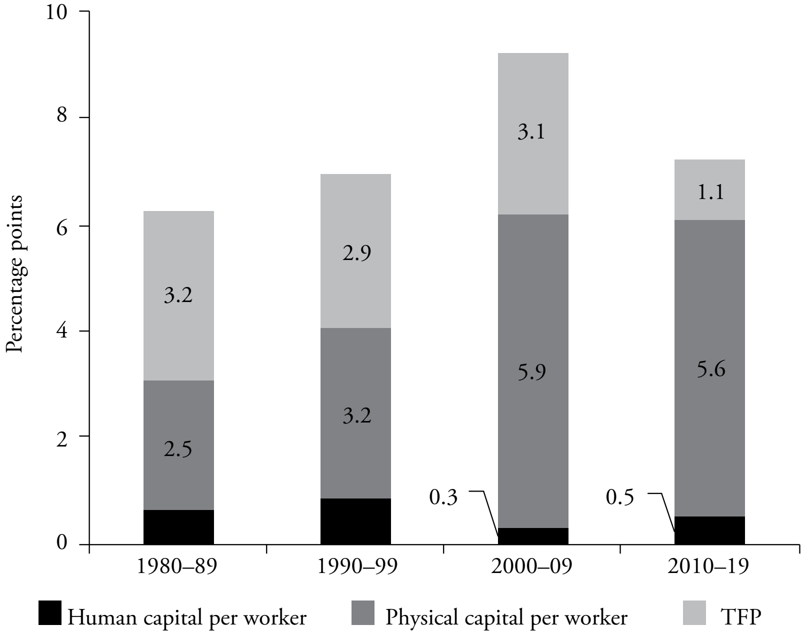
[11] In a Cobb–Douglas production function, output (Y) is a function of physical capital (K), the capital share of income (α), labour (L), educational attainment and the return to education (H), and TFP (A): $Y = AK^{\alpha}(LH)^{1-\alpha}$. Dividing both sides of the production function by the labour input L, taking logarithms of both sides, and taking first differences yields: $\Delta\ln(Y/L) = \alpha[\Delta\ln(K/L)] + (1-\alpha)\Delta\ln H + \Delta\ln A$. Growth in output per worker, $\Delta\ln(K/L)$, is decomposed into contributions from growth in capital per worker, $\Delta\ln(K/L)$, increases in education per worker, $\Delta\ln H$, and a residual measure of improvement in TFP, $\Delta\ln A$.

[12] Richard Herd, "Estimating Capital Formation and Capital Stock by Economic Sector in China: The Implications for Productivity Growth", World Bank Policy Research Working Paper, no. 9317 (2020).

[13] Feenstra, Inklaar and Timmer, "The Next Generation of the Penn World Table". The authors of this article used China's official statistics. PWT (Penn World Table) 10.0 adjusts China's GDP growth down by an average of 2.7 percentage points in the 1953–2019 period (with a standard deviation of 4.2) compared with National Bureau of Statistics (NBS) data. The average annual TFP (total factor productivity) growth in the PWT in the 1980–2019 period was 1.7 per cent versus 2.7 in the authors' estimates. Despite these differences, the two sets of variables are highly correlated with a correlation of 0.79 for output growth and 0.87 for TFP growth.

In China, the growth contribution of TFP was particularly high in the initial stages of market transition, when many structural reforms were implemented (Figure 1). Annual TFP growth averaged 3.0 per cent from 1980 to 2009, generating 40 per cent of growth in output per worker.[14]

Figure 1. Decomposition of Annual Average Growth in China's Real Output per Worker



Sources: Richard Herd, "Estimating Capital Formation and Capital Stock by Economic Sector in China: The Implications for Productivity Growth", World Bank Policy Research Working Paper, no. 9317 (2020); data from the National Bureau of Statistics, China; Penn World Table 10.0; and authors' calculations.

However, productivity growth decelerated sharply after the global financial crisis. TFP growth fell from 3.1 per cent per year in the 2000–09 period to 1.1 per cent in the 2010–19 period.[15] A slowdown in productivity was observed in many countries. In the PWT 10.0, world TFP growth (excluding China) decreased from 1.1 per cent in the five years before the global financial crisis to 0.6 per cent in the 2010–14 period. Several long-term trends have contributed to slower TFP growth globally, including

[14] An alternative method of decomposing growth would attribute to TFP both the direct increase in GDP due to TFP growth and the indirect effect that results from the endogenous increase in capital in response to higher TFP. Following this approach and multiplying TFP growth by $1/(1-\alpha)$ yields a growth contribution of 6.0 percentage points (four-fifths of growth in output per worker) from 1980 to 2009. Using the alternative growth decomposition, Zhu Xiaodong also finds that TFP accounted for 78 per cent of per capita GDP growth in China in the 1979–2008 period; see Zhu, "Understanding China's Growth".

[15] In the PWT 10.0 data, China's annual average TFP growth was 3.1 per cent in the 2000–09 period and 0.7 per cent in the 2010–19 period.

the declining effects of the information and communication technology boom, weaker investment, an ageing workforce, slower human capital accumulation and slowing global trade integration.[16]

Although external factors may have contributed to the slowdown in China's productivity growth, domestic issues and policy choices have also played a role. Since 2008, China has relied, to a significant extent, on physical capital accumulation which accounted for almost 80 per cent of growth in output per worker. High investment growth was in part driven by the large fiscal stimulus concentrated in infrastructure and housing which was introduced in response to the 2009 and 2015–16 growth slowdowns. During these years, the GDP share of gross fixed capital formation in the business sector declined, while the shares of infrastructure and housing increased (Figure 2). At the same time, the capital-output ratio in the infrastructure sector almost doubled, and that in housing increased by 56 per cent (Figure 3). Given that public infrastructure was no longer a major constraint on growth, government investment brought much lower returns to growth than in previous years. By comparison, the capital-output ratio in the business sector went up by about a quarter.[17]

Rapid improvement within sectors, as well as gains from the reallocation of resources between sectors, were key factors in raising China's labour productivity. Over the 1980–2019 period, productivity growth *within* sectors contributed 5.9 percentage points to aggregate labour productivity growth of 7.4 per cent per year (Figure 4).[18] The movement of workers *between* sectors generated 1.5 percentage points, while

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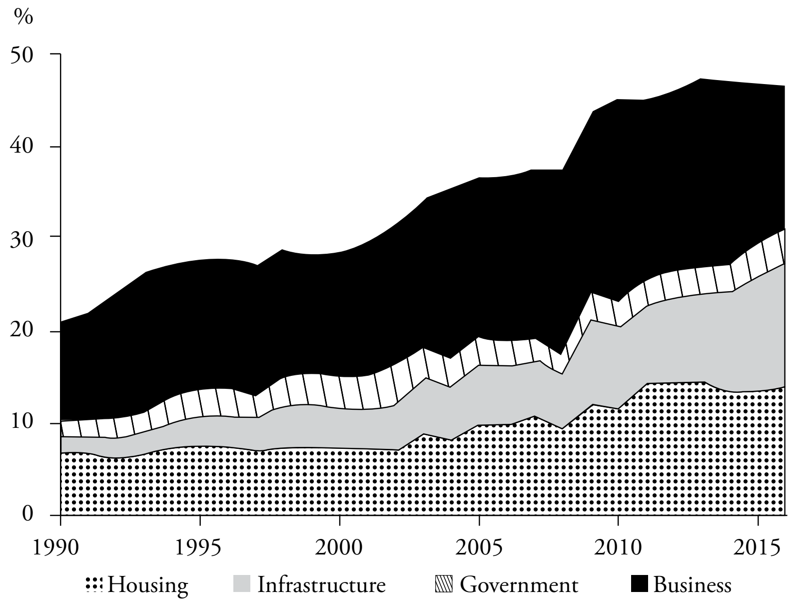
[16] Gustavo Adler, Romain A. Duval, Davide Furceri, Sinem Kiliç Çelik, Ksenia Koloskova and Marcos Poplawski-Ribeiro, "Gone with the Headwinds: Global Productivity", IMF Staff Discussion Notes, no. 17/04 (2017). See Robert J. Gordon, *The Rise and Fall of American Growth: The US Standard of Living Since the Civil War* (Princeton, NJ: Princeton University Press, 2016) for a discussion of the decline in TFP growth in the context of the United States.

[17] Herd, "Estimating Capital Formation and Capital Stock by Economic Sector in China".

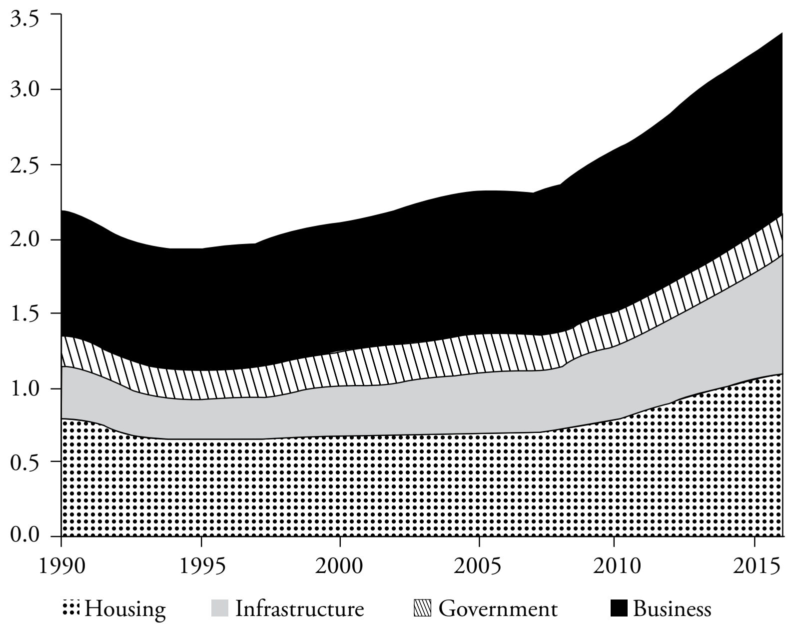
[18] The decomposition follows the methodology in Marcel Timmer, Gaaitzen J. de Vries and Klaas de Vries, "Patterns of Structural Change in Developing Countries", in *Routledge Handbook of Industry and Development*, ed. John Weiss and Michael Tribe (Abingdon: Routledge, 2015), pp. 65–83. Labour productivity growth can be decomposed into changes in productivity *within* individual sectors, weighted by the employment share of each sector (first term on the right-hand side of the equation below); *between-sector* productivity growth (i.e. the movement of workers to sectors with above-average productivity levels, second term); and a covariance term that captures the aggregate productivity effect of simultaneous changes in sectoral employment and productivity level (last term): $\Delta P = \sum_i \left(P_i^T - P_i^0\right) S_i^0 + \sum_i \left(S_i^T - S_i^0\right) P_i^0 + \sum_i \left(P_i^T - P_i^0\right)\left(S_i^T - S_i^0\right)$. ΔP is the change in aggregate labour productivity, while *Pi* and *Si* are the labour productivity level and employment share of industry *i*. The superscripts *0* and *T* denote the initial and final period. The *cross-sector* term is positive when labour is moving to sectors that experience positive productivity growth and it is negative when workers relocate to sectors with negative productivity growth. The latter may occur when the marginal productivity of additional workers in expanding sectors is below that of existing activities in those sectors. Such decomposition uses average rather than marginal labour productivity to compare productivity gaps across sectors. However, the reallocation of labour between two sectors affects output per worker in both sectors, likely reducing average productivity in the new sector. Hence, the gains from reallocation may be overestimated.

Figure 2. GDP Share of Real Gross Fixed Capital Formation by Sector



Source: Richard Herd, "Estimating Capital Formation and Capital Stock by Economic Sector in China: The Implications for Productivity Growth", World Bank Policy Research Working Paper, no. 9317 (2020).

Figure 3. Capital-Output Ratio by Sector



Source: Richard Herd, "Estimating Capital Formation and Capital Stock by Economic Sector in China: The Implications for Productivity Growth", World Bank Policy Research Working Paper, no. 9317 (2020).

labour moving to sectors with positive productivity growth (*cross-sector* effect) contributed 0.1 percentage points.

Tracking the standard path of industrialisation, labour moved from agriculture to industry. In 1978, 75 per cent of the labour force was in agriculture. That share declined to 26 per cent in 2019, as the tight controls on rural–urban migration were gradually relaxed and workers relocated to higher-productivity sectors. Between 1978 and 2010 (in which period more disaggregated data are available), the employment shares of manufacturing and construction increased by six and seven percentage points, respectively (Figure 5). Labour also moved to services, with the employment share of the trade, restaurant and hotel sectors rising by eight percentage points and that of non-market (community, social and personal) services by 12 percentage points.

In the decade (2010–19) after the global financial crisis, aggregate labour productivity growth weakened to 7.6 per cent per year, from 9.4 per cent in the 2000–09 period. Services experienced the largest decrease—from an annual average of 8.1 per cent in the 2000–09 period to 4.9 per cent in the most recent decade. Today resources are being reallocated from agriculture and industry into services.

The decline in productivity growth as the economy matures is almost inevitable.[19] As incomes rise, households spend more of their income on services. Correspondingly, higher-income countries tend to have a higher share of employment in services where productivity is generally lower than in industry. However, services in China have been much less open to competition and foreign direct investment (FDI) than industry, which has likely contributed to lower productivity. By one measure—the OECD services trade restrictiveness index (STRI)—China was ranked 42nd out of 45 countries and has shown limited improvement over time.

WEAKER PRODUCTIVITY GROWTH OF MANUFACTURING FIRMS

This section updates through 2013 the manufacturing productivity estimates developed by Brandt et al.[20] The new estimates facilitate the comparison of productivity growth in industry before and after the global financial crisis.

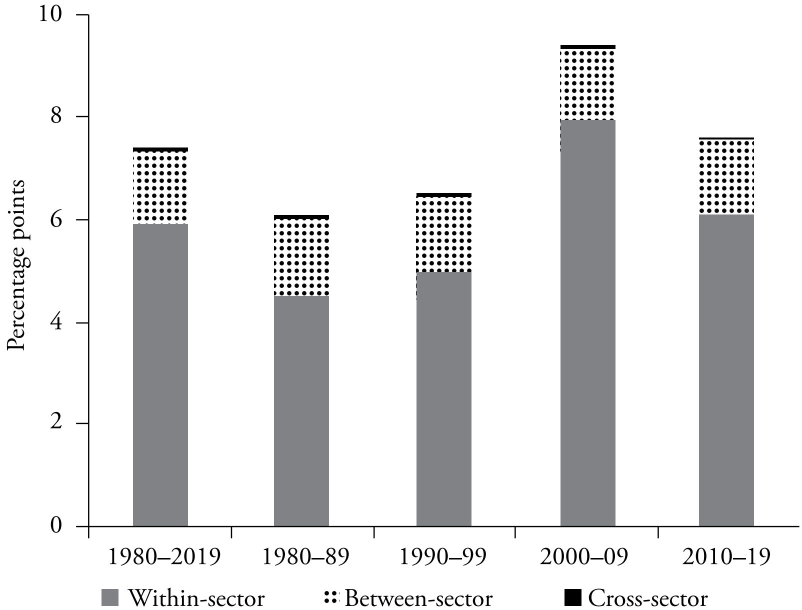
Data and Measurement Issues

The panel data are from the NBS annual Industrial Enterprise Survey which covers all industrial firms with annual sales above RMB5 million before 2010 and above RMB20 million thereafter. Several challenges, e.g. data availability and measurement, were encountered in the construction of the post-2007 productivity estimates.

[19] William J. Baumol, "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis", *American Economic Review* 57, no. 3 (June 1967): 415–26.

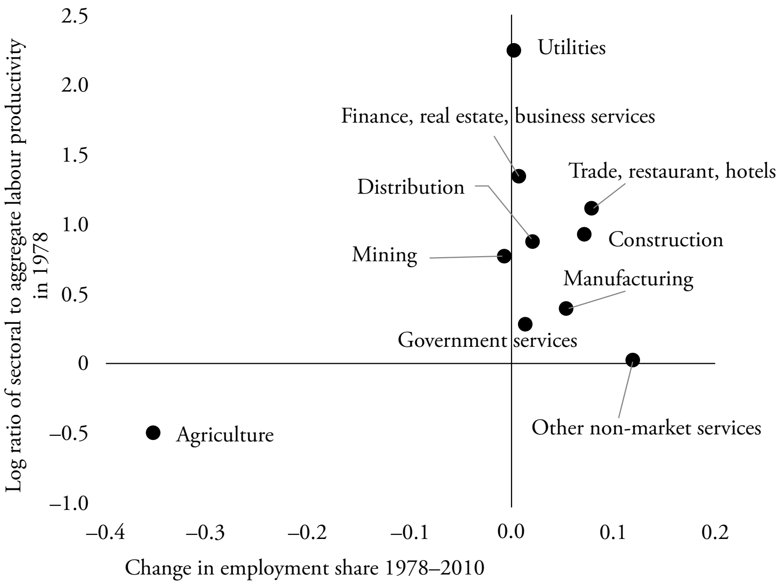
[20] Brandt, Van Biesebroeck and Zhang, "Creative Accounting or Creative Destruction"; Loren Brandt, Johannes Van Biesebroeck, Wang Luhang and Zhang Yifan, "WTO Accession and Performance of Chinese Manufacturing Firms", *American Economic Review* 107, no. 9 (2017): 2784–820.

Figure 4. Contributions to Annual Average Growth in Labour Productivity



Sources: National Bureau of Statistics, China; and authors' calculations.

Figure 5. Labour Moving Out of Agriculture



Sources: Marcel Timmer, Gaaitzen J. de Vries and Klaas de Vries, "Patterns of Structural Change in Developing Countries", in *Routledge Handbook of Industry and Development*, ed. John Weiss and Michael Tribe (Abingdon: Routledge, 2015), pp. 65–83; and authors' calculations.

First, there exists a large gap in observations between 2008 and 2011 in the data set. Data for 2009 sum up to the aggregate sector-level values reported in the *China Statistical Yearbook* but are inconsistent at the individual firm level for the 2007–08 data. There were also no firms that report 2009 as their year of establishment. The authors also did not have data for 2010. To deal with the missing data, the authors estimated a translog production function based on two-digit sectoral-level data from the unbalanced panel in 1998–2007, which they then used to estimate productivity at the firm level in 2008 and in the 2011–13 period.[21]

Second, as firm-specific prices are not available, input and output deflators at the sector level were used.[22] As a result, the authors were able to estimate only firm "revenue" productivity. An important implication of this is that the differences in revenue productivity between firms within a sector, as well as between types of firm (e.g. SOEs versus private, entrants versus incumbents) within a sector, will reflect differences in "true" efficiency and differences in firm market power as expressed in their markups over marginal cost. The same also applies for changes in firm-level revenue productivity over time: an increase in a firm's revenue productivity may be a consequence of either an improvement in efficiency or an increase in markups. In the case of firm ownership type, only under the assumption that relative market power remains the same (i.e. input and output prices change at the same rate by type of firm) will changes in revenue productivity map exactly into changes in efficiency.

The aforementioned is not an issue at the sector level. A measure of actual production efficiency in a sector can be obtained by aggregating revenue productivity of all firms within a sector, weighted by firm market share.[23]

The third data challenge is that value added at the firm level is not reported after 2008; hence, it is imputed using an equation that links value added with other variables in the NBS survey. The first step is to impute the values of intermediate input for the missing years. Production cost is estimated using available information on output value, sales revenue and sales cost, assuming that the ratio of production cost to output value is equal to the ratio of sales cost over sales revenue. Labour cost and capital depreciation are subtracted from the total cost to impute the cost of intermediate input:

Intermediate input = output × sales cost/sales revenue –
labour cost – depreciation (1)

[21] For a detailed discussion of the production function estimation, see Brandt, Van Biesebroeck, Wang and Zhang, "WTO Accession and Performance of Chinese Manufacturing Firms". To eliminate outliers (e.g. due to measurement errors), five per cent of the extreme values on both ends of the distribution for each year and industry pair were trimmed.

[22] However, the use of sector-level price deflators does not pose problems for the estimation of the production function coefficients.

[23] This can be seen by noting that $TFPR_{it} = \omega_{it} + \epsilon_{it} + \left(p_{it}^{Q} - \overline{p_t^{Q}}\right) - \beta_m \left(p_{it}^{M} - \overline{p_t^{M}}\right)$, where *TFPR* is revenue productivity; ω_{it} denotes efficiency; and $\left(p_{it}^{Q} - \overline{p_t^{Q}}\right)$ and $\left(p_{it}^{M} - \overline{p_t^{M}}\right)$ are deviations of firm output and input prices, respectively, from the sector means. The sum of *TFPR* of all firms within a sector yields $TFPR = \omega$.

However, information reported on labour cost had changed over time. Data on the wage bill, employment insurance and welfare payments were reported for the 1998–2002 period; pension benefits were added for 2003; and housing benefits for the 2004–07 period. For 2008, only the wage bill and welfare payments were reported; and for the 2011–13 period only the wage bill. To obtain a consistent measure of labour cost, the 2004–07 data were used to construct a four-digit industry multiplier—the average of the ratio of total labour cost (the sum of the wage bill, employment insurance, welfare, pension and housing funds) over the wage bill. This multiplier is applied to the value of the wage bill in years with incomplete information.

The imputed value added has four components: operating profits before tax (term 1), adjusted labour cost (term 2), capital component (term 3) and value-added tax (VAT) (term 4):

$$\textit{Imputed value added} = \textit{output} \times (1 - \textit{sales cost/sales rev}) + \textit{wage bill} \times \textit{industry multiplier} + \textit{depreciation} + \textit{VAT} \quad (2)$$

It is difficult to determine whether using imputed value added has a positive or negative impact on estimated productivity and productivity growth.

Fourth, there appears to be a systematic upward bias in the reported gross value of industrial output (GVIO) that increases over time when GVIO is compared to GDP by industry as reported in the national accounts. The inflation in the reported GVIO (*output* in equation (2)) thus affects imputed value added through the first term. Given that the share of that term in value added is around 50 per cent, the inflation in value added would be about 50 per cent of the inflation in GVIO. The inflation of GVIO affects estimated TFP via two channels: directly through the bias in the measure of output; and indirectly through the imputed intermediate input in equation (1).[24]

Fifth, there was a significant increase in reported employment in 2013. Total employment rose by 40 per cent between 2012 and 2013 in the firm-level data, with an increase observed across all firm types, sectors and regions. The increase was not due to the entry of new firms. Rather, it is a product of an overall shift of the distribution of firm-level employment to the right. Hence, the employment figures reported by province and by sector in the *2013 China Economic Census Yearbook* were used to adjust downwards the data in the Industrial Enterprise Survey.

[24] Given a ratio of sales cost to sales revenue of 85 per cent, labour and capital costs of roughly 13 per cent of total cost (or 11 per cent of total output value), and intermediate input of 87 per cent of total cost (or 74 per cent of total output value), an inflation by a factor of Y in GVIO will result in the inflation by a factor of X in imputed intermediate input: $X = (0.85 \times Y - 0.11)/0.74$, where $0.85 \times Y$ is the inflated estimate of total cost and 0.11 represents the reported (accurate) labour and capital cost. Given an output elasticity of materials of 0.8, the bias in the TFP estimate will be equivalent to $(Y - 1) - 0.8 \times (X - 1)$.

Sixth, the NBS changed the threshold for firms included in the Industrial Enterprise Survey from minimum sales of RMB5 million before 2010 to RMB20 million after 2010. If firms with sales between RMB5 million and RMB20 million are systematically different from larger firms, the analysis of productivity could be biased. For example, if these smaller firms have a higher average level of productivity, removing them from the sample will reduce the estimate of industry-level TFP.

To examine such a possibility, firm-level TFP is regressed on an indicator for firm size and industry fixed effects. The results show that the productivity of the "excluded" firms was on average lower than that of larger firms. This "discount" declined over time and was much smaller in 2008 than in 2007 but, conservatively, it was about 15 per cent. Second, the "excluded" firms' share of output declined over time to 4.1 per cent in 2008. Given that industry TFP is a weighted average of individual firm TFP, these results suggest that industry TFP and TFP growth were overestimated after 2010 and 2008, respectively, compared to earlier years. However, the bias is not likely to be too great as these firms represent a relatively small share of the aggregate.

Results

Average annual TFP growth in manufacturing fell from 2.0 per cent in the 1998–2007 period to 1.1 per cent in the 2007–13 period. This decline was spread across industries: 24 of 28 sectors at the two-digit level had lower TFP growth in the 2007–13 period than in the 1998–2007 period (Figure 6). More than a quarter of all sectors also experienced a decline in productivity levels.

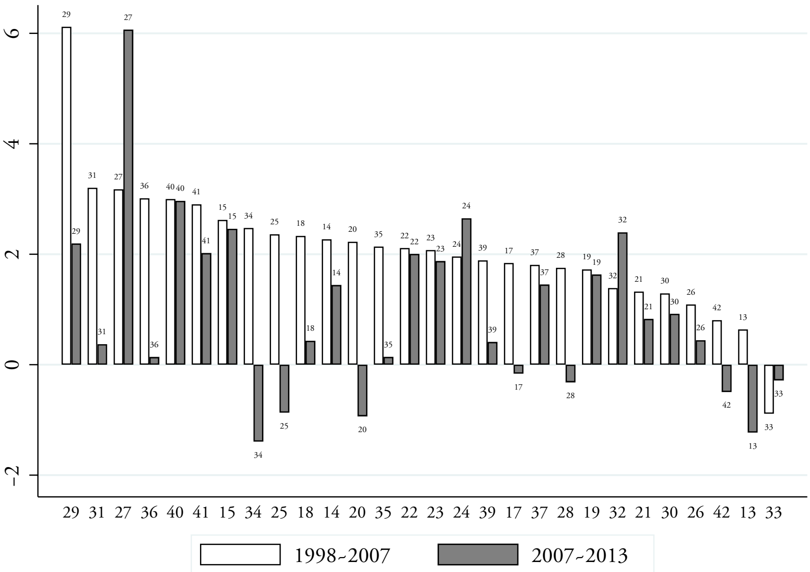
Industry TFP growth can be decomposed into improvements within incumbents, reallocation of resources to more productive existing firms, entry of new firms and exit of firms.[25] New firms would contribute positively if they entered the productivity distribution at a level that is higher on average than incumbents. Analogously, the exit of poorly performing firms could raise productivity. And reallocating resources towards more productive firms in the same sector could also improve sector productivity growth.

[25] Industry TFP growth is the sum of *within-firm* TFP growth (first term on the right-hand side of the equation) and three *between-firm* terms—reallocation of resources to more productive existing firms (term 2), entry of new firms (term 3) and exit of firms (last term):

$$\Delta y_t = \sum_{i \in C} \bar{s}_i \Delta y_{it} + \sum_{i \in C} \Delta s_{it} [\bar{y}_i - y_{t-k}] + \sum_{i \in E} s_{it} [y_{it} - y_{t-k}] - \sum_{i \in X} s_{it-k} [y_{it-k} - y_{t-k}],$$

where y_t is industry TFP; y_{it}, TFP of firm i in year t; s_{it}, the output share of firm i in the industry; and C, E and X denote the sets of continuing, entering and exiting firms, respectively, within each industry. Current TFP levels of firm i are normalised by y_{t-k}, the industry average TFP in the initial period $t–k$, based on John C. Haltiwanger, "Measuring and Analyzing Aggregate Fluctuations: The Importance of Building from Microeconomic Evidence", *Federal Reserve Bank of St. Louis Review* 79, no. 3 (1997): 55–77. Time-average weights are used for continuing firm, $\bar{s}_i$ and $\bar{y}_i$, as suggested in Zvi Griliches and Haim Regev, "Firm Productivity in Israeli Industry 1979–1988", *Journal of Econometrics* 65, no. 1 (1995): 175–203. This amounts to splitting a third covariance term, containing $\Delta s_{it} \Delta y_{it}$ interactions, equally between the first two terms.

Figure 6. Annual Average TFP Growth by two-digit NBS Sector



Notes: The tobacco sector, which is an outlier, is excluded. X-axis represents the NBS industry classifications: 14 food processing; 15 beverages; 17 textiles; 18 garments; 19 leather and furs; 20 timber and bamboo products; 21 furniture; 22 paper, paper products; 23 printing, record medium reproduction; 24 cultural, educational, sports goods; 25 petroleum refining and coking; 26 chemicals; 27 medical and pharmaceutical products; 28 chemical fibre; 29 rubber products; 30 plastic products; 31 nonmetal mineral products; 32 smelting of ferrous metals; 33 smelting of nonferrous metals; 34 metal products; 35 ordinary machinery; 36 special equipment; 37 transport equipment; 39 electric equipment and machinery; 40 electronics and telecommunications; 41 instruments and meters; 42 other manufacturing.
Source: Authors' estimates.

For the 1998–2013 period, two-thirds of the increase in productivity came from the entry of new firms (Figure 7).[26] To put this into perspective, the rate of entry of new firms averaged 10 per cent annually during that period. The other key source of growth was improvements in productivity of incumbents, which contributed 40 per cent.

Over the entire period, firm exit contributed negligibly to manufacturing productivity growth, reflecting one of several possibilities.[27] Poor-performing firms either did not exit or exited but accounted for only a small share of aggregate output. Or the productivity of some firms that exited was average or better. Similarly, there were no gains from reallocating resources (labour, capital, and intermediate inputs) to more productive firms, which, all else being equal, would have increased aggregate

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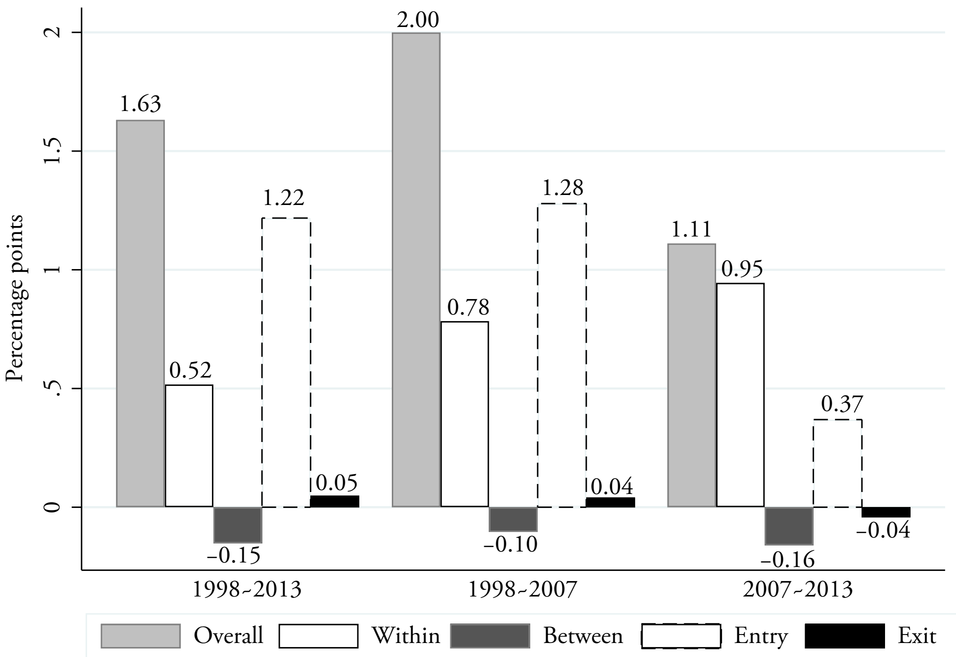
[26] New firms are those that were established in either the current year or previous year; the date was given in the NBS Survey.

[27] There is a potential measurement issue with respect to firm exit. There are two kinds of exit from the sample: (i) a firm's sales fall below the threshold of RMB5 million/RMB20 million, and (ii) a firm goes out of business. Theoretically, the productivity decomposition should measure the latter. This suggests that the above estimates of the contribution of exit to productivity growth may be biased upwards. The fact that the estimates are so small suggests this is not a big issue.

productivity. In fact, the contribution was slightly negative. By comparison, this is the most important source of productivity growth in advanced countries.[28]

Figure 7. **Decomposition of Annual TFP Growth in Manufacturing, 1998–2013**



Note: Calculations exclude the small number of firms that switched between sectors.
Source: Authors' estimates.

After 2007, average manufacturing productivity growth in China decreased almost by half. A key factor for the decline was the notably smaller TFP growth contribution of better entrants. In some sectors, the contribution of new entrants was actually negative, implying that these firms entered the productivity distribution at a point lower than the sector average. One possibility is that the entry process in these sectors depended less (and not more) on economic factors. So, firms with the highest potential did not get the opportunity to enter.[29]

Estimates of the rate of entry of new industrial firms with annual sales above RMB20 million indicate that, after falling slightly during the 1997 Asian financial crisis, entry rates rose from less than eight per cent annually in the late 1990s to more

[28] See, e.g., Eric J. Bartelsman and Phoebus J. Dhrymes, "Productivity Dynamics: U.S. Manufacturing Plants, 1972–1986", *Journal of Productivity Analysis* 9, no. 1 (1998): 5–34.

[29] Similar results are reported at the prefecture level in Loren Brandt, Gueorgui Kambourov and Kjetil Storesletten, "Barriers to Entry and Regional Economic Growth in China", *CEPR Discussion Paper No. DP14965* (2020).

than 12 per cent in 2004. Subsequently, entry rates began to fall and by 2013 were 3.54 percentage points lower. This suggests that a potentially important reason for the declining role of new firms in manufacturing productivity growth was the fewer number of new firms. In the end, most productivity growth in a sector came from incumbents.

Next, following the approach in Dollar and Wei's work,[30] the differences in productivity and profitability between state-owned and private firms before and after the global financial crisis are estimated. The pooled regression specification is:

$$\ln Y_{j,t} = \alpha + \beta_1 SOE + \sum year + \sum \beta_{2,t} year \times SOE + \sum industry + \sum year \times industry + \sum province + \ln employment_{j,t} + error_{j,t}. \quad (3)$$

$Y_{j,t}$ is one of five measures of the performance of firm j at time t: the logarithm of average real revenue product of capital (calculated as the ratio of real value added to the real capital stock); the logarithm of average real revenue product of labour (real value added divided by total labour); TFP; return on assets (ratio of operating profit to total assets); or leverage (ratio of total liabilities to total assets). The ownership variable, *SOE*, takes the value of "1" for majority state-owned enterprises and "0" for all other firms.[31] The sum of the coefficients $\beta_1 + \beta_{2,t}$ is interpreted as the relative efficiency of SOEs compared to private firms, holding other factors constant.

The rest of the dummy variables and interaction terms control for the effects of factors unrelated to ownership structure, including regional differences (for example, if SOEs are overrepresented in provinces with lower returns), industry- and year-specific shocks (say, if SOEs dominate an industry exposed to a large temporary shock such as a sharp rise in commodity prices), and also firm size (e.g. if SOEs tend to be larger, and enterprises employing more workers are on average less productive).

Confirming the results of Hsieh and Song (2015), Figure 8 shows that the gaps between returns to capital and labour in SOEs and in private competitors within manufacturing narrowed over the 1998–2007 period.[32] In the late 1990s, manufacturing sector returns to capital in SOEs lagged far behind private firms. Over time, the difference in returns declined to about 15 percentage points in 2011. This was still a sizeable gap, which widened again after 2011, likely indicating continued SOE

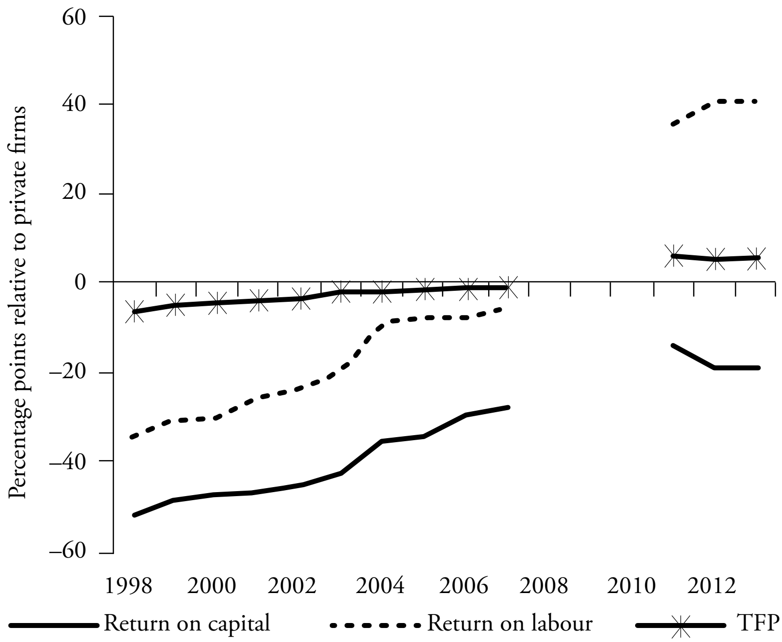
[30] Dollar and Wei, "Das (Wasted) Kapital".

[31] State-owned enterprises (SOEs) are firms in which the state paid-in capital share is larger than 50 per cent. Similar results are obtained if SOEs are defined as firms with 30 per cent or more state ownership and also if SOEs with foreign equity stakes are treated as non-SOEs (around 10 per cent of majority state-owned companies had some foreign ownership in the later years of the sample; that share was smaller in the earlier years).

[32] The regressions were estimated with standard errors clustered by firm. The results are available from the authors upon request.

preferential access to capital.[33] The difference in the returns to labour between SOEs and private firms in the late 1990s was smaller than the difference in returns to capital; that gap narrowed over time and even turned positive in the 2011–13 period.

Figure 8. **Efficiency of SOEs Relative to Private Firms**



Note: The figure plots the sum of the coefficients $\beta_1 + \beta_{2,t}$.
Source: Authors' estimates.

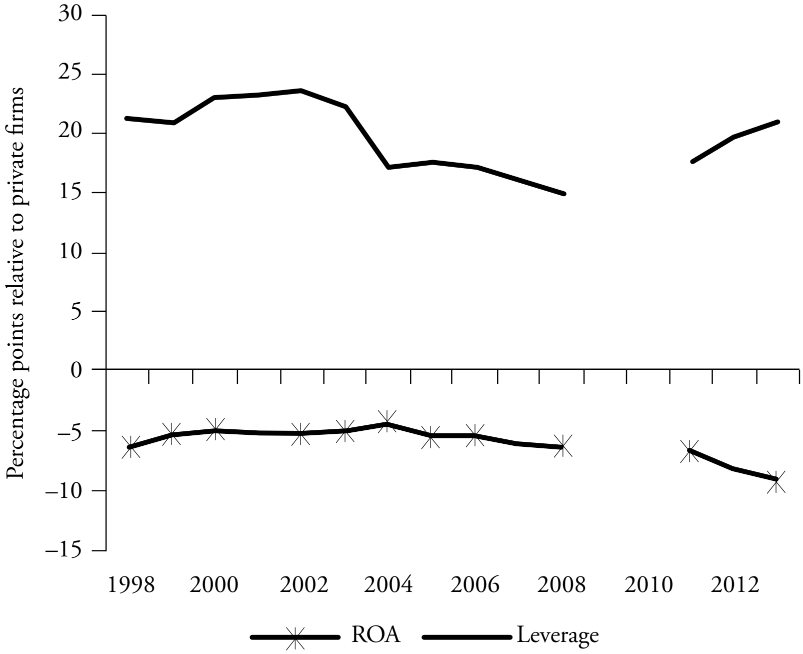
The TFP gap between state-owned and private manufacturing firms also narrowed and became slightly positive after 2007. However, this "revenue" productivity gap could reflect differences by firm type in either efficiency or market power, as explained above, and so should be interpreted with caution.

Finally, the estimated differences in the return on assets reveal that manufacturing SOEs were less profitable than their private competitors throughout the period. In 2013, SOE return on assets was on average 9.0 percentage points lower than that of private firms (Figure 9). The deterioration in relative profitability of the state-owned firms coincided with an increase in their relative indebtedness since 2008. While the leverage ratio of SOEs relative to private firms in manufacturing was on a declining

[33] Cong and Ponticelli find that a larger share of new credit in 2009–10 was allocated to state-owned, low-productivity firms than to privately-owned, high-productivity firms. However, their results rely to a significant extent on the 2009–10 NBS Industrial Enterprise Survey data which we have found to be less reliable than in other years. Cong Lin, Gao Haoyu, Jacopo Ponticelli and Yang Xiaoguang, "Credit Allocation under Economic Stimulus: Evidence from China", Chicago Booth Research Paper No. 17-19 (2018).

trend before the global financial crisis, it rose again after the crisis. The latest available data—aggregate numbers from the *China Statistical Yearbook*—suggest that the financial performance of SOEs had weakened further in recent years (Figure 10).

Figure 9. Profitability of SOEs Relative to Private Firms



Notes: The figure plots the sum of the coefficients $\beta_1 + \beta_{2,t}$. ROA: return on assests.
Source: Authors' estimates.

In the 1980s, non-SOEs were allowed to enter the market, boosting competition, and SOEs were given management autonomy. After 1992, China prioritised ownership reforms—large SOEs were corporatised and small and medium-sized ones were privatised ("grasping the large, letting go of the small"). SOEs shed redundant workers. In 2003, the State-owned Assets Supervision and Administration Commission was established with the goal to preserve and increase state-owned assets through restructuring and consolidation. In line with other studies,[34] the results of this study show that labour productivity and efficiency of manufacturing SOEs improved after 1998.

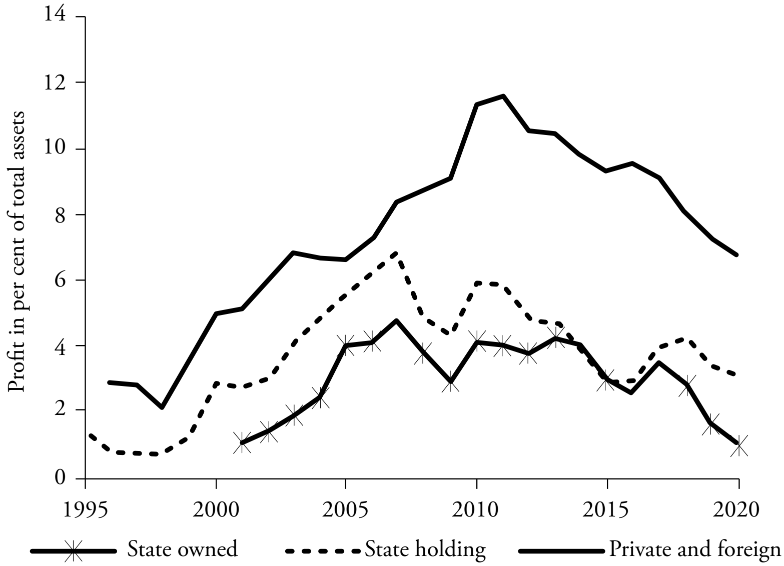
However, the results also demonstrate that industrial SOE performance—both in terms of efficiency and financially—worsened after 2007. According to the "multitask theory" of SOE reform,[35] SOEs were assigned a mix of commercial and policy objectives.

[34] Loren Brandt and Zhu Xiaodong, "Accounting for China's Growth", IZA Discussion Paper No. 4764 (2010); Hsieh and Song, "Grasp the Large, Let Go of the Small".

[35] Bai Chong-En, Lu Jiangyong and Tao Zhigang, "The Multitask Theory of State Enterprise Reform: Empirical Evidence from China", *The American Economic Review* 96, no. 2 (2006): 353–7.

As a result, SOEs played an important role in maintaining macroeconomic and social stability, and in investing in public infrastructure and in underdeveloped regions, which came at the expense of financial performance. To be able to provide these public goods, SOEs had benefited from a soft budget constraint (i.e. preferential access to government subsidies, tax exemptions, credit and land).[36] The deterioration in performance could reflect the role of SOEs in fulfilling public policy objectives in the aftermath of the global financial crisis, as they had done before the SOE reforms of the 1990s.

Figure 10. Aggregate Return on Assets in the Industrial Sector



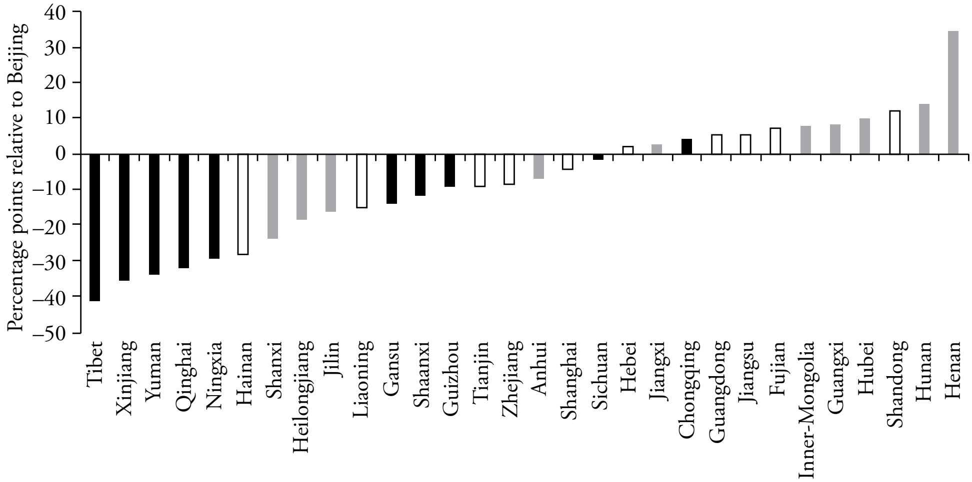
Source: National Bureau of Statistics, China; authors' calculations.

In addition to difference in performance between SOEs and private firms, there is a large variation in returns across China's provinces. Firms in many western provinces have considerably lower returns to capital than firms in central and eastern provinces (Figure 11).[37] This is partly the result of government policies supporting regional development inland.

Regional differences in "revenue" TFP growth before and after 2007 are also notable, with the caveat that these relative comparisons may be biased if there were systematic differences between regions in the behaviour of input and output prices. In the 1998–2007 period, productivity growth was robust in all regions (Figure 12). In the 2007–13 period, productivity growth fell sharply, and in all but two regions it

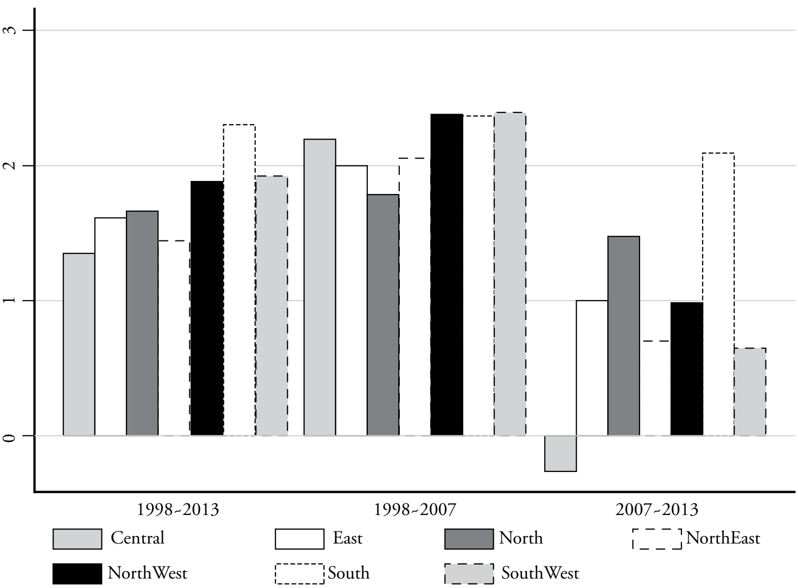
[36] János Kornai, Eric Maskin and Gérard Roland, "Understanding the Soft-Budget Constraint", *Journal of Economic Literature* XLI, no. 4 (December 2003): 1095–136.
[37] Similarly, the returns to labour are on average lower in many western provinces.

Figure 11. Average Difference in Returns on Capital across Provinces, 1998–2013



Notes: The figure plots the coefficient on province dummies. Western provinces are shaded in black; eastern ones in white.
Source: Authors' estimates.

Figure 12. Average Annual TFP Growth by Region



Source: Authors' estimates.

was negative or zero. Productivity growth fell least in the south, the region of the economy most likely exposed to the shock of the global financial crisis.

POLICY IMPLICATIONS

The macro- and firm-level evidence presented above identifies a sharp drop in productivity growth as an important driver of China's declining economic growth. To enhance productivity growth in recent years, policymakers have focused on fostering innovation. By some measures, China's innovation capacity has improved steadily, placing the country 12th on the Global Innovation Index.[38]

At the same time, China has substantial potential for catch-up growth. Per capita income is less than a quarter of the high-income country average at market exchange rates and less than a third in purchasing power parity (PPP) terms. Despite advances in sectors such as e-commerce, fintech, high-speed trains, renewable energy and electric cars, China generally remains distant from the global technology frontier. TFP is less than half that in the United States and lags the TFP levels in many middle-income countries (Figure 13). The adoption of more advanced technology and management skills from high-income countries, as well as improvement to the efficiency of resource allocation, can provide a less costly and more stable source of growth over the medium term.

However, China's access to foreign technologies has become more challenging. The country's overseas investment expansion has raised concerns in high-income countries over reciprocity in investment conditions. In recent years, China has reduced the number of sectors in which foreign investment is restricted or prohibited both in the "Negative List for Foreign Investment" and the "Catalogue of Industries Encouraging Foreign Investment". A new FDI Law, effective in 2020, explicitly prohibits forced technology transfer. These measures address some of the concerns over market access, intellectual property rights and foreign investor protection, but their impact will depend on successful implementation.

Achieving productivity growth through reallocation will require deepening reforms to increase the role of the market, the private sector and competition. China has recently introduced policies to improve the business climate. China climbed to attain 31st in the World Bank Ease of Doing Business rankings in 2020, gaining more than 40 positions from its 2018 ranking.[39] The analysis in this article points to additional reforms required to facilitate market entry and exit, deal with debt distress, and harden the budget constraints of SOEs.

The exit of less efficient firms is one of the main sources of productivity growth in many countries, but in China, the contribution of market exit to productivity growth has been negligible or negative. Strengthening market institutions for the

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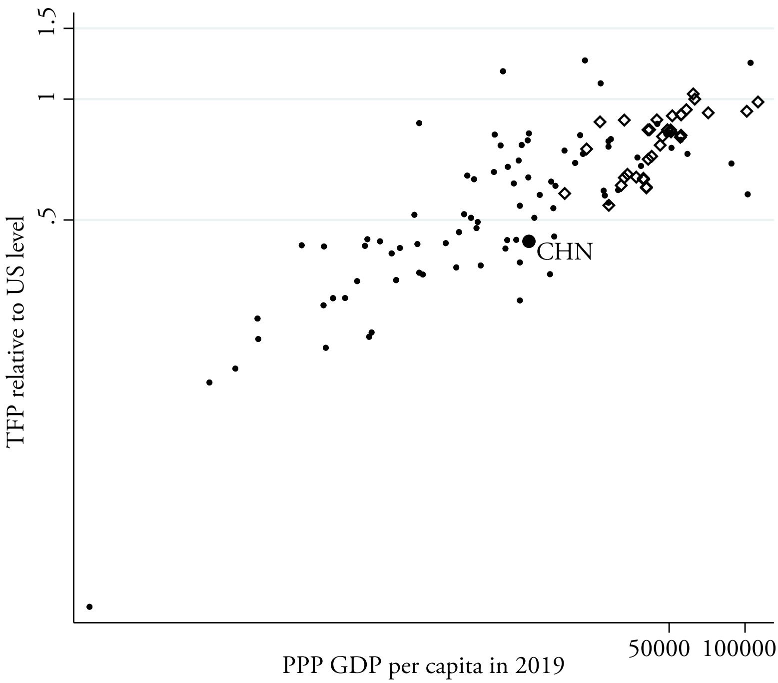
[38] World Intellectual Property Organization (WIPO), *Global Innovation Index 2021: Tracking Innovation through the COVID-19 Crisis* (Geneva: WIPO, 2021).

[39] World Bank, "Doing Business 2020" (Washington, DC: World Bank, 2020).

effective management of insolvency, firm restructuring and bankruptcy could accelerate productivity growth. China has recently made some progress in this area, with rising corporate defaults and debt restructuring through creditor committees affecting the pricing of risk in credit markets, but a deeper reform is needed.[40]

Figure 13. China's TFP Relative to the Global Technology Frontier, 2019



Notes: Diamonds indicate OECD countries. Both axes are in log scale.
Sources: Penn World Table 10.0; authors' calculations

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[40] International Monetary Fund (IMF), "People's Republic of China: Staff Report for the 2019 Article IV Consultation", IMF Country Report No. 19/266 (2019).