The two faces of urbanisation and productivity: Enhance or inhibit? New evidence from Chinese firm-level data

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The two faces of urbanisation and productivity: Enhance or inhibit? New evidence from Chinese firm-level data

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This study employs industrial survey data from China's National Bureau of Statistics covering Chinese manufacturing enterprises during the period 1998–2007 to examine the impact of urbanisation on total factor productivity (TFP) in various industries. In recent years, urbanisation development has varied greatly across China. So Chinese cities can be divided into three urbanisation categories based on the proportion of the urban population to the total population: highly urbanised areas (60 per cent and over), moderately urbanised areas (30–60 per cent), and low urbanised areas (0–30 per cent). We estimate industrial TFP levels across these three categories using the Levinsohn–Petrin semi-parametric estimation method. We also divide regional productivity into a productivity index and an industry composition index. We use aspects of these indexes to analyse the impact of urbanisation on TFP. The results confirm that urbanisation can lead to the gathering of economic activities, which in turn generates a positive impact on TFP by reducing transportation cost, promoting new technology spillovers, and encouraging a higher degree of specialisation. Further, the empirical results indicate that the highest TFP does not always occur in highly urbanised areas—most of the industries with the highest TFP are in moderately urbanised areas. These findings have important policy implications regarding how to improve the TFP of enterprises in order to generate scale effects.

Introduction

Urbanisation is one of the most important aspects of global change. The impacts of urbanisation have long been a major focus in economic geography, regional economics, management, and other related fields. Enterprises generally agglomerate in urbanised areas in response to urban population or industrial agglomeration (Marshall 1890; Weber 1929; Shefer 1973; Sveikauskas 1975; Segal 1976; Fogarty and Garofalo 1980; Moomaw 1981; Tabuchi 1986; Krugman 1991, 1993 and Cohen and Morrison-Paul 2009 among others). Along with economic growth, the spatial structure of economic

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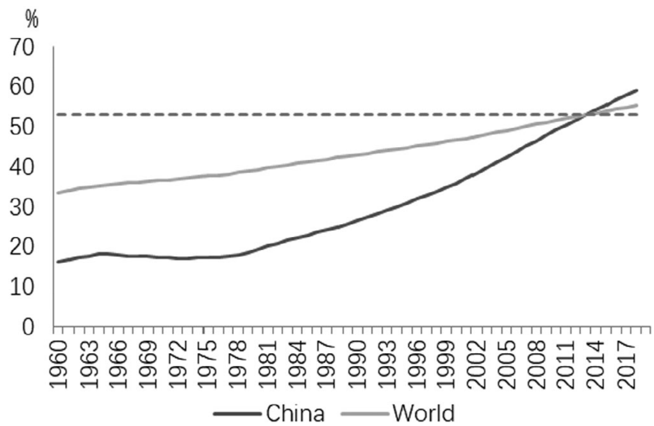
activities has also experienced significant changes. Geographically, enterprises tend to agglomerate in order to achieve increases in labour market scale, and diversity in product, as well as specialisation in production processes.

The level of urbanisation in China has increased significantly, with the urbanisation rate exceeding the world average of 53 per cent in 2013 (see Figure 1). The proportion of the services industry and consumption driven by urbanisation is rising, and urbanisation is becoming a new engine for China's development. It is estimated that China's urbanisation rate exceeded 60 per cent in 2019.[1] Meanwhile, the number of cities has also increased significantly. At the end of 1949, there were 132 cities in China. By the end of 2018, the number of cities reached 672, including 297 cities above prefecture-level, and 375 county-level cities. Moreover, the scale of the urban population has expanded significantly. At the end of 1949, the urban population was 39.49 million. By the end of 2017, the registered population in cities above prefecture level was 483.56 million.[2]

This paper studies the impact of urbanisation on total factor productivity (TFP) using industrial survey data from the National Bureau of Statistics (NBS) covering Chinese manufacturing enterprises with annual sales of at least RMB 5 million during the period of 1998–2007. China is particularly suitable for studying urbanisation effects because it is one of the most urbanised and densely populated places in the world, while also clearly exhibiting disparity across urbanisation development.

Enterprise agglomeration generally occurs in urbanised areas and usually we can see enterprises in the same industry gather in a certain area to maximise their profits (Schumpeter 1947). The geographic concentration of economic activities in urbanised areas can generate a snowball effect, where enterprises in the agglomeration area experience improvement in their TFP. The core thesis of this paper is that firms agglomerate in urbanised areas. We study the extent to which their productivity is able to benefit from urbanisation. To this end, Chinese cities are divided into three urbanisation categories:

Figure 1
China vs. world urbanisation rate



Source: WDI (2019).

[1] http://www.cs.com.cn/xwzx/hg/201910/t20191029_5993568.html
[2] http://www.stats.gov.cn/tjsj/zxfb/201908/t20190815_1691416.html

highly urbanised areas, moderately urbanised areas, and lowly urbanised areas. We estimate the TFP of enterprises in the different urbanised categories using the Levinsohn–Petrin semi-parametric estimation method, and then focus on the relationship between urbanisation and the TFP of enterprises. Empirical findings, based on our large sample of Chinese manufacturing firms for the period 1998–2007, show that the highest TFP does not always occur in highly urbanised areas: most of the industries with the highest TFP are in moderately urbanised areas.

This paper contributes to several strands of literature on urbanisation and productivity. We challenge the premise in previous research that urbanisation always has a positive impact on productivity (Mills and Mitra 1997; Krupka 2008). Second, given that China's urbanisation has increased significantly and rapidly and that it aims to base international competitiveness on firm performance such as productivity, this research should be of scholarly and practical value to researchers and practitioners who are interested in China's urbanisation and in its role in firm performance.

The paper is organised as follows: in Urbanisation and productivity: a brief review section, we provide a theoretical background and literature review; in The two faces of urbanisation and productivity section, we theoretically illustrate the relationship between urbanisation and productivity; in Enterprises' TFP estimation model section, we briefly introduce the semi-parametric estimation of enterprises' TFP and the econometric model; In Data and empirical methods section, we describe the industrial enterprise survey data from the NBS—which is used in our empirical analysis—and illustrate the productivity decomposition method. In Estimation results section, we test the causal relationship between urbanisation and productivity, and then use the LP semi-parametric estimation method to estimate the TFP of enterprises in the three urbanised categories. We next conduct a comparative study of different industries; after which we discuss the results. The last section is the conclusion.

Urbanisation and productivity: a brief review

Among the early regional studies, many have confirmed the positive relationship between urbanisation and productivity. As Mills and Hamilton (1994) point out, labour demands in a specific industry are subject to random uncorrelated, seasonal, or cyclical fluctuations. Hence, when more industries agglomerate in urban areas, the rate of employment increases. Higher levels of urbanisation also mean a larger overall labour market, and a larger service industry interacting with manufacturing industries. Further, it has been argued that average productivity increases with the scale of the labour market, as the average match between the workers' skills and job requirements improves with an increase in the scale of the labour market (Kim 1991). Fan and Scott (2003) also report a positive relationship between industrial concentration and province-level productivity. Additionally, specialisation of labour is related positively to the size of the labour market, as workers in larger labour markets tend to invest in more specialised human capital, in turn resulting in productivity growth (Kim 1989).

Higher productivity levels in larger urban areas can also be an outcome of higher technology levels, characterised by higher capital-labour ratios (Segal 1967). Using US data, Ciccone and Hall (1996) find a positive influence from population density on productivity. Based on Russian data, Kolomak (2012) assess the impact of urbanisation on regional productivity; the estimates obtained show that an increase in the share of the urban population by 1 per cent increased average regional productivity by 8 per cent. However, the effect of urbanisation is reducing. Growth in a city's size per 1000 residents would increase economic productivity by a mere 0.1 per cent. Based on Netherlands data, Louw et al. (2012) show that spatial productivity is influenced by the urbanisation rate. Using Chinese province-level data, Kumbhakar (2017) examine urbanisation's impact on productivity, revealing an urban Kuznets curve exists. However, in that case productivity is measured by GDP per capita. Rosenthal and Strange (2004) conclude that doubling the size of a city will increase the productivity of firms from 3 to 8 per cent in different countries. In any case, it is quite natural to recognise the 'productivity gained from the geographical concentration of human capital' (Rauch 1993). This line of research has been reviewed by Moretti (2004).

However, some research suggests the contradictory view that urbanisation has a negative effect on productivity. In examining the population density of US cities, Rappaport (2008) confirms a negative relationship between productivity and agglomeration and argues that it is because the productivity required to sustain above-average population densities exceeds, considerably, the estimates of the increase in productivity caused by such high population agglomeration. Broersma and Oosterhaven (2009) select a functional typology based on the degree of urbanisation and population density that is used by the CBS (Het Centraal Bureau voor de Statistiek)—as well as other government departments—to analyse the regional differentiation and find a negative agglomeration effect on productivity growth in The Netherlands. Andersson et al. (2009) suggest that aggregated productivity is increased by the deliberate policy of decentralisation.

There is also literature that focuses on comparisons between different regions. Ciccone (2002) empirically estimate agglomeration effects in France, Germany, Italy, Spain, and the UK. The results suggest that agglomeration effects in these European countries are only slightly smaller than agglomeration effects in the USA—that is, the estimated elasticity of (average) labour productivity with respect to employment density is 4.5 per cent as compared to 5 per cent in the USA. A study undertaken by Melo et al. (2009) lead to the conclusion that for China, Japan, and Sweden the rate of return is less than for the USA and France. Greenstone et al. (2010) quantify agglomeration spillovers by comparing changes in TFP among incumbent plants in both 'winning' counties that attracted a large manufacturing plant as well as 'losing' counties that were the new plant's runner-up choice.

With respect to industrial employment, Henderson (1986) finds a 10 per cent increase in own industry employment induces a 1 per cent increase in output. Sveikauskas et al. (1988) assert that productivity is associated with industrial size rather than city size in the food processing industry. Meanwhile, Nakamura (1985) estimates that a doubling of industry scale leads to a 4.5 per cent increase in productivity, while a doubling of city population leads to a 3.4 per cent increase. Some scholars study the urbanisation economies effect, Glaeser et al. (1992) find that local competition and urban variety—especially the spillover across industries—can increase employment growth, which contributes to enhancing productivity. Mitra (1999) attempts to assess the significance of agglomeration within two Indian industries—electrical machinery and cotton textiles—and the results suggest a positive association between technical efficiency and city size. Coulibaly et al. (2007) build a database combining two-digit manufacturing data and some geographical, infrastructural, and socio-economic data collected at the provincial level by the Turkish State Institute of Statistics. The sector-by-sector estimation confirms that the urbanisation economies effect is weak for natural-resource-based sectors such as the wood and metal industries. Wetwitoo and Kato (2017) estimate the agglomeration elasticities of 11 industries and compare the indirect benefit of productivity improvement generated by urbanisation among them. Xuan and Yu (2017) examine the impact of the agglomeration of urban producer service industries on the enterprises' TFP, and suggest that the spatial agglomeration of the producer service industry can improve the big city manufacturing enterprises' production efficiency.

Most research has shown the significant role urbanisation plays—both positive and negative—in firm-level productivity.

Henderson (2003) focuses on machinery and high-tech industries that allow for scale externalities from other plants in the same local industry—as well as from the scale or diversity of local economic activity outside their own industry—and shows that local information spillovers have significant productivity effects in high-tech industries, but not machinery industries. Cingano and Shivardi (2004) use a panel of plant-level data across Italian cities to estimate the long-run impact of city employment on firms' productivity. Lall et al. (2004) use a plant-level database to examine the impact of improved market access, intra-industry localisation economies and inter-industry urbanisation economies on Indian manufacturing firms' productivity. They find that access to markets through improved interregional infrastructure is an important determinant of plant-level productivity, whereas the benefits of locating in dense urban areas do not appear to offset the associated costs. Based upon the estimation of a translog production-inverse input demand system, Graham (2009) uses distance-based measures of localisation to test for the spatial transmission of externalities and identifies positive localisation economies for 13 of the 27 examined sectors. Combes et al. (2010) employ large-scale French firm-level data and find that productivity is higher in larger cities as well as denser areas. Widodo (2013) argues that the benefits of agglomeration mainly accrue to agglomerated firms in the form of externalities that improve efficiency as well as productivity through specialisation diversity and competition. Hervas-Oliver et al. (2017) focus on population agglomeration as drivers of TFP growth in Japan. Their results reveal that population agglomeration stimulates TFP growth, and that productive efficiency is higher in regions where manufacturing industries are concentrated.

There is a considerable body of research empirically assessing the impact of urbanisation on productivity, however, the mainstream of research is about developed countries and focuses at the regional and industry-level. Chinese firms have received less attention. Also, the existing empirical research has not demonstrated the positive impact of urbanisation on productivity. In particular, few studies have taken into account a possible non-linear relationship between urbanisation and productivity. Given that China's urbanisation growth rate increased dramatically over the past decade, productivity is an indicator of firm performance as it is representative of a firm's general resource efficiency (Datta et al. 2005), sustained competitive advantage (Lieberman and Dhawan 2005), and competitiveness (Koch and McGrath 1996; Causa and Cohen 2004). Thus more empirical research on urbanisation and productivity is required. This paper aims to advance this stream of research by paying attention to the impact of urbanisation on firm productivity, in emerging economies in general, and in China in particular.

The two faces of urbanisation and productivity

Along with urbanisation, the spatial structure of economic activities has also changed. Geographically, enterprises tend to gather in order to achieve product diversity and specialisation in production processes. As a result, the relationship between the spatial agglomeration of economic activities and the performance of enterprises is not only the focal point of geo-economics, but one of the core issues relating new economic growth theory to geo-economics.

Theoretically, urbanisation can positively affect productivity in several ways. The first way is through costs. If technologies have constant returns and the transportation of products from one stage to the next involves costs—which increase proportionally with distance—the production of all goods within a particular geographical area will have increasing returns, which can positively affect productivity. Next is the positive externality brought about by urbanisation and how its effect can promote productivity. If there are positive externalities associated with the geographical proximity of production, industrial agglomeration—which can help a large number of enterprises deepen the connection with each other—they can easily share innovative and managerial information as well as production resources such as capital and labour (Marshall 1890). Thus, knowledge spillover is important to production, especially for high-tech enterprises. At the same time, population and enterprise agglomeration in urbanised areas has a positive impact on regional infrastructure development. The effectiveness price of infrastructure services, such as power, water supply, and roads, is reduced if there is concentration of users of these services. To gain the economic benefits of industrial scale, professional services and the professional production of components will also be attracted to the region. Industrial concentration not only strengthens the forward and backward linkages, it also reduces the cost of operation by developing complementary services (Graham 2009). The third way involves enterprises improving production technologies and management while cultivating skilled labour due to the increasing competitive pressure in the high specialisation area, which will have a positive effect on enterprises' TFP.

Urbanisation also affects the local economy through the congestion effect, which in turn has a negative impact on productivity. The congestion effect refers to the excess-aggregation that may occur when a large number of enterprises agglomerate in the same city or region. When the number of enterprises exceeds the affordability of the local economy, there will be a series of adverse effects on regional economic growth, such as competition for public infrastructure and raw materials, excessive competition, and decline in corporate profits. As a consequence, when the congestion effect dominates, it impedes the improvement of productivity. Secondly, the congestion effect will result in various costs as the population increases. Brakman et al. (2001) believe that congestion will expose each firm to the problem of increasing costs, prompting manufacturers and workers to move from central cities to relatively dispersed marginal areas. In addition, the congestion effect brought by agglomeration exacerbates urban traffic congestion, which means that workers in large cities have to bear the burden of higher commuting costs. Therefore, urbanisation will cause enterprises and workers to face higher costs in the production process, which will have a negative impact on TFP.

Enterprises' TFP estimation model

When economists talk about productivity, they may mean either output per unit of a particular input such as labour or output per unit of all inputs, including labour, capital, and all other inputs employed in production. The latter measure is known as TFP, which is the output per unit of all inputs combined. It provides a more complete indicator of the economic efficiency of an industry. The classical method of estimating TFP starts with estimating the production function, and there are several methods—based on different production function estimation methods—for doing so. Because the simple linear method used to estimate the TFP of an enterprise may lead to simultaneity bias and sample selection bias, Olley and Pakes (1996) developed a method based on uniform semi-parametric estimation. This approach requires the proxy variable (investment) to be monotonically related to the total output, which means that some samples with zero investment cannot be estimated. In fact, not every economic activity has a positive investment, which leads to many samples being abandoned during the estimation process. To solve this problem, Levinsohn and Petrin (2003) propose a so-called LP semi-parametric method. This method does not use investment as the proxy variable, but rather the more easily available intermediate inputs. The intermediate inputs are more flexible, so they can reflect the changes in productivity more accurately. Therefore, this paper uses the LP method to estimate the TFP of enterprises.

The LP method has the following advantages. First, it can effectively resolve the endogeneity problem of production function estimation, and obtain consistent estimation of each parameter. Second, the LP method uses the intermediate inputs as the proxy variable, which is more accurate than the Olley–Pakes method and, also avoids the possibility of correlation between the estimators and the residuals. Finally, because data on investment is more often missing than values of the intermediate inputs, use of the LP method can reduce the loss of sample observations, which ensures the regression results are more reliable.

Data and empirical methods

Data

The firm-level data used come from the Annual Survey of Industrial Enterprises in China (ASIEC), which is conducted annually by the NBS. The ASIEC is the most comprehensive firm-level dataset in China and has been widely used (for example, Hsieh and Klenow 2009; Brandt et al. 2012; Aghion et al. 2015). The dataset covers all Chinese firms with an annual turnover of more than RMB 5 million for the period 1998 to 2007. It contains detailed information on these firms, including name, ownership, location, industry, assets, revenue, investment, profit, exports, employment, and cash flow. Brandt et al. (2012) show that these firms account for most economic activity in China. We cleaned the data through extensive checks for misrepresentations and coding mistakes. In particular, we dropped observations that had missing values for crucial financial variables (such as total assets, fixed assets, and industrial output). We also dropped firms with less than 10 employees. In addition, following Cai and Liu (2012), and guided by generally accepted accounting principles, we deleted observations if any of the following rules were violated: (1) total assets must be higher than current assets; (2) total assets must be larger than total fixed assets; (3) total assets must be larger than the fixed assets' net values; and (4) the year of its establishment must be valid. The data for estimation of the urbanisation rate for each city in China came from the China City Statistical Year Books.

The enterprises' intermediate inputs are the sum of values of raw materials, fuel, and electricity. The nominal value of each variable is deflated by the corresponding price deflator to obtain the real value. The price deflators are from the China Statistical Year Book, and all were adjusted to 1998 as the base period. For the first period of the enterprise appearing in the database, the real fixed asset equals the original value of fixed assets minus accumulated depreciation. For the second period, we used the perpetual inventory method to calculate the enterprises' real fixed assets, K_t, which means $K_t = (1-\delta)K_{t-1} + I_t$, where we assume the annual depreciation rate δ is 10 per cent. The manufacturing industries were identified on the basis of their GB classification[3] at the two-digit level, and include 30 industries in total. The urbanisation rate was calculated as the proportion of the non-agricultural population to the total population. Urbanisation rate measures the level of urbanisation of each city in China. The greater the absolute value of the index, the higher the urbanisation level of the city. The TFP was based on the real industrial added value, net fixed assets, number of employees, and the total intermediate inputs of each enterprise. Based on the enterprises' TFP, we calculate the industry TFP of each city by the weighted average method (using the added value of the enterprise as the weight).

The real industrial added value—the new value added by the production processes of enterprises—is one of the most important indicators and reflects the contribution of production to GDP. The annual net fixed assets reflect the actual amount of fixed assets of enterprises. Thus, the urbanisation rate can reflect the spatial agglomeration of cities. This paper divides Chinese cities into three categories: highly urbanised, moderately urbanised, and lowly urbanised. In these categories, the

[3] The National Economic Industry Classification (GB/T 4754) issued by the National Bureau of Statistics in China.

proportion of the urban population to the total population is 0–30, 30–60 per cent, and above 60 per cent, respectively. The greater the absolute value of the urbanisation index, the higher the urbanisation level of the city.

Econometric model

To examine the relationship between urbanisation and productivity, we estimate the following basic model:

$$Productivity_{it} = \alpha_0 + \alpha_1 urban_{ct} + \beta_i X_{it} + F_i + T_t + \varepsilon_{it} \quad (1)$$

where $Productivity_{it}$ is the TFP of firm i in year t, $urban_{ct}$ is the urbanisation rate of city c in year t. X_{it} is a vector of control variables that affect firms' productivity. We include firm-level variables: firm size (*size*), age (*age*), ownership (*SOE*), city-level variables: gdp per capital (*agdp*), higher education ratio (*education*), and foreign direct investment inflows/GDP (*FDI*). F_i is firm-fixed-effects, T_t is year-fixed-effects, $_{idt}$ is the error term. We lagged all the explanatory variables by one year. Variable definitions and measurements are provided in Table 1.

The effect decomposition of regional productivity

Using the above model, we estimate the TFP of all enterprises in the u region (u = high/moderate/low levels of urbanisation). In this section, we analyse differences in regional productivity across urbanisation categories and industry types by applying decompositions of productivity levels and changes following Rice et al. (2006) and Oosterhaven and Broersma (2007). Saito and Gopinath (2009) and Combes et al. (2009) identify and compare the importance of agglomeration factors and firm (and industry) selection for regional productivity. Therefore, in the decomposition we consider these two factors as sources of the spatial variation in regional productivity (productivity changes). First, differences in individual firm productivities (productivity changes) within each industry, resulting in different average productivities (productivity changes) across industries, depend on the strength of various agglomeration economies. Second, differences in the industry composition within each region

Table 1
Variable definitions and measurements

Variable	Measurement	Mean	S.D.
Productivity	Total factor productivity (TFP) of firm (firm-level)	6.319	1.007
Urbanisation	Urbanisation rate of city (city-level)	0.348	0.227
Size	Total assets, take logarithm (firm-level)	9.722	1.436
Age	Firm age, take logarithm (firm-level)	1.961	0.838
soe	If the firm is a stated-owned firm equals 1, otherwise equals zero (firm-level)	0.054	0.226
agdp	gdp per capita, take logarithm (city-level)	9.090	1.476
Education	The number of people in higher education/total population (city-level)	0.008	0.013
FDI	Foreign direct investment inflows/GDP (city-level)	0.043	0.036
Infrastructure	Highway milage/land area (city-level)	0.529	0.416
Innovation	Patent granted to each city, take logarithm (city-level)	4.854	1.494
Specialisation	Specialisation defined as the proportion of city c's patents accounted for by sector divided by the proportion of patents accounted for by this sector nationally	0.963	0.180

depend on firm (and industry) location choices driven by selection.

We use the added value of the enterprises s_u^n as a weight to estimate the TFP of industry n in the region, denoted by q_u^n. The total industrial added value of the region is $S_u = \sum_u s_u^n$. Therefore, the industrial added value of the industry n in the region u accounts for the proportion of the total industrial added value, that is $\overline{\lambda}^n = \sum_u s_u^n / \sum_u S_u$. The industry-wide TFP q_u is the weighted average of the industry's productivity using the industry's added value as the weight. Based on the above analysis, the regional productivity can be expressed with the following parts:

$$\mathrm{q_u} = \sum\nolimits_{\mathrm{n}} \mathrm{q_u^n} \lambda_u^n = \underset{(b)}{\sum\nolimits_{\mathrm{n}} \mathrm{q_u^n} - \lambda^n} + \underset{(c)}{\sum\nolimits_{n} - q^n \lambda_u^n} \text{-} \underset{(d)}{\sum\nolimits_{n} - q^n - \lambda^n} + \underset{(e)}{\sum\nolimits_{n} (\mathrm{q_u^n} \text{-} - q^n)(\lambda_u^n \text{-} - \lambda^n)} (2) \qquad (2)$$

Part (b), the first term on the right-hand side of Equation (2), is the average of the TFP of the region—that is, under the assumption that the industrial composition is the same in all industries. We call it the *productivity index*. Part (c) is the average level of TFP in the region u given the industrial structure of the region; but the productivity of each industry is equal to the average productivity of the industry in all regions. We call it the *industry composition index*. The differences in TFP in different urbanised areas can be reflected in the differences in the productivity index and the industry composition index. The difference in the productivity index reflects the spatial variance of the TFP for the industry with a large market share. By comparison, the discrepancy of the industry composition index is the spatial difference in the industries' market share that the industries are with higher TFP in different urbanised areas.

Table 2
Basic regression results

Dependent variable: *productivity*	(1)	(2)	(3)
Urbanisation	1.296***	0.578***	0.266***
	(97.45)	(43.45)	(18.60)
Size		−0.157***	−0.109***
		(18.46)	(12.65)
Age		0.109***	0.080***
		(58.06)	(41.74)
soe		0.285***	0.258***
		(171.49)	(151.20)
agdp			0.045***
			(45.03)
Education			4.823***
			(38.71)
FDI			−0.412***
			(10.07)
Constant	5.967***	3.265***	3.222***
	(1104.96)	(211.79)	(186.99)
Observations	804,024	803,493	797,663

Notes: The value in parentheses is the t value. ***, **, and * represent significant levels at 1 per cent, 5 per cent, and 10 per cent, respectively. We lagged all explanatory variables by one year.

Table 3
Testing channels

	Infrastructure	Innovation	Specialisation
Dependent variable	(1)	(2)	(3)
Urbanisation	0.935***	1.299***	0.056*
	(12.35)	(10.71)	(1.94)
Constant	0.231***	4.550***	0.954**
	(9.37)	(116.99)	(104.13)
Observations	2416	2501	2501

Notes: The value in parentheses is the *t* value. ***, **, and * represent significant levels at 1 per cent, 5 per cent, and 10 per cent, respectively. We lagged all explanatory variable by one year.

The two remaining parts, (d) and (e), measure the residual error covariance of industry productivity and industry value-added ratio. When considering the residual error covariance terms, a comparison between productivity index and industry composition index can provide useful information about the net impact of spatial agglomeration, as well as selectivity factors on regional TFP. If the covariance term for a given region is positive, it means that the market share of industries with higher TFP will also be relatively large, indicating a positive effect of regional specialisation.

Estimation results

Basic regressions results

Table 2 presents empirical results on the relationship between urbanisation and productivity. The coefficients are in columns (1), (2), and (3), and are all significant at the 1 per cent significance level. These results indicate that urbanisation can significantly increase TFP.

Testing channels

We investigate some of the channels through which urbanisation affects firms' TFP. Specifically, we investigate whether urbanisation reduces transport cost (*infrastructure*[4]), promotes new technology spillovers (*innovation*), and encourages a higher degree of specialisation (*specialisation*). The estimation results are provided in Table 3. The results suggest that urbanisation can lead to the gathering of economic activities, which has a positive impact on TFP through reducing transport cost, promoting new technology spillovers, and encouraging a higher degree of specialisation.

Analysis of input factors' contribution

After TFP estimation, we first make a preliminary analysis of the production function estimation in order to determine the contribution of capital and labour to economic growth. (The results are available upon request from the Corresponding Author.)

Looking across whole industries, the elasticity of the labour input is V-shaped in relation to the degree of regional urbanisation. The labour input elasticity of the highly-urbanised areas is the largest, while the elasticity in the moderately-urbanised areas is the least. This result indicates that the highly-urbanised areas have the largest capacity to absorb labour, while the moderately-urbanised areas are the weakest in this respect. The moderately-urbanised areas are based on labour-intensive activities—absorbing the largest amount of labour in manufacturing

[4] For variable definition and measurement, please see Table 1.

industries—so an increase in the labour force will have the least effect on the output due to the decreasing marginal return of labour. From the above result, we can conclude that in a highly urbanised area, when the labour force increases, output will have the highest growth rate. Therefore, labour has an incentive to migrate from a moderately-urbanised area to a highly-urbanised area.

The results suggest the elasticity of capital investment is positively related to the level of urbanisation. The higher the level of urbanisation, the greater the elasticity of capital investment. In a highly-urbanised area, due to the advanced development of the economy and labour skills, capital investment in manufacturing industries plays the greatest role in stimulating economic growth. However, the elasticity of capital investment varies among different industries, so capital investment has a strong incentive to move from low-elasticity industries to high-elasticity industries.

From the perspective of different industries, the input elasticity of labour is, for all industries, lower than that of capital in highly-urbanised areas; which indicates that manufacturing industries in highly-urbanised areas have almost become capital-intensive. Thus, we can divide all industries into three categories. In the first group, the input elasticity of labour is lower than that of capital in all three levels of urbanisation. There are 24 industries in this category, which are: *Manufacturing of agricultural and non-staple foodstuff*; *foodstuff manufacturing*; *beverage manufacturing*; *textiles*; *manufacturing of textile costumes, shoes, and caps*; *manufacturing of leather, fur, feather (cloth with soft nap), and their products*; *cabinetmaking*; *papermaking and paper product*; *printing industry and reproduction of record media*; *manufacturing for culture, education, and sports goods*; *petroleum processing, coking, and nuclear fuel manufacture*; *chemical feedstock and chemical manufacturing*; *medicine manufacturing*; *chemical fibre manufacturing*; *rubber production*; *plastics*; *non-metallic minerals product*; *ferrous metal smelting and extrusion*; *non-ferrous smelting and extrusion*; *general-purpose equipment manufacturing*; *transport and communication facilities manufacturing*; *electric machinery and equipment manufacturing*; *artwork and other manufacturing*; and *processing of discarded resources, and waste and scrap recovery*.

For the second group, the input elasticity of labour is lower than that of capital in both the high and middle level of urbanisation. This category includes three industries, which are: *Wood processing and manufacturing industry of wood, bamboo, rattan, palm, and straw-made articles*; *specialised facility manufacturing*; and *manufacturing of instruments and meters, and machinery for culture and office*.

In the third group, the input elasticity of labour is lower than that of capital in only the high-level urbanisation category, which includes three industries: *Tobacco*; *metalwork*; and *manufacturing of communication equipment, computers and other electronic equipment*. The industries in groups two and three can be regarded as relatively labour-intensive.

To sum up, we can conclude that, firstly, capital and labour inputs both have a positive

Table 4
Total factor productivity in three urbanised areas

Industry name	Highly-urbanised	Moderately-urbanised	Lowly-urbanised
Whole industry			
Labour	0.1438***	0.1105***	0.1249***
	(56.09)	(93.99)	(166.44)
Capital	0.2692***	0.2081***	0.2029***
	(153.24)	(72.37)	(31.90)
Observations	238,301	506,518	399,393
TFP	8.2038	9.1979	8.6011

Notes: The value in parentheses is the t value. ***, **, and * represent significant levels at 1 per cent, 5 per cent, and 10 per cent, respectively.

Table 5
Productivity, by two-digit industries

Code	Industry name	Highly urbanised	Medium urbanised	Lowly urbanised
13	Manufacturing of agricultural and non-staple foodstuff	7.1501	9.2488	8.0104
14	Foodstuff manufacturing industry	7.2901	8.2550	8.4235
15	Beverage manufacturing industry	7.5802	7.7665	7.2962
16	Tobacco industry	6.9247	8.6963	7.3453
17	Textile industry	8.2162	10.0301	5.7854
18	Manufacturing industry of textile costumes, shoes, and caps	8.5987	8.1648	8.4090
19	Manufacturing industry of leather, fur, feather (cloth with soft nap), and their products	7.7502	8.2931	8.5652
20	Wood processing and manufacturing industry of wood, bamboo, rattan, palm, and straw-made articles	8.2118	8.4532	10.0444
21	Cabinetmaking industry	7.7234	9.3108	7.7305
22	Papermaking and paper product industry	6.6353	7.5597	7.2199
23	Printing industry and reproduction of record media	7.1778	7.8314	7.6644
24	Manufacturing industry for culture, education, and sports goods	8.7063	8.8830	8.1573
25	Petroleum processing, coking, and nuclear fuel manufacture	8.7960	10.5608	8.6836
26	Chemical feedstock and chemical manufacturing industry	7.4143	8.6347	8.0447
27	Medicine manufacturing industry	7.1106	7.5670	7.7778
28	Chemical fibre manufacturing industry	8.0075	8.1596	7.6436
29	Rubber production industry	7.0236	8.0056	7.9537
30	Plastic industry	8.7524	9.4016	8.5505
31	Non-metallic minerals product industry	8.1650	9.0831	8.8924
32	Ferrous metal smelting and extrusion	8.2474	9.0378	9.2050
33	Non-ferrous smelting and extrusion	8.4381	8.3177	9.8185
34	Metalwork industry	7.4227	8.7607	7.7141
35	General-purpose equipment manufacturing industry	7.2414	9.5284	9.4118
36	Specialised facility manufacturing industry	7.3936	7.3585	7.7965
37	Transport and communication facilities manufacturing industry	6.0901	10.6075	7.7303
39	Electric machinery and equipment manufacturing industry	6.9548	8.4931	7.1507
40	Manufacturing industry of communication equipment, computers and other electronic equipment	6.9546	7.8658	7.2441
41	Manufacturing industry of instruments and meters, and machinery for culture and office	7.4512	7.9487	7.9603
42	Artwork and other manufacturing industries	6.4743	6.8897	7.5517
43	Processing of discarded resources, and waste and scrap recovery	7.2974	8.1192	7.4053

effect on the output growth of China's manufacturing industries; however, the impact of capital investment is greater than that of labour. For most sectors, the input elasticity of labour is lower than that of capital in all three urbanised categories. Lastly, the moderately-urbanised areas have the lowest ability to absorb labour, while the highly-urbanised areas have the greatest capacity to absorb capital investment.

Table 6
Effect decomposition of regional total productivity (industrial value added as weight)

	Regional TFP	Productivity index	Industry composition index	Residual covariance	
	(a)	(b)	(c)	(d)	(e)
Highly-urbanised	8.2038	7.3501	8.2337	8.5401	1.1601
Moderately-urbanised	9.1979	9.3101	8.1827	8.5401	0.2451
Lowly-urbanised	8.6011	8.5210	8.7225	8.5401	−0.1024

Table 7
Effect decomposition of regional total productivity (sales as weight)

	Regional TFP	Productivity index	Industry composition index	Residual covariance	
	(a)	(b)	(c)	(d)	(e)
Highly-urbanised	7.3430	7.7051	6.9542	7.2132	−0.1030
Moderately-urbanised	7.6915	8.0476	7.0101	7.2132	−0.1529
Lowly-urbanised	7.4014	7.6482	7.3211	7.2132	−0.3546

TFP of enterprises: classification analysis by region

We calculated the productivity of industry in regions with different levels of urbanisation (see Table 4). Across all industries, TFP is lowest in the highly-urbanised areas, at 8.2. The TFP in lowly-urbanised areas is 8.6. The moderately-urbanised areas have the highest TFP, at 9.2. These results indicate that either agglomeration is not positively related to urbanisation, or that agglomeration is not positively related to the enterprises' TFP. To further investigate this result, we next discuss TFP by industry.

TFP of enterprises: cross-industry comparison

After analysing the overall performance of enterprises in China, we further examine TFP from the perspective of two-digit industries. The results are reported in Table 5. It is worth emphasising that using the LP method for TFP estimation is based on micro-level data. The TFP of two-digit industries is the weighted average of enterprises' TFP—that is, the added value of the enterprise as a weight. The industry TFP is a reflection of the average level of TFP for all enterprises within the same industry.

For most industries, we find TFP is highest in moderately urbanised areas. We can conclude, therefore, that agglomeration has a positive impact on TFP. However, we also find that the agglomeration of manufacturing industries in China is not positively related to urbanisation. Although some existing literature has discussed this phenomenon, it is attributed to the congestion effect of highly-urbanised areas.

TFP of enterprises: decomposition of regional productivity

Here we split industry TFP into highly-urbanised, moderately-urbanised, and lowly-urbanised areas, respectively (the results are reported in Table 6).

According to the breakdown of total productivity, we assert that the productivity index of the moderately urbanised area is the highest, at 9.3. The highly-urbanised area and the lowly-urbanised area have a lower productivity index. The productivity index exists as an optimal value within the degree of urbanisation, which means that an increasing or decreasing degree of urbanisation will lead to a lower productivity index. The index for industry composition of the lowly-urbanised area is the highest, 8.7. For the other two area categories, the indexes are lower. The industry composition index is lowest in the moderately-urbanised area. These results indicate that the industries with higher TFP will take a higher market share when agglomeration is low. The covariance terms of the three urbanised areas are positive, which indicates that the industries with higher TFP have a larger market share. Highly-urbanised areas have the largest covariance term, which means productivity varies widely among industries with larger market shares in highly-urbanised areas. For a robustness check, we use the sales variable as the weight (the results are reported in Table 7).

Conclusion

Urbanisation is widely recognised as a driving force behind economic development at the macro-level and the survival and growth of firms at the micro-level, which has attracted considerable academic study, including investigating the urbanisation-productivity relationship. Most empirical evidence on the impact of urbanisation on productivity is positive (for example, Mills and Mitra 1997; Krupka 2008).

In recent years, China has rapidly urbanised, and has a high urban population density. In this paper, we study the effect of urbanisation on the TFP of enterprises in different urbanised categories. The results suggest that urbanisation can lead to the gathering of economic activities, which has a positive impact on TFP through reducing transportation costs, promoting new technology spillovers, and encouraging a higher degree of specialisation. Further, our results indicate that the highest TFP does not always occur in the highly-urbanised areas; most of the industries that have the highest TFP are located in moderately-urbanised areas.

We divide the TFP estimates into a productivity index and an industry composition index. The differences in the productivity index reflect the spatial variance of the TFP for the industries with a larger market share. The discrepancy of the industry composition index is the market share difference of industries with higher TFP that are within areas of a different urbanisation level. The productivity index is highest in moderately-urbanised areas, and within the productivity index exists an optimal value with the degree of urbanisation. The industry composition index is lowest in moderately-urbanised areas. These results indicate that the industries with higher TFP will hold a higher market share when agglomeration is lower. The covariance terms of the three urbanised categories used are positive, which indicates that the industries with higher TFP have larger market shares.

This study has important implications for further research and the policy agenda. First, while there is a considerable body of work empirically assessing the impact of urbanisation on productivity, most research is about the developed countries and from the regional and industry-level, research on Chinese firms has received limited attention. Our research contributes to the understanding of the variation in the urbanisation-productivity relationship among a large sample of firms in the same context and provides new evidence. Second, existing studies have largely focused on linear functions. Seldom has a nonlinear relationship been detected. This paper offers validation of the need for this study. We found that the highest TFP does not always occur in highly-urbanised areas—most of the industries with the highest TFP are in moderately-urbanised areas. Third, the paucity of literature on the interplay between urbanisation and productivity in China's unique context makes this study an important contribution. Though there is a growing trend of research on urbanisation in China, given China is one of the most urbanised and densely populated places in the world, while also clearly exhibiting disparity across its urbanisation development, we need to understand more about how urbanisation affects firms' productivity.

Our research is not without limitations. First, the empirical setting of the present study is based on a single emerging market context, China. Although the hypotheses are developed by taking into account shared features of emerging economies, the empirical findings may vary across emerging countries. Therefore, the generality of the findings needs to be established through future studies in different emerging contexts. Second, the service sectors play an important role in urbanisation. Since the dataset only has industrial sectors, we acknowledge this as a limitation of our study. Future studies may consider analysing the role of services sectors by utilising other sources of data.

AUTHOR CONTRIBUTIONS

Lichao Wu: Conceptualization (lead); data curation (equal); formal analysis (lead); investigation (lead); methodology (lead); resources (lead); supervision (lead); writing – review and editing (equal). **Yanpeng Jiang:** Investigation (equal); writing – review and editing (equal). **Lili Wang:** Methodology (supporting); writing – review and editing (equal). **Xinhao Qiao:** Data curation (equal); investigation (equal); software (equal).

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