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Urbanization Economies in China:
Nature, Location and Effects

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Abstract

The nature and location of urbanization economies and their effects on productivity per worker in China are examined. Unlike previous studies, more accurate resident-based measures of urban scale from the 2010 census are used. The size of urbanization economies is similar to those in other countries and they occur only in bigger cities and not in smaller towns, and operate only through tertiary sector activity. Efforts by government to disperse urbanization, through land use and migration restrictions and by stimulating construction and manufacturing in China's counties, are unlikely to create beneficial agglomeration effects.

Keywords

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JEL Codes

R12; O15

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1. Introduction

Spatial concentration of economic activity is an inherent feature of market economies (World Bank 2009) and is socially beneficial since firms and workers are more productive in dense and populous urban areas (Puga 2010). After three decades of market reforms in China, firms and workers are no longer trapped in place by either the central plan or by the *hukou* household registration system, allowing spatially concentrated patterns of development to emerge. This change is also reflected in the academic literature, with several recent studies estimating the size of agglomeration effects in China (for example, Au and Henderson 2006, Xu 2009, Combes, Demurger and Li 2015). These effects are the positive externalities due either to *localization economies* from firms being near to other firms in the same industry or to *urbanization economies* arising from the scale of an area and the diversity of its economy.

These existing studies rely on inappropriate measures of city scale, so findings need to be re-examined with better data. One problem is that sub-national population counts for China were not reliable before 2010 because they are for the population with local *hukou* registration (a *de jure* measure) and not the resident population (a *de facto* measure).[1] For example, Xu (2009) used the local *hukou* registered population for cities from 1990 to 1997, ignoring urban residents who had their *hukou* registration from elsewhere; at the time these non-*hukou* urban residents numbered more than 100 million (Chan 2012). Other statistical sources also are incomplete, perhaps because they continue to be collected and reported as they were when China was a state-run economy. For example, Au and Henderson (2006) measure city scale by employment but many private sector workers do not get counted in the data they use.[2] Combes et al. (2015) use urban density rather than employment or population counts, but their survey data are from a sample frame that excludes those urban residents whose *hukou* registration is from elsewhere.

In light of these data issues, this paper uses 2010 census of population data to study the nature, location, and magnitude of urbanization economies in China using more accurate measures of city scale. Another contrast with existing studies is that we test for urbanization economies over the entire hierarchy of urban units in China while previous studies tend to concentrate on one particular type of urban unit. Our results suggest positive effects of urban

[1] Li and Gibson (2013) discuss this data problem, which biases even simple descriptive claims. For example, Au and Henderson (2006, p.557) say China had nine cities over 3 million and 125 of 1-3 million in 2000; a ratio of large to small cities (0.07) well below the global average of 0.27. But measured by residents in the 2000 census, China had 20 cities over 3 million and 89 cities of 1-3 million, giving a ratio of 0.23. The 2010 census has 38 cities with more than 3 million residents versus 97 cities of 1-3 million, giving a large-to-small ratio of 0.39. Using the local *hukou* registered population rather than the resident population makes the ratio just 0.18.

[2] Au and Henderson use *City Statistical Yearbook* (*CSY*) data, where 'private sector' employment was titled as self-employed (with a very low share of the total) so employees are apparently excluded. Long-form census data on employment by sector in 2010 show that *CSY* substantially undercounts overall employment, with an average of only 43 percent of the employment for each city that the census reports in the same year.

scale on productivity that are of similar size to those found in other countries, but these effects occur only for urban districts (containing the core of prefectural cities) and not for county-level cities and smaller towns, and operate only through tertiary sector activity. Census data from 2000 and 2010 show that tertiary sector activity is ever more concentrated in the urban districts while secondary sector activity – especially construction and manufacturing – is moving into counties. Hence, these results imply that efforts to disperse urbanization towards counties and county-level cities will not generate beneficial agglomeration effects.

Understanding the nature of urbanization economies is one of the most policy-relevant research questions in China, where there is debate about whether small and medium-sized cities should be favored over expansion of existing mega-cities like Shanghai. Public policy in many places tries to foster agglomeration effects by luring mobile industry, by building clusters, or by attracting 'talent' (Combes, Duranton and Gobillon 2011). But efforts to shape urban structure are especially salient in China. There is a long history of planning policies that affect city size and location and even in the early reform era policy aimed to limit growth of big cities and favor small ones. The 1990 'City Planning Law' (*Zhonghua Renmin Gongheguo Chengshi Guihua Fa*) mandated 'strictly controlling the size of large cities and developing medium-sized and small cities' (Xu 2009). Many new cities in this era were simply relabeled counties; this experiment of creating cities was deemed a failure and was ended in the late 1990s (Fan *et al*. 2012). A period of more even-handed policy treatment followed, with the Tenth Five-Year Plan (2001-2005) seeking balanced development of large, medium-sized, and small cities and the Eleventh Five-Year Plan (2006-2010) emphasizing development of metropolitan regions. In tune with this more even-handed approach, the 1990 'City Planning Law' was replaced in 2008 by a new 'Urban and Rural Planning Law' (*Zhonghua Renmin Gongheguo Chengxiang Guihua Fa*) and the key phrase "strictly controlling the size of large cities" was dropped from the law (Fan *et al*. 2012).

But the policy pendulum is again swinging against the biggest cities. In 2014 President Xi Jinping announced *hukou* reforms to assist rural migrants into small towns and county-level cities but restrict their access to bigger cities: "…the overall principle is to fully remove *hukou* restrictions in towns and small cities, gradually ease restrictions in medium-sized cities, set reasonable conditions for settling in big cities, and strictly control the population of megacities".[3] In addition to ongoing *hukou* controls, big city growth also may be limited by land use controls. Citing food security concerns, land on the outskirts of the biggest cities like Beijing, Shanghai, and Guangzhou is being classified as "permanent basic farmland" to be used only for cultivation. In announcing these controls the Minister for Land and Resources, Jiang Daming, claimed that good farmland has been 'eaten by steel and cement'.[4]

[3] A report on the speech is here: http://english.peopledaily.com.cn/n/2014/0607/c90785-8738238.html.

[4] Details are in *Xinhua* 2014-11-04: http://news.xinhuanet.com/english/china/2014-11/03/c_133763130.htm

In spite of this pro-small policy bias, millions of non-*hukou* migrants voting with their feet seem to prefer large cities.[5] Our analysis of the 2010 census of population reveals two population relocation processes: First, there is an agglomeration process where about 1400 locations lost people due to non-*hukou* migration and just over 400 locations gained people; three-quarters of the gain is from 43 cities with more than 0.5 million migrants each. The second process is urbanization without agglomeration, which sees migrants without non-agricultural *hukou* found in over 1000 dispersed urban locations.[6] The strength of the agglomeration process is shown by there even being some cities that are losing population, because increasingly mobile workers and firms judge these cities as unsuitable locations for realizing urbanization economies, contrary to what central planners might once have thought. Given this mis-match between where migrants go and where urban planning policy may try to direct them, research on the nature and location of urbanization economies in China may contribute to better policy settings.

The next section gives a brief review of prior studies of agglomeration effects in China. Section 3 discusses the data, paying attention to China's different spatial units. Results from the 2010 census of population are used to describe the agglomeration and urbanization processes in Section 4, with changes in the economic structure of various spatial units examined using long form census data on sectors of employment in 2000 and 2010. The econometric specification and the empirical results for the elasticities of output with respect to urban scale are discussed in Section 5. These results include comparisons between economic sectors, and between types of spatial units. The conclusions are in Section 6.

2. Previous Literature

In one of the first and most widely cited studies for China, Au and Henderson (2006) found that output per worker had an inverted U-shaped relationship with city size in data from 205 cities in the 1990s.[7] The productivity cost of small cities (below the peak of the inverted U) exceeded that for oversized cities and these authors note that most Chinese cities were smaller than the peak point. This paper is the source of the often repeated claim that China has too many small cities, and foregoes agglomeration-based productivity gains as a result. But the data Au and Henderson (2006) use may not be the best for drawing these conclusions. They use city yearbooks that at the time only counted local *hukou* holders and did not include employees in private sector firms. But the GDP data reflected output of both private and state sector workers, and the consumption of both the locally registered *hukou* population and the

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[5] Non-*hukou* migrants are people who move somewhere other than where their *hukou* registration is from without converting either their type of *hukou* (agricultural or non-agricultural) or their place of registration (*hukou suozaidi*).

[6] The number of urban migrants in each urban unit is calculated as urban residents in the 2010 census minus the number with non-agricultural *hukou* registration for that place and totals 216 million.

[7] Specifically they use data for urban districts within some prefectural cities.

city residents with *hukou* from elsewhere. Hence, the measured scale of cities should reflect both types of population and the employment denominator for GDP should cover all types of workers.

A similar miscounting problem likely affects results reported by Xu (2009), who finds positive effects of city population and density on productivity (GDP per worker) using city-level panel data for urban districts in 155 prefectural cities in the 1990s. City size is from the locally registered population rather than from the actual number of residents, so it greatly understates the size of cities with many non-*hukou* residents. The GDP per worker data also have problems since city yearbooks did not count all private sector employees. It is thus unclear if the estimate of peak productivity at a city size of four million people is valid, which may undermine Xu's conclusion that most of China's cities are too small to achieve this peak level of productivity.

One way to sidestep problems with the employment denominator is to use survey data on wages, which is the approach of Combes *et al*. (2015). But findings in this study also may be distorted since the employment density variable is just for workers with local *hukou*, while the share of workers whose *hukou* is from elsewhere augments the 'native' density. The reason for separating these effects is unclear, since non-*hukou* residents should be an intrinsic part of urbanization economies, but it may reflect a limitation of the Urban Household Survey in omitting non-*hukou* residents from the sampling frame. Aside from this concern, an important contribution is made by Combes *et al*. (2015) in showing that workers in China do not appear to sort across cities, in terms of variation in the measured productive qualities of workers in cities of various sizes.[8] Consequently, micro data are not needed to control for cross-city variation in worker characteristics when urbanization economies are being estimated. This is advantageous since most survey data in China have gaps in sample frames due to the exclusion of non-*hukou* urban residents. Using city-level data rather than worker- or firm-level data is common in the literature on urbanization economies, and in the meta-analysis of Melo *et al*. (2009) the choice of data type is shown to have no influence on results.

In addition to these estimates of urbanization economies, a related literature describes the agglomeration process in China, concentrating on changing patterns of industrial location. For example, Ge (2009) estimates location regressions to explain the share that a locality has in national employment for each manufacturing sector. This analysis suggests that industrial agglomeration is driven by foreign trade and investment, and is centered on the east coast in places with easy access to foreign markets. Two concerns with this study are that the spatial units used (provinces) are quite broad and may miss finer scale patterns, and that there is no attention to the services sector. Yet services may have large urbanization economies because

[8] Even in developed countries there may be limited sorting of workers due to the complementarity of different labor types within local labor markets (Albouy 2008). For example, Eeckhout *et al*. (2014) find that both the very high and the very low skilled sort into the biggest U.S. cities and so average skill levels are constant across city size.

the proximity of service providers to consumers in denser cities allows greater substitution away from home production due to a lower time cost of buying services (Murphy 2013). In contrast, locations for the production and consumption of goods are more easily separated and so goods producers may not benefit as much from locating in a larger, denser, more diverse urban area.

3. Data Description

The data are from China's second and third administrative levels that are described in Appendix Table 1. In most of China the unit at the second administrative level is a prefectural city, *diji shi*. Every prefectural city has district(s), *shiqu*, and merging contiguous districts within a prefectural city gives urban cores that best correspond to a city proper (Roberts *et al.* 2012). Most prefectural cities also have counties that are largely rural (less than one-fifth of the registered population have non-agricultural *hukou*).

Prefectural cities also may have county-level cities, which are closer in urbanization to counties than to districts. In parts of China, especially in the west and southwest, the equivalent to a prefectural city is a League, a Region, an Autonomous Prefecture or a Provincially Administered area; there are 76 of these compared to 287 prefectural cities. These other types of second-level units are distinguished by having no urban districts, and contribute only a small share of GDP (3%) and population (6%) so we ignore them in our analysis. Our estimation sample is the 287 (merged) districts, 321 county-level cities and 1262 counties.

The dependent variable for estimating urbanization economies is non-agricultural GDP per worker in 2010, which we have for all districts, counties and county-level cities. We also use breakdowns of GDP into the secondary sector (which is mainly manufacturing and construction) and the tertiary sector (services). The long form census given to 10% of all households provides details on industry of employment, for 20 industries in 2010 and 16 broader industries in 2000. These industries and our concordances between the two years are defined in Appendix Table 2. The scale measure used to estimate urbanization economies is the urban resident population in the 2010 census. Summary statistics in Appendix Table 3 show that this averages 1.3 million people for (merged) districts and 0.2 million for counties (including county-level cities). It is also notable that average GDP per worker in the secondary sector is twice as high as in the tertiary sector, while it is only 12% higher in districts than in counties.

Several control variables also are included in the regressions, and are summarized in Appendix Table 3. These controls include the average years of schooling of residents in 2010, the employment rate, and proxies for the industrial structure of each urban area (the ratio of secondary sector to tertiary sector GDP and the share of the primary sector in GDP). The control variables also include measures of domestic market potential (using the Haversine formula to calculate average population-weighted distances to all other districts and counties

in China) and foreign market access (population weighted distance to the ten largest ports).[9] An instrumental variable for dealing with possible endogeneity in the urban scale of each county or district is also used, based on the count of people from each area who had non-agricultural *hukou* registration ten years earlier.[10] We rely on four main sources for these data: the city statistical yearbook (NBS 2011a), the statistical yearbook for regional economy (NBS 2011b), the yearbook on registered *hukou* population (MPS 2001, 2011), and the population census tabulations (NBS 2003, 2012a).

4. China's Agglomeration and Urbanization Processes

The 2010 population census reveals a process of funneling migrants from many source areas into just a few urban destinations. This is shown in Table 1, which classifies areas according to the scale of their in-migrant or out-migrant stocks, initially for the total population, and then in the bottom panel for just the urban population. The number of non-*hukou* migrants is calculated as:

$$M_i = PR_i - HR_i \quad (1)$$

where PR_i is the count of residents at location i in the 2010 census and HR_i is the number with *hukou* registration from location i. The number of non-*hukou* urban migrants (UM_i) is:

$$UM_i = U_i - NAi \quad (2)$$

where U_i is the urban resident population for location i in the 2010 census and NA_i is the number of people who had non-agricultural *hukou* registration from that place in 2010. The estimates of HR_i and NA_i come from the Ministry of Public Security (MPS 2011).

The funnelling noted above is seen in the top panel of Table 1. 110 million people came from over 1400 source areas to live in 460 destinations. This relocation affects both agricultural and non-agricultural *hukou* holders since the type of *hukou* is not being considered; some of these migrants will have had non-agricultural *hukou* and made urban-to-urban moves. Another view of the funnelling process is seen within rows in the top panel of the table; 84 million non-*hukou* out-migrants are registered in 1099 different counties yet as many in-migrants are living in just 62 districts (focusing on those with at least 0.2 million migrants) and just seven districts are home to 41 million non-*hukou* migrants.

Other evidence on spatial relocation of the population is shown by the fact that some urban areas are losing people, as shown in the right-hand columns in the bottom panel of Table 1. Specifically, there are almost 12 million fewer urban residents in some areas than the

[9] These are Shanghai, Shenzhen, Ningbo-Zhoushan, Guangzhou, Qingdao, Tianjin, Xiamen, Dalian, Lianyungang and Suzhou.

[10] The justification for this variable, and its relationship to other identification strategies, is explained in Section 5.

Table 1. Agglomeration and Urbanization Processes, as Revealed by Stocks of Non-*hukou* (Urban) Migrants in the 2010 Census

	In-Migrants						Out-Migrants				
	≥ 3mil	≥ 1mil	≥ 0.5mil	≥ 0.2mil	≥ 0mil	Total	≥ 1mil	≥ 0.5mil	≥ 0.2mil	≥ 0mil	Total
						Non-*hukou* Migrants					
District	40.9	27.6	9.3	7.1	10.5	95.4			3.0	4.1	7.0
	(7)	(20)	(13)	(22)	(139)	(201)			(12)	(74)	(86)
County-level City			2.4	2.9	4.0	9.3			7.7	11.4	19.1
			(3)	(8)	(86)	(97)			(26)	(198)	(224)
County				1.3	3.1	4.4		1.9	27.4	55.1	84.4
				(4)	(159)	(163)		(3)	(94)	(1002)	(1099)
						Non-*hukou* Urban Migrants					
District	38.8	30.5	12.9	18.3	15.0	115.4	1.5	0.7	1.7	1.3	5.2
	(7)	(20)	(19)	(61)	(154)	(261)	(1)	(1)	(5)	(19)	(26)
County-level City			5.4	10.7	17.5	33.6		0.6	0.4	1.7	2.7
			(8)	(34)	(232)	(274)		(1)	(2)	(44)	(47)
County			0.6	8.2	58.6	67.4				3.7	3.7
			(1)	(30)	(1092)	(1123)				(139)	(139)

Notes

Non-*hukou* migrants are the resident population minus the registered population, calculated by Equation (1). Sums of non-*hukou* in-migrants and out-migrants do not balance because the 'irregular' prefectures such as Leagues and Provincially Administered areas are omitted from the table. The non-*hukou* urban migrants are the urban resident population minus the non-agricultural registered population, calculated by Equation (2).

The table cells have the number of migrants, in millions, with the number of locations in ( ).

Sources: MPS (2011), NBS (2011a, 2012a).

non-agricultural *hukou* counts for those places; these are cities that in some sense are in the 'wrong' place since already-urbanized people voted with their feet by moving out of them to find agglomeration benefits elsewhere.[11]

In contrast to the agglomeration process, once the focus is on just urban residents and the holders of non-agricultural *hukou* (bottom panel), the urbanization process is apparent. In this bottom panel the most numerous cell is for counties with from 0-0.2 million more urban residents than their number of non-agricultural *hukou* registrations. The people who urbanize by moving from a village to their county seat, or whose village is engulfed as the county seat expands, are counted in this cell. We argue that this is a distinct process from the agglomeration process shown in the top panel where people have to, at the very least, leave their county to show up as a non-*hukou* migrant. Accounts of China's urbanization note that China has over 200 million rural-urban migrant workers, and this is confirmed in Table 1 by the total of 216.4 million non-*hukou* urban migrants. But little attention is paid to the unequal spatial distribution that results from migrants voting with their feet, shown in the top panel of the table. A lack of spatial awareness may contribute to misguided policies that encourage people to move to small urban locations thinking that it is urbanization that matters more than agglomeration.

Another way to consider differences between the two processes is in terms of scale. If we set an arbitrary rule that sites of agglomeration are urban areas that at least half a million people chose to move to, 46 districts and nine counties qualify. An average of 1.8 million in-migrants live in those 46 districts. For the county-level cities and county the average is 0.67 million. In contrast, the urbanization process shown in the other cells in the lower left part of Table 1 affects far more places – specifically, 1122 counties, 266 county-level cities and 215 districts – but the scale for each destination is tiny, averaging just 0.08 million in-migrants. Collectively the urbanization process is bigger (just over 60% of the 216 million non-*hukou* urban migrants are living outside the 46 districts we highlight as agglomeration locations) but far fewer people go to each of those small locations. Yet small places are the current target of China's land use and urbanization policy, encouraging migrants to settle in these places with an easier process of *hukou* conversion and with lower house prices (due partly to fewer land use restrictions).

The industrial composition of the workforce also shows the effects of public policy in encouraging urban growth in small places. In Table 2, long-form census employment data are used to compare 2000 and 2010. There was a 16.6 percentage point fall in agriculture's share of employment, with four industries increasing shares by about the same total amount. These industries, with percentage point increases in ( ), are: manufacturing (4.6%), construction (2.9%), transport (1.6%) and trade (5.5%).

[11] For example, the number of people with non-agricultural *hukou* for districts of Shantou city is 5.2 million but the urban resident population in 2010 was just 3.6 million, indicating a substantial out-migration.

Table 2. Distribution of Employment by Industry and Location, 2000 and 2010

	Employment Distribution by Industry			Distribution of Each Industry's Employment Across Spatial Units					
				----------2010----------			----------2000----------		
Industry	2010	2000	Change	District	County-level City	County	District	County-level City	County
Agricult	46.6%	63.2%	-16.6%	15.1%	19.4%	65.5%	15.7%	19.9%	64.4%
Mining	1.1%	1.1%	0.1%	41.9%	20.4%	37.7%	42.7%	22.7%	34.6%
Manufact	17.8%	13.1%	4.6%	50.9%	22.5%	26.6%	59.4%	20.1%	20.6%
Utilities	0.7%	0.6%	0.1%	57.9%	15.5%	26.7%	55.1%	16.6%	28.3%
Construct	5.7%	2.8%	2.9%	40.8%	18.7%	40.6%	50.9%	20.7%	28.4%
Transport	4.3%	2.6%	1.6%	55.5%	15.3%	29.2%	50.6%	18.6%	30.8%
Trade	12.4%	6.9%	5.5%	55.2%	16.5%	28.3%	55.0%	17.2%	27.8%
Finance	0.8%	0.6%	0.2%	70.1%	11.5%	18.4%	60.6%	13.7%	25.7%
Property	0.7%	0.2%	0.5%	81.2%	8.8%	10.0%	86.2%	6.9%	6.9%
Social Serv	2.7%	2.2%	0.5%	56.8%	15.9%	27.3%	64.5%	14.6%	20.9%
Research	0.7%	0.4%	0.4%	74.2%	10.4%	15.4%	76.6%	9.0%	14.5%
Welfare	4.0%	3.6%	0.3%	54.3%	14.8%	30.9%	46.5%	16.3%	37.2%
Govt	2.5%	2.6%	-0.1%	53.3%	14.2%	32.6%	46.4%	17.5%	36.1%
Total	100%	100%		35.2%	18.8%	46.0%	30.3%	19.3%	50.4%

Notes

Each industry is named and defined in Appendix Table 2, along with a concordance between the classifications in 2000 and 2010. Some industries are merged to allow the concordance; with 'Transport' being industries 6 & 7, 'Trade' being industries 8 & 9, 'Social Serv' being industries 12 & 15, 'Research' being industries 13 & 14, 'Welfare' being industries 16, 17 & 18, and 'Govt' being industries 19 & 20 in Appendix Table 2. Other than that, 'Agricult', 'Mining', 'Manufact', 'Utilities', 'Construct', 'Finance', 'Property' respectively refers to industries 1, 2, 3, 4, 5, 10, 11 in Appendix Table 2. Employment is defined as the population aged 16 or older working and receiving income (NBS, 2012c).

Sources: NBS (2003, 2012a).

Some of these growing industries are moving away from possible agglomeration effects; manufacturing and construction had declines in the shares of their employment in urban districts of about 10 percentage points while employment in counties rose, especially for construction. Indeed, 41 percent of all construction employment was in counties in 2010, compared with only 28 percent in counties in the 2000 census. Government-directed efforts at growing new cities in less urbanized regions typically require urban infrastructure and housing to be built, which may explain this dispersion of employment in the construction sector. Similarly, efforts of local governments to attract footloose manufacturing factories may account for the rise in the share of manufacturing employment in counties.

In contrast to dispersed construction and manufacturing employment, most large service industries in Table 2 show concentration of employment into urban districts. This concentration confirms that it is harder to separate the location of production and consumption for services than it is for goods, making services better candidates for urbanization economies (as seen below). Since China currently has a smaller services sector and a larger manufacturing sector than would be predicted from income levels (Ghani 2012), it is likely that future employment growth will be greater for services than for manufacturing as China attempts to rebalance the structure of the economy. In some sense, therefore, the employment growth of the secondary sector in counties and county-level cities may reflect an anti-agglomeration urban planning approach that will not best exploit the urbanization economies that are estimated in the next section.

5. Econometric Estimates of Urbanization Economies

We use local area GDP estimates and the 2010 census counts to relate output per worker to the size of the local urban population, letting the relationship vary between the sub-sample of counties (including county-level cities) and of districts:

$$ln(GDP_i/N_i)^d = \alpha^d + \beta^d lnU_i^d + \theta_j^d C_{ji}^d + \varepsilon_i^d \quad (3a)$$

$$ln(GDP_i/N_i)^c = \alpha^c + \beta^c lnU_i^c + \theta_j^c C_{ji}^c + \varepsilon_i^c \quad (3b)$$

where superscripts indicate if variables and coefficients are from the model for districts (d) or for counties (c), GDP_i/N_i is non-agricultural GDP per worker for area i, and U_i is the urban resident population there.[12] The parameter of interest is β, the elasticity of output per worker

[12] Studies of urbanization economies sometimes use wages to measure productivity, especially with micro data (see, for example, Glaeser and Mare 2001, Combes *et al*. 2010). Micro data for China typically omit the non-*hukou* migrants and city average wage data do not cover all private sector workers. We therefore use GDP per worker to measure productivity, and use urban resident population to proxy for city scale following studies such as Sveikauskas (1975) and Rosenthal and Strange (2004).

with respect to urban scale, which shows the urbanization economies.[13] The regressions include a rich set of covariates to deal with omitted variable bias. The control variables in C_j include dummies for each province, average years of schooling (to control for labor quality differences), employment rates (to control for labor utilization), proxies for the industrial structure of each area (*msgdp* and *gdp1*), and measures of domestic market potential and foreign market access.

But even with control variables included, the literature has a concern that the error term, ε_i may correlate with U_i due to 'endogenous quantity of labor bias' (Combes et al, 2011). Rather than firms and workers becoming more productive in a more populous area, it may be that being more productive – for whatever reason – causes an urban area to grow. To deal with this, studies typically use historical population as an instrumental variable (IV). The idea is that what affected population location in the agrarian past is different to what affects it today, but location patterns persist due to durability of housing and urban infrastructure.[14] China's command economy era means one does not need the distant past to find causes for the patterns of population location that differ from current causes. Under central planning China was too rural and had too many people in the interior, with regional self-sufficiency upheld for military reasons and to simplify planning. Also, the early Soviet-style focus on heavy industry favoured the northeast region, which was poorly situated compared to the coastal southeast once an outward-oriented strategy was adopted in the reform era. The factors affecting the planned urban ('non-agricultural') population in a given location in the command economy era are less relevant to location decisions in the market era, so the exclusion restrictions needed by a valid instrumental variable are plausible. It is possible to observe the 'echo' of the planned economy urban structure in modern data, since *hukou* status is inherited. So based on this reasoning, our instrumental variable is the non-agricultural *hukou* population for each location, as of the year 2000.

The main results of equations (3a) and (3b) are in Table 3, with more details in Appendix Table 4. In a pooled OLS regression the elasticity of output per worker with respect to urban scale is 0.09 (Table 3, column 1). But once we let coefficients differ between the sub-samples of districts and counties the effect of urban scale on productivity is seen to be almost three times as large for districts as for counties and county-level cities.

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[13] We do not follow Au and Henderson (2006) in using non-agricultural employment to proxy for city scale. While the right employment variable (from long form census counts, in our case) helps measure worker productivity, urbanization economies are really about the overall size of an urban area. A larger population may improve matches between workers and firms, and may let workers more narrowly specialize and raise their productivity (Puga 2010).

[14] Ciccone and Hall (1996), Combes *et al*. (2008) and Mion and Nattichioni (2009) use long lags of population as instruments, while Rosenthal and Strange (2008) and Combes et al (2010) also use geological characteristics. All of these studies find almost no endogenous quantity of labor bias, with elasticities of urban scale hardly changing in the IV estimates (see summaries in Puga 2010, p.207; Combes *et al*. 2011, p.261).

Table 3. Effects of Urban Scale on 2010 GDP per Worker for Different Spatial Units and Economic Sectors

	Non-agricultural Sector				Secondary Sector		Tertiary Sector	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV	IV	IV	IV	IV	IV
U	0.090							
	(0.013)***							
U^d (districts)		0.149	0.181	0.088	0.142	-0.008	0.226	0.151
		(0.037)***	(0.039)***	(0.038)**	(0.054)***	(0.052)	(0.031)***	(0.034)***
U^c (counties)		0.057	0.064	-0.028	0.025	-0.073	0.098	0.014
		(0.019)***	(0.022)***	(0.019)	(0.031)	(0.025)***	(0.018)***	(0.017)
α^d		4.506	5.218	-0.619	5.799	-4.131	4.232	0.583
		(0.483)***	(0.326)***	(2.456)	(0.445)***	(3.375)	(0.258)***	(2.225)
α^c		4.673	4.707	-0.479	4.672	-3.498	4.756	0.974
		(0.477)***	(0.472)***	(0.980)	(0.643)***	(1.346)***	(0.374)***	(0.888)
Constant	4.423							
	(0.275)***							
Full controls				Yes		Yes		Yes
Adjusted-R^2	0.29	0.99						
IV F statistic			2432	2235	2432	2235	2432	2235
Chow p-value		0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes

U is (log) resident urban population for districts (d) or counties and county-level cities (c). All models include province fixed effects. Other controls include *AYS*, ER, msgdp, gdp1, *DMP*, and *FMA* (defined in Appendix Table 3) used for the models in columns (4), (6) and (8) with detailed results in Appendix Table 4. The IV models use the (log) non-agricultural *hukou* population in 2000 as an instrument for U, and the IV F statistic is the Cragg-Donald first-stage F statistic for the instrument. The Chow p-value is for testing the null hypothesis that coefficients for the county-level model are the same as for the district-level model.

N=1870, with 287 districts and 1583 counties (1262 counties and 321 county-level cities). Standard errors are in parentheses. *significant at 10%; ** at 5%; *** at 1%.

The difference in coefficients between the county sub-sample and district sub-sample is statistically significant (p<0.01) according to a Chow test. The finding that urbanization economies are three times as large in districts as in counties persists when IV estimation is used (column (3)). The diagnostic tests for the IV models show that the number of people with non-agricultural *hukou* registration for each area, ten years earlier, is a very strong instrumental variable (first-stage F=2432). Using this instrument slightly raises the urbanization elasticities, by between one-fifth and one-tenth.[15]

In contrast to the small effect from using IV estimation, introducing the full set of control variables (in column (4)) reduces the elasticity of urban scale by one-half for districts, while for counties and county-level cities the elasticity becomes negative and statistically insignificant. The results for the control variables (in Appendix Table 4) suggest that the industrial structure of each urban area is a highly significant covariate, as are average school years and employment rates in counties, while domestic market potential in counties and district average school years are weakly associated with average output per worker. Controlling for all of these factors, the IV estimate of the elasticity of output per worker with respect to scale for urban districts is 0.088. As a reminder, these are the core of prefectural cities and average 1.3 million residents. In contrast, county-level cities and urban areas in counties average just 0.2 million urban residents and seem to provide no urbanization economies. Whatever else may be achieved by planners trying to steer rural migrants into these smaller urban areas, the results in Table 3 give no reason to expect any increase in local non-agricultural productivity by making these non-core urban areas bigger.

The output-scale elasticity of 0.088 for urban districts also has another implication, based on its similarity to findings in the literature for other countries. For example, Melo *et al*. (2009) report an average elasticity of urban scale of 0.08, based on 264 estimates from 34 studies across the world. Similarly, an early study by Sveikauskas (1975) has an elasticity of output per worker with respect to local population of 0.06, while the Rosenthal and Strange (2004) survey puts the elasticity between 0.03-0.08. The (merged) districts of China's prefectural cities best match the urbanized parts of the metropolitan statistical areas used in other countries (Au and Henderson 2006) so the elasticity reported here may be comparable to these results.

If urbanization economies for China are of similar size to those in countries where the city size distribution has been less distorted by mobility restrictions and planning policies, it suggests that China's contemporary city size distribution may be less malformed and may cause smaller productivity losses than is often claimed.[16] Indeed, a related study suggests that

[15] This corroborates the common finding in the literature that endogenous quantity of labor bias has minor effects.

[16] For example, the urban scale elasticity from survey data on Chinese wages in Combes et al (2015) is about three times what is found with similar data in other countries. This large elasticity could

most of China's cities are close to their productivity-maximizing scale, with the number of workers in cities that are too small about the same as the number in cities that are too big (Li and Gibson 2015).

In addition to showing the location of urbanization economies, the results in Table 3 help to reveal something about the nature of these effects in China. When output per worker in the secondary sector is considered separately from the tertiary (services) sector, it is apparent that urbanization economies operate only through tertiary sector activity. In the models using the full set of controls, output per worker in the secondary sector has no relationship with urban scale for districts, and has a negative relationship (with an elasticity of -0.07) for counties (column (6)). In contrast, for output of the tertiary sector, the scale elasticity is 0.15 for districts and is highly significant, while there is no significant effect of urban scale on tertiary sector productivity in counties and county-level cities (column (8)). Thus, to the extent that positive externalities due to urban scale exist in China, they appear to be a feature of the services sector only but even in that sector they only occur in the bigger urban areas that make up the core of prefectural cities.

6. Conclusions

In this paper we contribute to the growing literature on agglomeration effects in China, using data that are more reliable than those available to previous studies. It is only since China's 2010 census that accurate estimates of the urban population and of total employment are available. Since measures of local population scale are crucial for estimating urbanization economies, having these more reliable data makes it timely to re-examine previous results. Our data also are more comprehensive than those used in prior studies, covering the entire urban hierarchy, and coming from 287 prefectures that provide 97 percent of China's GDP. Prior studies have used samples with more limited spatial coverage and focus on only one type of urban unit, or else use survey data that omit major population groups, such as the non-*hukou* urban residents.

Our results show that effects of urbanization economies on China's non-agricultural GDP per worker are of similar size to what is found in other countries, with an elasticity of urban scale of about 0.09. The similarity to what is found elsewhere may count against the argument that a legacy of China's command economy era, and especially its *hukou* restrictions on population mobility, is that it does not reap the full agglomeration benefits that it might with a different urban structure. Indeed, even the simple descriptive claim that China has too many small cities relative to large ones can be questioned, since this claim is based on incorrect measures of city scale that use the number of people with local *hukou* registration (a *de jure* measure) rather than the actual number of residents (a *de facto* measure).

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be used as evidence that China is not yet fully exploiting available agglomeration benefits due to cities being too small.

Our focus on the resident population shows that an important reshaping of China's economic geography is under way, due in part to the effects of non-*hukou* migrants who have voted with their feet. The total of 216 million non-*hukou* urban migrants enumerated in the 2010 census represents two processes; a funnelling towards 46 urban districts that accounts for about two-fifths of the total, which we argue is an agglomeration process, and a more dispersed urbanization towards 1612 counties, county-level cities, and districts which we argue is not an agglomeration process.

A comparison of 2010 and 2000 census employment by industry data suggest that the dispersed urbanization operates especially through the secondary sector, with increasing shares of construction and manufacturing employment located in counties. In contrast, the services sector increasingly concentrates into the larger urban districts. There may be a mismatch between people's choices, as revealed by their funnelling into a few big cities, and a pro-small bias in China's urban planning policy that encourages migrants to settle in smaller, dispersed, urban areas through an easier process of *hukou* conversion and fewer land use restrictions.

Notwithstanding this pro-small policy bias, the econometric evidence is that agglomeration effects in China occur only in urban districts (the urban core of prefectural cities) and do not occur in county-level cities or counties. Moreover, it is only in the tertiary (services) sector that there are significant urbanization economies, with the secondary sector (manufacturing and construction) not showing a positive effect of urban scale on productivity. Specifically, our results suggest that a ten percent increase in scale for the urban districts of prefectural cities raises output per worker by 1.5 percent in the tertiary sector. In contrast, increases in urban scale for counties and county-level cities have no effect on output per worker in the tertiary sector and are associated with lower secondary sector output per worker.

These patterns imply that the recent efforts of local and central government in China to encourage a dispersed form of urbanization, by stimulating construction and manufacturing activity in counties, is unlikely to create beneficial agglomeration effects. A more even-handed urban planning approach that is not biased against the biggest cities is needed if China is to make the most of the potential productivity gains from its on-going urban transformation.

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Appendix

Table 1. Shares of Various Administrative Divisions in National Population and GDP, and Urbanization Rates, 2010

Admin Level *(Chinese Name)* (Number)	Registered Population	Resident Population	Non-agricultural Population	Urban Population	GDP	Non-agricultural Rate	Urban Rate
Prefectural City *(diji shi)* (287)							
District (*shiqu)* (287)	28.0%	34.8%	54.8%	53.9%	54.3%	66.7%	77.8%
County-level City (*xianji shi)* (321)	17.4%	16.8%	15.4%	15.1%	18.1%	30.0%	45.1%
County (*xian)* (1262)	47.1%	41.5%	24.9%	26.5%	24.2%	18.0%	32.2%
League *(meng)* (3), **Region** *(diqu)* (17),							
Autonomous Prefecture *(zizhi zhou)* (30)							
County-level City (49)	1.3%	1.4%	1.7%	1.5%	1.0%	42.4%	55.8%
County (358)	5.2%	4.7%	2.3%	2.3%	1.7%	15.0%	24.2%
Provincially Administered *(shengxia)* (26)							
County-level City (14)	0.7%	0.6%	0.8%	0.6%	0.5%	37.4%	46.5%
County (12)	0.3%	0.2%	0.3%	0.2%	0.1%	31.5%	36.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%		
Prefectural city	92.5%	93.1%	95.0%	95.5%	96.7%		
League, Region, Autonomous Prefecture	6.5%	6.1%	4.0%	3.8%	2.7%		
Provincially Administered	1.0%	0.8%	1.0%	0.7%	0.6%		

Notes: Prefectural cities include Beijing, Tianjin, Shanghai and Chongqing, which are at provincial level but are similar to prefectural cities (according to NBS, 2011a). A prefectural city's districts are contiguous areas, which collectively represent its city proper (Roberts et al, 2012). County-level cities here include Chongqing's 10 districts (Puling, Wansheng, Shuangqiao, Changshou, Jiangjin, Hechuan, Yongchuan, Nanchuan, Wanzhou and Qianjiang), Wuhan's 4 districts (Caidian, Jiangxia, Huangpi and Xinzhou according to NBS, 2011a), and Kunming's 1 district (Dongchuan). Counties here include banners (*qi*, 49), autonomous banners (*zizhi qi*, 3), and forestry area (1). There are 13 prefectural cities, Wuhai (Inner Mongolia), Xiamen (Fujian), Laiwu (Shandong), Ezhou (Hubei), Shenzhen, Zhuhai, Foshan, Dongguan and Zhongshan (Guangdong), Haikou and Sanya (Hainan), Jiayuguan (Gansu) and Karamay (Xinjiang) having neither county-level cities nor counties. Registered Population is from the 2010 *hukou* household registration system administered by the Ministry of Public Security, in which a household is given either "agricultural" (*nongye*) or "non-agricultural" (*fei nongye*) *hukou* by the local police station at the place of *hukou* registration. Resident Population is the population in the 2010 Population Census conducted by the National Bureau of Statistics of China, of which Urban Population includes households residing in urban areas in districts, county-level cities and counties while Rural Population includes the rest (NBS, 2012b&c). Non-agricultural Rate is the ratio of the non-agriculture population to the registered population while the Urban Rate is the ratio of the urban population to the resident population.

Sources: MPS (2011) noting that the reported registered population for districts and counties of five prefectural cities Fuyang, Suzhou, Bozhou, Liuan and Chaohu in Anhui province are incorrect and have been corrected by the authors according to NBS (2011a,b&c), NBS (2011a,b&c, 2012a).

Appendix

Table 2. Industry of Employment Definitions in 2010 and 2000 Long Form Census of Population

ID	2010	2000
1	Agriculture, Forestry, Farming, Fishery	Agriculture, Forestry, Farming, Fishery
2	Mining	Mining
3	Manufacturing	Manufacturing
4	Electricity, Gas, Water Provisions	Electricity, Gas, Water Provisions
5	Construction	Construction
6	Warehousing, Postal Services	Transportation, Warehousing, Postal, Telecommunication Services
7	Transportation, Computer, Software	
8	Information, Wholesale & Retail Trades	Wholesale & Retail Trades, Accommodation & Food Services
9	Accommodation & Food Services	
10	Finance	Finance & Insurance
11	Real Estate	Real Estate
12	Rental, Leasing, Business Services	Social Services
13	Scientific Research, Technical Services, Geological Survey	Scientific Research, Technical Services
14	Water Conservation, Environment, Public Facility Management	Water Conservation, Geological Survey
15	Resident Services	
16	Education Services	Education, Culture, Arts, Sports, Radio, Film, Television
17	Health Care, Social Security, Social Welfare	Health Care, Sports, Social Welfare
18	Culture, Sports, Entertainment	
19	Public Administration, Social Organizations	State Agencies, Party Agencies, Social Organizations
20	International Organizations	Others

Notes:
The long form census is filled in by 10% of households.
Compared to the usual census forms it has extra questions related to occupation, industry, marital status, family, and housing; ID is industry identification number.

Sources: NBS (2003, 2012a).

Appendix

Table 3. Variable Definitions and Summary Statistics

Variable	Definition	Districts		Counties	
		Mean	Std. Dev.	Mean	Std. Dev.
Dependent variables					
GDP/N	Non-agricultural GDP per worker (thousand yuan) in 2010	110.6	49.5	98.6	67.8
	Secondary sector GDP per worker (thousand yuan) in 2010	163.9	95.4	154.5	165.2
	Tertiary sector GDP per worker (thousand yuan) in 2010	79.7	34.4	68.3	38.3
Independent variables					
U	Urban resident population (millions) in 2010 census	1.26	2.09	0.18	0.14
AYS	Average years of schooling of residents in 2010	9.86	0.94	8.36	0.68
ER	Employment rate (employed workers/residents aged 16+) in 2010	0.62	0.08	0.72	0.07
msgdp	Manufacturing to service ratio (secondary GDP/tertiary GDP) in 2010	1.43	0.91	1.70	1.15
gdp1	Primary sector share in GDP (primary GDP/GDP) in 2010	0.07	0.07	0.21	0.11
DMP	Domestic market potential (distance to other districts/counties, kilometers)	1192	343	1154	313
FMA	Foreign market access (distance to 10 largest Chinese ports, kilometers)	1175	450	1165	405
IV	Instrument (non-agricultural *hukou* population in 2000, millions)	0.62	0.95	0.08	0.06

Notes

There are 287 districts and 1583 counties (including 321 county-level cities).

Sources: MPS (2001); NBS (2011a&b, 2012a).

Appendix

Table 4. Detailed Results for Control Variables in Models Reported in Columns (4), (6) and (8) of Table 3

	GDP/N					
	Non-agricultural Sector		Secondary Sector		Tertiary Sector	
	District	County	District	County	District	County
	(1)	(2)	(3)	(4)	(5)	(6)
	IV	IV	IV	IV	IV	IV
U	0.088	-0.027	-0.007	-0.067	0.150	0.014
	(0.027)***	(0.019)	(0.035)	(0.027)**	(0.026)***	(0.017)
AYS	0.506	1.087	1.154	1.334	0.106	0.937
	(0.289)*	(0.158)***	(0.377)***	(0.219)***	(0.275)	(0.143)***
ER	0.019	0.756	-0.661	0.845	0.835	0.845
	(0.314)	(0.167)***	(0.409)	(0.231)***	(0.299)***	(0.151)***
msgdp	0.192	0.130	0.265	0.249	-0.042	-0.113
	(0.021)***	(0.010)***	(0.027)***	(0.014)***	(0.020)**	(0.009)***
gdp1	-2.321	-1.967	-2.269	-1.725	-2.626	-2.103
	(0.371)***	(0.126)***	(0.484)***	(0.174)***	(0.353)***	(0.114)***
DMP	0.146	0.282	-0.187	0.257	0.502	0.485
	(0.269)	(0.164)*	(0.351)	(0.227)	(0.256)**	(0.148)***
FMA	0.346	-0.093	0.549	-0.097	0.049	-0.258
	(0.260)	(0.162)	(0.340)	(0.224)	(0.248)	(0.146)*
Observations	287	1583	287	1583	287	1583
IV *F* statistic	1587	3751	1587	3751	1587	3751

Notes

Variables in *italics* are in logarithms. Each regression also includes province-level fixed effects (30 for districts, 29 for counties and county-level cities).

The IV is the (log) non-agricultural *hukou* population in 2000. IV *F* statistic is the Cragg-Donald first-stage *F* statistic for the instrument.

The number of observations includes the 287 districts and 1583 counties (1262 counties and 321 county-level cities).

Standard errors are in parentheses. *significant at 10%; ** at 5%; *** at 1%. Variable definitions and summary statistics are shown in Appendix Table 3.