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The Erroneous Use of China's Population and *per capita* Data:

A Structured Review and Critical Test

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Abstract

Hundreds of studies in economics misinterpret China's sub-national population and *per capita* data. The most widely used population counts are of *hukou* registrations from each province, prefecture, county, or city rather than of the people living in each place and generating local GDP. Over 220 million people have left their place of registration, while almost none had when reforms began, creating time-varying errors in estimates of *per capita* income of sub-national units. We survey empirical articles in blue ribbon journals, in development journals, and in regional and urban economics journals that use China's sub-national data. Over 80 percent of articles use these data erroneously; most commonly the wrong population or employment counts are used to measure the size of sub-national units, and *per capita* data are calculated with the wrong denominator for the interpretation placed on variables. We provide examples of errors from each group of journals, and a critical test of one highly-cited study. Specifically, we show that if *hukou* registrations are erroneously used to measure the local population, following existing practice, conclusions about driving forces for urban area expansion are reversed. We give recommendations for more careful use of China's sub-national population and *per capita* data.

Keywords

JEL Codes

Acknowledgements

1. INTRODUCTION

Researchers who work with sub-national data for China face an important but largely ignored problem. The most widely available population counts for provinces, prefectures, counties, and cities do not count people living in each place. Instead they are counts of people with an address for their household registration (*hukou suozaidi*) from within each locality. Many people now live hundreds of miles away from their place of *hukou* registration so this is a *de jure* count of where they are legally registered to live rather than a *de facto* count of where they actually live. While these counts are reported in annual yearbooks put out by China's statistics office they are based on data from the Ministry of Public Security - China's police force – since Chinese are meant to (but, evidently, no longer do) stay registered at local police stations. It is only the census counts - available every ten years - that fully enumerate China's population on a resident basis.

The 'counting errors' from treating the *de jure* count of *hukou* holders from a particular place as the *de facto* local population may distort economic analysis since population counts are central to many branches of applied economics. First, and most obviously, the *de jure* count of *hukou* holders does not correspond to the population who consume and produce local GDP. Second, in urban and regional economics, the size of cities is used to study the scope for higher productivity from agglomeration effects, so if the wrong measure of population or employment is used it may bias results. Third, in studies of economic growth, welfare, and inequality, interest is usually in income or output *per capita* and the rate of change in these variables over time, since comparing totals for unequally populated areas is not very informative. In this regard, there is a literature in economics on the accuracy of China's output and price statistics (for example, Holz 2004, Chow 2006, Nakamura *et al*. 2015) but almost no attention is paid to the much more basic errors in the population denominator of *per capita* indicators.

For the first three decades of the reform era in China, local GDP was divided by the count of *hukou* registrations from a particular sub-national area rather than by the count of local residents. For most purposes, the *hukou* count yields biased measures since it does not match the population whose production and consumption went into local GDP. Moreover, the bias grew with the rising tide of migration, as millions left their place of *hukou* registration. By 2010, the census counted over 220 million of these non-*hukou* migrants; one-third of China's urban residents. In contrast, when the reform era began in 1978, almost no one lived away from the place where their *hukou* was registered. Now, coastal provinces have millions more residents than their registered population, while the reverse is true for migrant-sending inland provinces. The resulting errors in provincial GDP *per capita* data are systematic, time-varying, and spatially correlated. At finer spatial scales, such as for counties and cities, the errors are, proportionately, much larger. The city of Shenzhen provides an outstanding example; its *hukou* population was just over one million by the time of the 2000 census but

its residents numbered seven million, so *per capita* GDP was overstated by almost 600 percent in the official data of the time (Chan 2009).

Most economists are broadly aware of the *hukou* system, and perhaps are aware of China's two-track approach to collecting and reporting statistical data that results from interplay of planned economy components, such as the *hukou*, with more conventional survey and census approaches used in decentralized economies. Yet they may not connect the dots, by noting that the two systems can generate numbers that differ starkly, with official statistical yearbooks publishing data that are as if some population segments do not exist, such as those who do not register with the local police or who just obtain a temporary residential permit (Chan 2007). For example, a recent survey of the literature on China's urbanization (Lu and Wan 2015) covers studies whose results likely are distorted by using population and employment statistics from the planning system that neither match the statistics available in decentralized economies nor support the inferences drawn, yet the review uncritically covers these studies. First, a claim from Au and Henderson (2006a) that China suffers large productivity losses due to under-sized cities is repeated without noting that the *City Statistical Yearbook* (*CSY*) data used by Au and Henderson omit many private sector workers (who are outside of the former planned economy); long-form census data show that *CSY* reports an average of just 43% of the employment for each city that the census counts in the same year (Li and Gibson 2015). Secondly, studies of Zipf's law, that claim that the size distribution of China's cities is becoming more even, are covered, without noting that these studies rely on yearbook data for the *hukou* population and, thus, ignore a funnelling of millions of non-*hukou* migrants into just a few cities, which gives a less equal city-size distribution. Finally, the review repeats claims that China lacks large cities, but these claims may just be an artefact of wrongly measuring cities by how many local *hukou* holders there are, rather than by how many residents they have.[1]

A clear distortion from using the wrong sub-national population data is seen in studies of regional inequality, which seemed to rise from 1990 until 2004, when a fall coincided with China investing heavily in lagging regions (Fan *et al*. 2011). Both the apparent rise, and the turning point, are statistical artefacts due to provincial GDP figures initially being denominated by the count of people with *hukou* registration from each province, and then switching to a resident denominator (Li and Gibson 2013). When local *hukou* registrations were the denominator, regional inequality rose mechanically every time a worker moved from the interior to the coast, since the migrant contributed to the numerator of GDP *per capita* for coastal areas, and to the denominator for interior areas. The apparent turning point

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[1] Au and Henderson (2006a, p.557) claim that China had just nine cities with over 3 million people, compared with 125 in the 1-3 million range in 2000. This ratio of large to small cities (0.07) was well below the global average of 0.27. But this claim is wrong because if cities are measured by their residents (as counted in the 2000 census), which is what is needed to compare to other countries, China had 20 cities over 3 million and 89 cities of 1-3 million, giving a ratio of 0.23; more than three times higher than Au and Henderson report and just below the global average.

reflects the fact that by 2005 the largest provinces had all switched to reporting *per capita* GDP on a resident basis.[2] Yet these denominator issues are ignored in the comprehensive review by Wang *et al.* (2015) of the literature on inequality in China along three dimensions: inter-household disparity, regional divides, and urban-rural gaps. The neglect of the biases caused by statistical yearbooks using the *hukou* count as a denominator, and then switching (in an uncoordinated way) to using a resident denominator, is surprising since the review had a focus on the *hukou* system and its possible reform.

These examples suggest a failure of the literature to interpret China's sub-national data in an appropriate way that recognizes the two-track approach to collecting and reporting statistics. In order to see how widespread this failure is, in Section 3 we survey empirical articles in blue ribbon economics journals, in development journals, and in regional and urban economics journals. Our structured review reveals that over 80 percent of articles that use China's sub-national data, do so in an erroneous way. The most common error is that the wrong population or employment counts are used to measure the size of sub-national units. Another typical error is that *per capita* data are calculated with the wrong denominator for the interpretation placed on the variables.

These errors are troubling, especially since the literature on China is large and growing quickly. For example, of 464 economics journal articles with 'China' and 'city' and 'economic growth' in the title or as keywords, 45% were published in the last four years.[3] One reason for the widespread use of China's sub-national data is the spatially detailed GDP data, which are reported for the third sub-national level (counties and urban districts, which are below prefectures, which are below provinces). Thus, even researchers with interest in other countries use data from China to validate proxy measures for local economic growth applied elsewhere (Storeygard 2013). Since so many studies misinterpret China's sub-national data, and since these data are increasingly used, some cautionary examples of the biases that can result may be useful.

In this review we do three things to raise awareness of the issues with China's sub-national data. In Section 2 we briefly review the main errors in China's sub-national population statistics. The errors mean that it is only for census years (2000 and 2010) that researchers can be confident in population data (and therefore *per capita* variables) for sub-national areas. We show that for non-census years, what is reported as a resident population will often be a registered population, exaggerating the population of migrant-sending areas and understating for migrant-recipients. In Section 3 we report on a structured survey of

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[2] There was also a double-counting problem because some provinces switched before others, so a migrant may have been counted in the denominator of GDP *per capita* for two different places at the same time; as a resident of one province and in the *hukou* registered population of a province that was slow to switch to reporting output per resident. In some years up to 26 million people were double-counted (Li and Gibson, 2013).

[3] Specifically, a search of EconLit (May 11, 2015) reveals that there were 23 papers published in all of the 1990s, 74 published between 2000 and 2005, 159 from 2006 to 2010, and 208 from 2011 to 2014.

empirical studies that use China's sub-national data, covering 94 articles in three groups of journals (blue ribbon, development, and regional and urban economics) to see how frequently the data are misinterpreted. Over 80 percent of articles seem to misinterpret statistics that typically originate in the planning system, such as employment counts and *hukou* counts, treating them as if they are from decentralized economies (for example, as all-sector employment or as *de facto* population). From amongst the articles we survey, we focus on five studies to provide exemplars of the sort of interpretation errors that are made, choosing one study from a blue ribbon journal, three from development journals (since the bulk of the literature we review is in these journals), and one from an urban economics journal.

The first two parts of our review note that data from China's planning system differ from more conventional surveys and censuses, and showcase some studies that pay insufficient attention to these differences. Other reviews cover some of the points that we make (for example, Scharping 2001, Chan 2007, Holz 2013, Li and Gibson 2013), and also may compare resident population counts for local areas with the *hukou* registered population. These find inconsistencies, with the resident counts presumed to be the more appropriate for most analyses. But previous reviews lack an independent arbiter of truth showing which type of data are more likely to be right. Therefore in the third part of this review we go further and provide a critical test based on one widely-cited study. We focus on a research question that can be studied using data from outside of China's statistical system, since official statistics on matters other than population and employment also are affected by the legacy of the planned economy (Holz 2013). Specifically, we use satellite-detected luminosity (*aka* 'night lights') as an arbiter for judging between *de jure* and *de facto* population counts. Night time lights also are used by Pinkovsky and Sala-i-Martin (2014) to sift between conflicting data (survey estimates of consumption versus consumption from the national accounts) so our review builds on an existing approach to assessing data quality.

In Section 4 we report on a statistical 'horse race' between models of the growth in urban area (as shown by night lights) for over 200 Chinese cities, between 2000 and 2010. One model uses the change in the *hukou* registered population for each city while the other uses the change in census counts. The models are based on the most cited article in our survey of regional and urban economics journals (Deng *et al.* 2008), which indicates that growth in urban area between 1995 and 2000 was due to growth in local GDP, with no independent effect of local population growth. The problem with this study is that *hukou* counts from the Ministry of Public Security are used as the local population variable; there is no reason for urban area to expand as the *de jure* population rises, since so many people live away from their place of *hukou* registration. We therefore repeat the analysis of Deng *et al.* (2008), albeit using cities rather than counties as the spatial units, to see how the results change when the more appropriate resident population is used in the model.

We focus on this study because it is highly cited, it can be tested using 'outside' data (from night lights) rather than relying just on China's published statistics, and because there

are important policy implications of the results. If it is truly the case that population growth does not affect urban area, ever more populous cities should become denser rather than more sprawling were it not for the effects of income growth. And given that income growth is widely considered to be desirable, urban sprawl might just be a necessary corollary of that growth. Yet this implied densification is contrary to what is often asserted about China (for example, Du *et al*. 2014, World Bank 2014), and is contrary to the trade-offs between food security and urbanization that China's policy makers often claim to face.[4] Thus, a critical test for distorted findings on this important topic may be a sufficient example to inform about the potential for distorted analyses, more generally, from failure of empirical research to correctly interpret China's sub-national data.

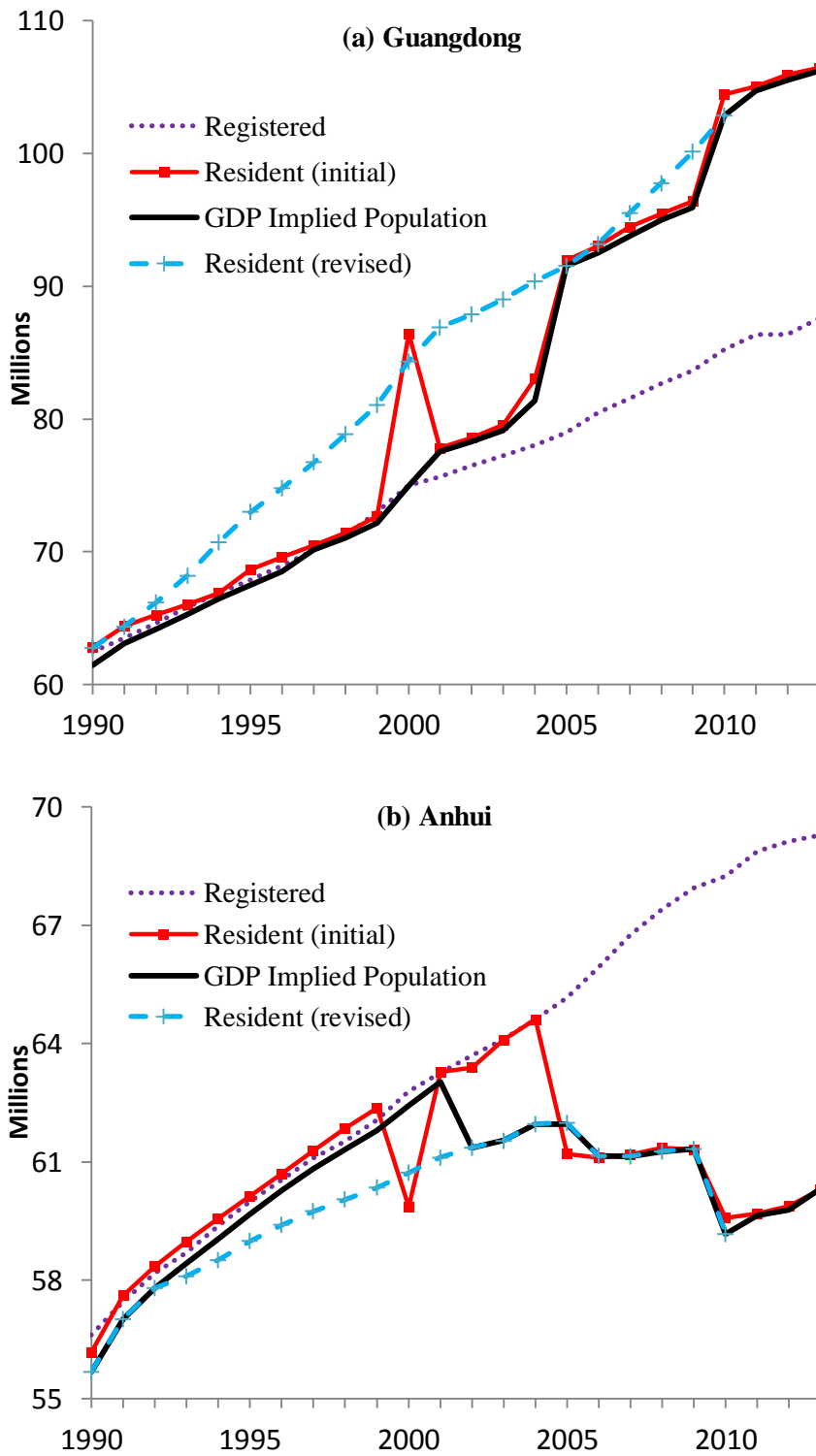## 2. A REVIEW OF THE COUNTING ERRORS

The main problems in China's sub-national population and GDP *per capita* data can be illustrated by examining four time series; shown in Figure 1a for a migrant-receiving province (Guangdong) and in Figure 1b for a migrant-sending province (Anhui). These series, in increasing order of complexity, are:

- Registered population - the year-end registered population for each province, as reported in various editions of what is now called the *China Population and Employment Yearbook* but with the original source of the data being the Ministry of Public Security.

- Resident (initial) population - the estimated year-end resident population, also reported in the *China Population and Employment Yearbook*. Most of these data come from the annual National Sample Survey on Population Changes (a 0.1% sample) except in years with a population census (1990, 2000, 2010) or microcensus (2005; 1% national sample).

- GDP implied population – the population values underlying reported GDP *per capita*, derived by dividing provincial GDP by provincial GDP *per capita*, where both series are published on the National Bureau of Statistics (NBS) website for each province.

- Resident (revised) population – in 2011 the NBS combined resident population counts from the 2010 census with economic census data, using a trend-deviation interpolation method to backdate estimates of GDP, the resident population, and GDP *per capita* on a resident population denominator basis. That exercise has not been carried forward, so the series only runs from 1990 to 2010. Moreover, the back-dating exercise was only carried out for provinces, so similarly corrected data are not available for prefectures, counties, or urban districts (contiguous urban districts are the best approximation to cities).

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4   For example, China recently announced strict controls to stop big cities expanding on to farmland, with the Minister for Land and Resources, Jiang Daming, justifying these controls by claiming that good farmland has been 'eaten by steel and cement' (for details, see http://news.xinhuanet.com/english/china/2014-11/03/c_133763130.htm).

Figure 1
Four Time Series of Provincial Population Estimates

(a) Guangdong

(b) Anhui

The time series for the registered population grows fairly smoothly, since it reflects deaths and births (*hukou* status is inherited), and, rarely, some *hukou* conversions. From 1990 to 1999, what China's statistical yearbooks report as the resident population almost exactly tracks the *hukou* registered population in both provinces. But the (initial) resident population figures for 2000 show a sharp movement away from the time series of registered population.

The census showed that Guangdong had 14 million more residents than was estimated the year before by the 0.1% National Sample Survey on Population Changes, while for Anhui the census count was almost three million less than the estimate from the year before. These census counts are plugged into the resident population time series by the NBS and the sharp peaks and troughs for the year 2000 do not reflect anything done by us to the data. The reported resident population for Anhui the year after the census rejoins the time series of registered population, which it tracks until the 2005 microcensus revealed 3.4 million fewer people living in Anhui than was reported the year before. The patterns are reversed for Guangdong, although the resident population series never fully returned to the time series of registered population after the 2000 census (but it still dropped by 8.4 million people from 2000 to 2001). The sharp jumps in the Guangdong population in 2005 (by 9 million) and in 2010 (by 8 million) reflect the extra residents found in years with a microcensus and a full census.

These volatile time series of what is reported as a resident population are repeated for all of China's provinces, with migrant receivers having patterns like Guangdong and senders having patterns like Anhui. In years without a census or microcensus, the number of non-*hukou* migrants is inaccurately estimated by the National Sample Survey on Population Changes and statistical offices in some provinces seem to use the number of registered *hukou* holders provided by the Ministry of Public Security to proxy for the resident population. Consequently, research relying on estimates of how populous is each province is likely to be distorted unless it is limited to years with a microcensus or census. This problem is magnified when researchers use sub-provincial units like prefectures, urban districts, or counties because there are more non-*hukou* migrants for smaller units; a person migrating from the countryside to the capital city of their province is not defined as a non-*hukou* migrant at the provincial level, but is at the prefectural or county level. Moreover, there are no revised resident population estimates for sub-provincial areas, unlike the series created by the NBS in 2011 for backdating provincial resident population estimates from 2010 to 1990.

The time series of the GDP implied population shows four problems that may bias results using GDP *per capita* data. First, the denominator is the *hukou* registered population, rather than the number of residents, up until 2001 (Guangdong) or 2002 (Anhui). Accordingly, *per capita* GDP of migrant-sending provinces was ever more understated, since the denominator was too large, while the reverse bias occurred for migrant-receiving provinces. Secondly, once provinces switch from using the number of *hukou* registrations as the denominator, the GDP *per capita* of migrant-senders rises since the denominator is now smaller, with a fall in GDP *per capita* (relative to trend) for migrant-receivers since their population denominator increases. Lo and behold, inequality between the coast (migrant-receivers) and the interior (migrant-senders) appears to fall, but this may just be an artefact of the switch in the denominator. Thirdly, there is scope for a double count, since some provinces stopped using *hukou* registration data as a denominator earlier than others. In the intervening years a migrant may be included in the GDP denominator of two provinces at
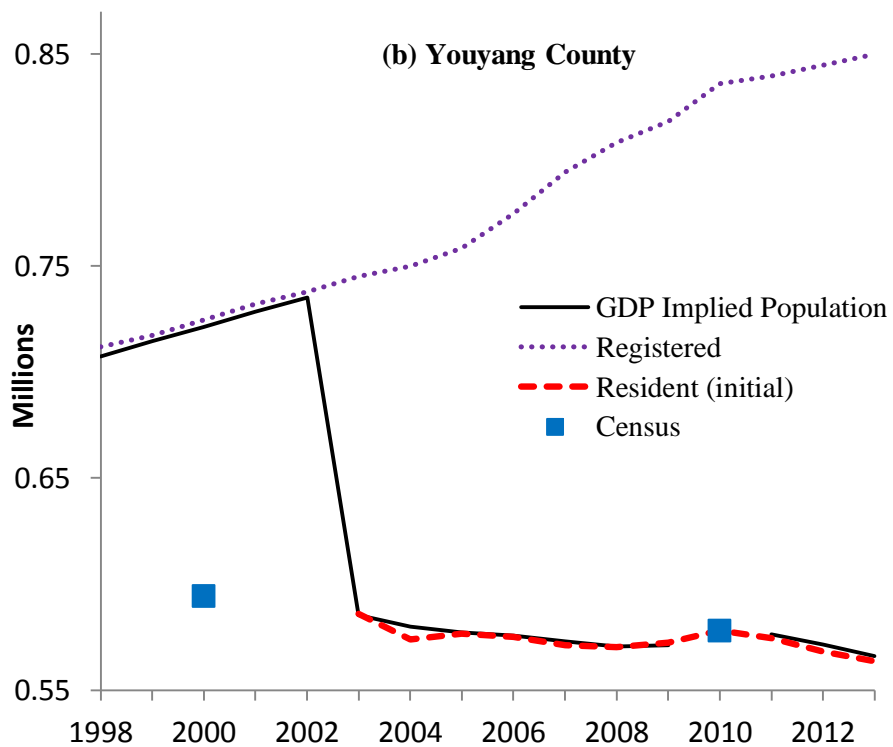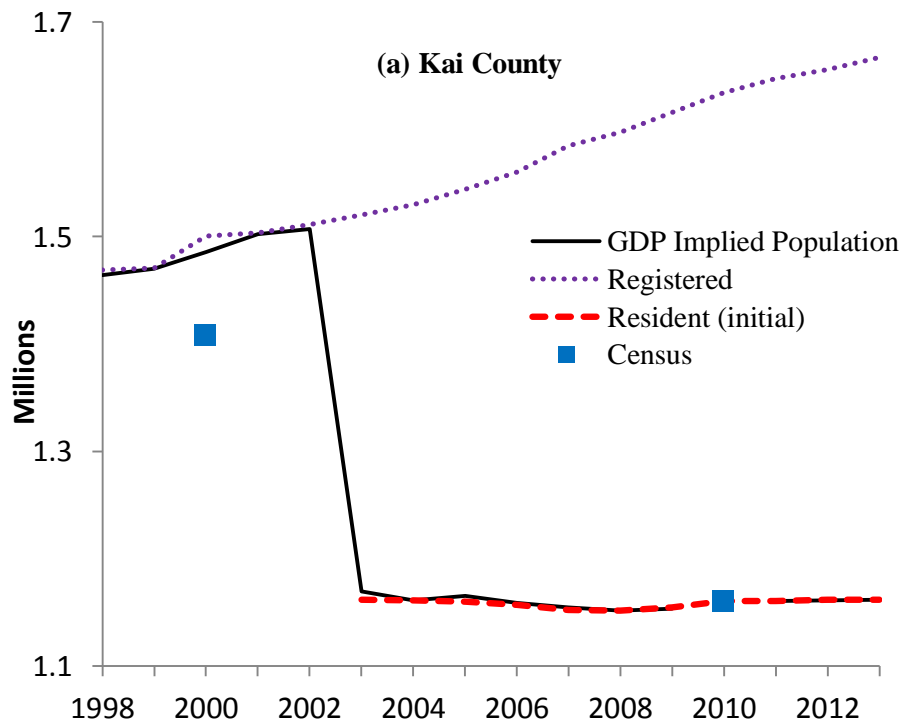
once; at peak, 26 million people were double-counted. Finally, the GDP implied population still jumps in years with a census or micro-census (e.g., 2005 and 2010). This suggests that *per capita* GDP data are not yet properly denominated by residents in non-census years. Thus, the 2015 micro-census will likely show the five-yearly 'saw-tooth' pattern, as the population in census and micro-census years does not fit with the trend in the previous four, non-census, years.

The problems with local population data are even more complex for sub-provincial areas, since there is variation in statistical practice between provinces. For example, some provinces do not report a time-series of resident population estimates for prefectures or counties, even for the period since 2005 when such estimates have been reported at the provincial level. The counting problems shown in Figure 1 also occur for these sub-provincial areas but two factors make the likely bias due to these problems worse at this finer spatial scale: first, there are no retrospective corrections to the resident population estimates, along the lines of what the NBS did in 2011 for provinces (as shown in Figure 1 for the 'resident (revised)' series). The second factor is that the switch to denominating GDP by the resident population rather than by the registered population entails proportionately larger breaks in the time series at the sub-provincial level.

We illustrate this second point using population time series for two counties from Chongqing Province in Figure 2, where the registered population, the resident (initial) population, and the GDP implied population are defined in the same way as for Figure 1. In 2003 the statistics yearbooks for Chongqing changed the denominator used for reporting GDP *per capita* from a *hukou* registered population basis to a resident population basis, leading to apparent falls in population for these two counties of between 21% and 22%. This is a large break in the time series, compared with the break at the provincial level where the largest drop in implied population from the switch in GDP denominator is for Sichuan, which seems to drop by only 7% (albeit, amounting to eight million people) between 2003 and 2004.

The sharp fall in apparent population (and rise in GDP *per capita*) for migrant-sending counties when provincial statistics offices switched GDP denominators is clear in Figure 2. But even with the more appropriate resident-based denominators used recently, a further problem is seen for Kai county (as an example of the same problem in many other counties). The resident population time series for Kai county varies by only 0.9% around its mean between 2003 and 2013 and the mean is just 0.2% away from the census count for 2010. But the 2003-2013 time series is 18% below the resident population count from the 2000 census, and it is unlikely that the resident population would fall so sharply between 2000 and 2003 and then stabilize. In contrast, the resident population time series for Youyang county appears more plausible, with a range over 2003-13 that is 3.9% of its mean, which is similar to the fall in resident population of 3.5% between the 2000 and 2010 censuses. The trend in the resident population time series for Youyang county seems reasonably consistent with the change in the census counts, unlike for Kai county.

Figure 2
Time Series of Population Estimates for Two Counties in Chongqing

Source: Chongqing Statistical Yearbooks.

Note: No GDP per capita data is reported for 2010 for these counties.

We have examined population time series for many other counties, and also for urban districts ('cities') and for prefectures, and we find similar examples of inconsistencies. It seems that for many sub-provincial areas the reported resident population outside of census years cannot be trusted. These estimates come from a 0.1% sample as part of the National Sample Survey on Population Changes and the likelihood of this survey finding non-*hukou* residents is much less than what can be expected from the complete census enumeration. It would be a mistake, however, to use this evidence to advocate for using the registered population data, which do maintain a consistent definition over time; this *de jure* population series is not a sensible choice for economists to use since it does not correspond to the number of people in each area who are consuming or producing local output. Moreover, the *hukou* registered population becomes an ever worse proxy due to the rising tide of non-*hukou* migration. Instead, our review of the various counting errors in China's sub-national population data leads us to advocate for restricting the scope of any analysis to relying on changes in local population between censuses, at least until more trustworthy data on annual population changes for sub-national areas are available.

3. A STRUCTURED REVIEW OF THE LITERATURE

Our review of the counting errors in Section 2 shows that the population time series for China's sub-national units may be unreliable. The errors also contaminate time series of *per capita* data and cross-sectional comparisons will be biased too. Although not shown in Section 2, employment data (and also output per worker) have related errors since non-*hukou* migrants mostly work in the private sector, and much of that sector is omitted from employment data in statistical yearbooks. Surveys are not inherently biased, since they can define residency by how long someone lives in a locality rather than just relying on their *hukou* status, but they face sampling problems. For example, the main urban and rural household surveys from the NBS had sample frames based on *hukou* registration rather than on the census, and so non-*hukou* migrants are omitted from the sample, and survey estimates are likely to be unrepresentative.

To see how widespread is the failure of the literature to account for these various flaws in China's sub-national data, we surveyed empirical articles on China published in three groups of economics journals: 'blue-ribbon' journals,[5] development journals,[6] and regional and urban journals.[7] We studied articles published from 2005, after the switch to reporting GDP *per capita* on a resident population basis.[8] Since the NBS also reports total

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[5] *American Economic Review*, *Review of Economic Studies* and *The Review of Economics and Statistics*.

[6] *Journal of Development Economics*, *World Development* and the *Journal of Comparative Economics*.

[7] *Journal of Urban Economics*, *Regional Science and Urban Economics* and the *Journal of Economic Geography*.

[8] Details on these articles are available in Appendix Table 3.

GDP for sub-national units, a researcher could, thereafter, derive a yearly average resident population for each locality from the ratio of the two numbers (although the reliability of such estimates still falls short of the census counts, as shown in Figure 1). In contrast, the most widely used population data are end of year counts of the number of people with *hukou* registration from each locality.

Of the 94 articles that we reviewed in these three groups of journals, just 15 appeared to correctly interpret China's sub-national data while the other 84% made various errors (Table 1). The most common error was using the wrong population or employment data to measure the level of, or growth in, the size of sub-national units. In total, 45 articles used population data that should not be expected to show how populous are sub-national units since the non-*hukou* migrants are excluded, while 21 articles used employment data that are similarly incomplete. These errors were just as prevalent in articles published recently as in earlier articles, and were most common in blue ribbon journals and in regional and urban economics journals. The next most common error was denominating by the wrong population or employment data (in terms of how the article interpreted the *per capita* variables), which was most common in the development journals and also showed no tendency to become less frequent over time. Another type of error that was common especially in development journals concerned survey data that are based on sampling frames that omit non-*hukou* migrants, with no consideration given to the likely biases that result from the omission of this segment of the population.

The 79 articles that incorrectly interpret the data are cited an average of 84 times each (in *Google Scholar*, as of May 2015). With the substantial impact for these articles, any errors in their results may contribute to wider misunderstanding of modern China. Moreover, since we surveyed just nine journals, if we extrapolate to all economics journals it is fair to say that there will be hundreds of articles in the literature that misinterpret the sub-national data from China.

While Table 1 gives a broad overview of the ways that China's sub-national data are misinterpreted, it is useful to have examples from particular articles. We chose to showcase five articles; one from the blue ribbon group of journals, three from the development journals, and the final one, from the regional and urban economics journals, is covered in Section 4. Two of the articles are published in 2013-15, and one each from the earliest three sub-periods in Table 1, so as to show that even recently published articles continue to misinterpret China's sub-national data. Some of the articles have good research designs and thoughtful identification strategies but treat statistical yearbook data on population and employment in non-census years at face value, with no awareness that these statistics often relate to notions from China's planned economy past rather than to either the *de facto* population or total employment that researchers may have in mind.

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Table 1. Distribution of Papers that Use China's Sub-national Data:
Wrong Interpretations and Correct Interpretations

	Unit Size Errors		Denominator Errors		Survey Errors	Total papers with errors	Total without these errors	Total of all papers
	Population	Employment	Population	Employment				
Type of Journal								
Blue Ribbon	9	3	4	1	4	12	2	14
	64%	*21%*	*29%*	*7%*	*29%*	*86%*	*14%*	*100%*
Development	25	15	26	4	15	52	12	64
	39%	*23%*	*41%*	*6%*	*23%*	*81%*	*19%*	*100%*
Regional/Urban	11	3	4	2	2	15	1	16
	69%	*19%*	*25%*	*13%*	*13%*	*94%*	*6%*	*100%*
Total	45	21	34	7	21	79	15	94
	48%	*22%*	*36%*	*7%*	*22%*	*84%*	*16%*	*100%*
Publication Date								
2005-2006	9	5	3	2	7	16	3	19
	47%	*26%*	*16%*	*11%*	*37%*	*84%*	*16%*	*100%*
2007-2008	6	4	5	2	3	12	1	13
	46%	*31%*	*38%*	*15%*	*23%*	*92%*	*8%*	*100%*
2009-2010	9	6	8	1	3	15	4	19
	47%	*32%*	*42%*	*5%*	*16%*	*79%*	*21%*	*100%*
2011-2012	7	1	7	1	5	15	2	17
	41%	*6%*	*41%*	*6%*	*29%*	*88%*	*12%*	*100%*
2013-2015	14	5	11	1	3	21	5	26
	54%	*19%*	*42%*	*4%*	*12%*	*81%*	*19%*	*100%*
Total	45	21	34	7	21	79	15	94
	48%	*22%*	*36%*	*7%*	*22%*	*84%*	*16%*	*100%*

Notes: Unit size errors are measuring sub-national areas with the wrong population or employment from *Statistical Yearbooks* which omit some residents or workers. Denominator errors are using incomplete *Statistical Yearbook* data on population or employment to denominate local GDP, or using *Yearbook* data on GDP per capita without noting that the denominator is registered population or an incomplete total of workers. Papers with survey errors use NBS annual household survey data without acknowledging the exclusion of non-*hukou* migrants. A paper may make more than one type of error, so the sum of the first five columns may exceed the total number of papers with errors in column (6). Papers without these errors may use census data, or NBS backdated provincial GDP per capita data corrected after the 2010 census, or NBS annual household survey data with acknowledgement of the exclusion of non-*hukou* migrants, or other data that is not affected by the counting error in NBS data for sub-national units (e.g. from the World Bank, from other NBS surveys such as firm-level data and so forth). The percentages in each cell are of all papers.

Faber (2014) is an example of using the wrong population to measure changes for sub-national units, in this case, rural counties. The impacts of transport infrastructure are studied, using China's National Trunk Highway System that links cities of urban population over 500,000, and whose placement lets some small, peripheral, counties along the route connect to bigger cities. The reduced trade costs might be expected to generate new activity in these peripheral regions and econometric models examine county-level changes between 1997 and 2006 to test this prediction. Amongst the seven outcome variables are population and urban population, both from statistical yearbooks; the results suggest an absence of highway connection effects on the urbanization of these peripheral counties. But county-level population data in non-census years are for *hukou* registrations rather than for residents (Scharping, 2001), and are therefore unsuitable for testing if connected counties urbanize faster. Any such urbanization would attract non-*hukou* migrants from elsewhere, and the statistical yearbooks do not count these people because the yearbooks rely on *hukou* data obtained from the Ministry of Public Security. In order to test the hypothesis of faster urbanization for connected counties one could use census data from 2000 and 2010 to examine growth in the urban resident population, but outside of census years China's county-level statistics do not show how many people actually live in each county.

Au and Henderson (2006b) are another example where yearbook data can mislead analysis that relies on the size of sub-national units. Using annual data from urban statistical yearbooks from 1991 to 1998, and rural data from 1995, 1997, and 1998, Au and Henderson estimate the effect that city scale (employment) has on per worker productivity, and the effect of township scale in the rural sector on the labour productivity of township and village enterprises (TVEs). The econometric estimates are used to simulate large, positive, effects on national output from doubling the size of urban agglomerations and rural industrial locations, where this increased scale would follow from relaxing migration restrictions. It surely is true that the restrictions lower productivity, but the employment data used by Au and Henderson are not a reliable basis for estimating these effects. Holz (2013) shows that all-sector employment is only available in the decadal population census and micro-census, while annual data are only for subsets of total employment. In particular, the enterprises that report regularly to the statistics bureaucracy (what Holz calls 'directly reporting industrial enterprises') as a legacy of the planning system have a share of industry employment that varies from about two-thirds in some years to as low as 40 percent in others. More evidence that yearbooks miss many employees is shown by their city-level averages being just 43 percent of the employment for each city that the census counts in the same year (Li and Gibson 2015).

The other two development articles we showcase are both examples of denominator errors, where GDP *per capita* data from yearbooks (or, equivalently, from www.chinadataonline.org) is used without acknowledging that these statistics divide GDP by local *hukou* registered population, rather than by the people actually producing or consuming the GDP, and so will overstate growth rates for migrant-destinations and understate for

source areas. Wei and Hao (2010) create a panel of five-yearly growth rates in GDP *per capita* for 1989-94, 1994-99, and 1999-2004, at the provincial level, and regress these on demographic variables and on other controls. The authors note that the 'floating' population (that is, the non-*hukou* migrants) may affect the demographic variables on the right-hand side of the regression but ignore the systematic errors in the dependent variable. Li and Gibson (2013) show that annual trend growth rates for destination provinces are exaggerated by up to two percentage points due to use of the *hukou* denominator in the statistical yearbooks. This systematic error may affect Wei and Hao's tests of whether changing demographic structure has an influence on economic growth, since demographic structure of migrant destination provinces is unlikely to be the same as for origin provinces.

Poncet and De Waldemar (2013) use data from a panel of China's cities to examine whether areas that specialize in more complex goods have faster growth. They calculate growth in city-level GDP *per capita* for 221 cities over three four-year periods from 1997 to 2009, and regress this on indicators of complexity, openness, foreign direct investment and economic structure. The 2010 census shows that the share of non-*hukou* migrants in the resident population of cities varies widely, from zero for the 10th percentile city (noting that 'unpopular' cities, with fewer residents than their registered population, have negative values) to just under one-half at the 90th percentile. Consequently, the measurement error in city-level growth rates of GDP *per capita* will vary considerably over space, and also over time as the rate of non-*hukou* migration varies, and can be expected to bias the coefficients of panel growth regressions.

4. A CRITICAL TEST OF A HIGHLY CITED STUDY

Our structured literature review indicates that important features of China's sub-national data are widely ignored in papers published in three groups of economics journals. The articles that we highlighted as examples of studies whose results may be biased due to authors misinterpreting these data add some specificity to our claims. However, we have not, and indeed, cannot because the right data do not exist, replicate these analyses using more appropriate *de facto* population data, *per capita* GDP on a resident denominator basis, or total employment data, in order to demonstrate the biases that we claim are likely to occur.

In this section, we do attempt such a demonstration, for the study by Deng *et al.* (2008) that was the most cited article (with 232 *Google Scholar* cites) from those reviewed in regional and urban economics journals. Deng *et al.* (2008) used Landsat data to measure urban area for China's counties in 1995 and 2000, and related the growth in urban area to changes in county GDP and population, with measures of agricultural investment, highway density, and industrial structure as controls. To see how using residents, rather than the *hukou* registered population, affects the results we need to restrict attention to census years, and Landsat estimates of urban area in 2010 are not yet available. However, estimates of urban area in 2000 and 2010 from the Defense Meteorological Satellite Program's Operational

Linescan System (DMSP/OLS) night lights data are available from Gibson *et al.* (2014). That analysis was for cities, or more specifically, urban districts (*shiqu*), which best proxy for an urban core in China (Roberts et al, 2012), starting with 260 cities that had data reported on built-up area, GDP, and registered population for at least 15 of the 20 years from 1993 to 2012. In later years, the lit area for some cities cannot be separated from their neighbours, especially in the Pearl River delta and the Yangtze delta. To provide consistent time series, cities whose night lights eventually join were merged for all years and after this aggregation, the number of cities in the sample dropped to *n*=225 (but they continue to cover the same total area). The population, GDP, and other data used in the current analysis are aggregated in the same way, for both 2000 and 2010.

Thus, in comparison to the original study by Deng *et al.* (2008), our demonstration uses different remote sensing data, for different spatial units. The different data should not matter since the Pearson correlation coefficient is 0.86 when comparing Landsat and night light-derived measures of city area in 2000.[9] To measure urban area from night lights, one needs a threshold level of brightness to exclude low-lit areas of sparse development, and cross-validation exercises by Gibson *et al.* (2014) indicate that 50% and 65% of the maximum luminosity is appropriate.[10] With these thresholds, a few dimly lit cities drop out of the sample, especially in earlier years when cities were smaller and less brightly lit, and at the higher threshold. Also deleted are any cities smaller than one square kilometer, which is the resolution of the night lights data. After these deletions, the sample sizes are 221 cities if using the 50% light threshold to define contiguously lit areas as urban and 203 cities if using the 65% threshold. The sample summary statistics are in Appendix Table 1 and it is notable that the resident population counts are over 40 percent higher than the *hukou* counts; the difference between the two types of counts is at the heart of our tests.

The models of growth in urban area are reported in Table 2, with the specifications that follow Deng et al (2008) in using the number of non-agricultural *hukou* registrations as the measure of local population change in columns (1) and (3). The results are similar to those of Deng et al (2008) in signifying that local GDP growth explains the urban area expansion, with no independent effect of local population growth. Specifically, the estimated elasticity of urban expansion with respect to growth in local GDP is about 0.2, while the elasticity with respect to the change in local *hukou* registered population is not significantly different from zero.

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[9] We thank Dr Xiangzheng Deng of the Chinese Academy of Sciences for providing us with these Landsat estimates of city area for the year 2000.

[10] These thresholds correspond to DN values of 32 and 41. By using two different thresholds, the robustness of the test results can be assessed. We use the fraction of the maximum luminosity (DN=63) recorded by DMSP/OLS to emphasize that these remote sensing observations give a relative rather than absolute measure of brightness, due especially to lack of on-board recording of amplification changes and to inter-satellite differences. Any errors due to these features are captured in the intercepts of the first-differenced models and so should not affect the analyses.

Table 2. Expansion of China's Urban Area is Related to Growth in Resident Population but not to Registered Population

	Dependent variable: Δln(Urban Area)			
	Area at 50% Luminosity Threshold		Area at 65% Luminosity Threshold	
	(1)	(2)	(3)	(4)
Δln(GDP)	0.191	0.031	0.190	0.064
	(0.103)*	(0.104)	(0.108)*	(0.110)
Δln(Non-agricult *hukou*)	-0.161		-0.072	
	(0.133)		(0.139)	
Δln(Urban residents)		0.431		0.380
		(0.175)**		(0.186)**
Constant	0.983	1.061	1.054	1.122
	(0.153)***	(0.151)***	(0.159)***	(0.158)***
Observations	221	221	203	203
Adjusted R^2	0.008	0.028	0.006	0.025
Zero slopes *F*-test	1.84	4.17**	1.59	3.57**
Cox-Pesaran stat[a]		-7.13***		-11.41***
		H_0:(1) / H_1:(2)		H_0:(3) / H_1:(4)
Cox-Pesaran stat[a]		-0.41		0.23
		H_0:(2) / H_1:(1)		H_0:(4) / H_1:(3)

Notes:
Standard errors are in parentheses.
* Significant at 10%; ** at 5%; *** at 1%.
[a] Tests for non-nested models are distributed as standard Normal.
The null and alternative models in ( ) refer to the numbered column headings.

The results reverse if the urban resident population from census counts is used (in columns (2) and (4)). For these models, the elasticity of urban area with respect to population growth ranges from 0.38 to 0.43, while there is no statistically significant effect of local GDP growth. In other words, growth in urban area between 2000 and 2010 appears to be due to population growth with no independent effect of rising incomes, if the population whose growth is measured is that of urban residents rather than of non-agricultural *hukou* registrations. Thus the Deng *et al.* (2008) result that urban expansion in China was due to local income growth rather than to local population growth may be an artefact of using inappropriate population data.

The reversal of results in Table 2 makes intuitive sense since the number of people whose *hukou* registration is from a particular place is a poor measure of local population in modern China, given the massive and rising tide of non-*hukou* migration. This measure is especially unsuited for research that seeks to explain urban area expansion, since the non-*hukou* urban residents need dwellings to live in, roads to drive on, and offices, shops and factories to work in. All of these activities by non-*hukou* residents require land being converted to urban use and so it is this *de facto* population that is the one that should cause an increase in city area.

We also back up this intuitive reasoning with a more formal testing procedure, by using the Pesaran (1974) version of a Cox likelihood ratio test of the validity of one linear model, H_0 as opposed to its non-nested alternative H_1.The results reported in the last rows of Table 2 provide strong support in favour of using the *de facto* resident population to explain urban area expansion. If the model that uses the number of local *hukou* holders is H_0 it is decisively rejected in favor of H_1, the model based on the resident population (with the test statistics significant at $p<0.01$ regardless of whether using a 50% or 65% luminosity threshold). When the test is reversed, with the model using the *de facto* resident population as H_0 the Cox-Pesaran statistics are insignificant, showing no rejection of this model against the alternative using the registered population.

In Table 2 the focus is on the choice of population measure, by using stripped-down models with just population and GDP as factors explaining city area expansion. In fact, the study by Deng et al (2008) also included other variables that the mono-centric model suggests as likely influences on urban expansion; agricultural productivity, road density, and economic structure. If the tests from Table 2 are repeated with these controls included there still is no effect of growth in the local *hukou* registered population on growth in urban area but there is a strong effect (shown by an elasticity of 0.4) of growth in the local urban resident population. The non-nested tests still support use of the *de facto* population, as enumerated in the census, for explaining growth in urban area.[11]

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[11] These results for the models with additional control variables are reported in Appendix Table 2.

5. CONCLUSIONS

Hundreds of published studies in economics may have their analyses distorted by misinterpreting China's sub-national population counts, and by construction, *per capita* variables based on those population counts. The most widely reported population data for provinces, prefectures, counties, and cities are *de jure* measures of where people are legally registered to live under the *hukou* system, rather than measures of where they actually live. With over 220 million non-*hukou* residents living somewhere other than their place of registration, compared with almost none when reform began in 1978, there will be large, time-varying, errors if the *hukou* counts are used as if they measure the population that consume or produce local GDP. Adding to this error is the discontinuity that results from the switch to denominating GDP by the number of local residents rather than by the number of local *hukou* holders. For some sub-provincial areas, this switch entails a discontinuity of more than 20 percent in the time series of population and *per capita* variables. Also, this switch was made in an uncoordinated way, with some provinces switching before others, so a double-count was created. Moreover, outside of years with a census or microcensus, the supposed resident population counts still seem to miss many non-*hukou* residents, as seen from the pattern in Figure 1, and so *per capita* data still may not be reliable.

Despite the magnitude and pervasiveness of these counting errors, they are largely ignored in the economics literature. Our structured review of empirical articles in three groups of journals suggests that many published studies use *de jure* population data from China's statistical yearbooks when *de facto* measures would be more appropriate, since the *de facto* measures relate to the people consuming and producing local output. Similarly, the employment data used either to measure the size of sub-national units or to examine productivity per worker are typically partial counts coming from enterprises that report regularly to the statistics bureau as a legacy from the planning system yet are wrongly interpreted as measuring total employment. For both population and employment data, the most trustworthy record comes from the decadal census, rather than from yearbooks that may publish data that are as if some population segments and groups of workers do not exist, where these omissions reflect the fact that non-*hukou* migrants and private sector workers were not conceived of by statisticians under China's planning system. Of course, relying on decadal census data may be unattractive to economists who are tempted by the prospect of estimating their models with annual data for finely-grained sub-national units such as cities and counties.

Does it matter that the economics literature ignores these features of China's sub-national population and employment data? It would be an impossible task to redo all the articles that misinterpret China's sub-national data because not only are there too many of them, and they are ever-increasing, in most cases the appropriate data do not exist. With the exception of the exercise by the National Bureau of Statistics in 2011, where they revised provincial resident populations back to 1990, there are no corrected estimates of the resident population for most of the reform era for most of China's sub-national units. Moreover, it is

unclear how such corrections could be made, so research that uses population, employment and *per capita* data from these sub-national units in the reform era requires an asterisk to note this source of doubt about the results.

However, if attention is restricted to census years it is possible to test whether treating the *de jure* population as if it is a *de facto* population matters to research in economics. Specifically, we used growth in city area derived from night lights as an arbiter to compare models that use the *de facto* population measure based on census counts of where people actually reside with the *de jure* measure from police records of where they are registered to live under the *hukou* system. The choice of population measure matters greatly to the research findings. One would conclude that expansion of China's urban areas from 2000 to 2010 was driven by income growth, with no independent role played by local population growth, if the *de jure* population from *hukou* registrations is used as a proxy for city-level population. This also is the conclusion reached in the study by Deng *et al.* (2008), who used the *de jure* population. This conclusion likely influenced views about China since the Deng *et al.* paper is highly cited. But if the more appropriate *de facto* population measure based on census counts of where people actually live is used, there is a strong effect of local population growth on urban expansion and no apparent effect of income growth. Our non-nested tests strongly favor using the resident-based *de facto* population rather than the *de jure* population for explaining urban growth.

From a policy point of view, since urban expansion is not independent of local population growth, there is no support in our revised findings for the hypothesis of increased densification of cities in China. Indeed, a recent study shows that the density of China's big cities is falling, relative to comparator cities elsewhere (Du *et al.* 2014) and so China's policy makers may justifiably be concerned about changing patterns of urban growth. In contrast, one might ignore these changes if the Deng et al results were believed, since those results suggest local population growth has no independent effect on urban growth.

In terms of implications for practitioners, our results suggest that economists should take more care in their use and interpretation of China's sub-national population and *per capita* data. Our experience is that what is labelled as a resident population in China's various statistical yearbooks will often be a registered population, as shown in Figure 1. Even when what is reported as a resident population differs from the *hukou* registered population counts, as it tends to at the provincial level since the mid-2000s, it still may not be trustworthy; the discrepancy between what is counted in census years and what is estimated in other years provides grounds for caution when using these estimates, and also when using any *per capita* variables derived from them. One recommendation for practitioners is to restrict attention to studying long difference inter-censual changes, as we have done in this study. While this means smaller sample sizes than when using panels of annual data for provinces, prefectures, cities, and counties, by restricting attention to census years it reduces the risk of introducing large, time-varying, errors into any analyses.

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Appendix Table 1
Variable Definitions and Summary Statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
	2000				
NA	Non-agricultural *hukou* population (million)	0.75	1.62	0.09	20.07
U	Urban resident population (million)	1.09	2.66	0.13	29.42
A65	Night light area at 65% threshold using satellite F15 (km^2)	156.78	639.07	2.17	7609.59
A50	Night light area at 50% threshold using satellite F15 (km^2)	195.34	770.39	2.23	9383.45
GDP	Gross domestic product (billion yuan)	21.02	68.07	1.27	795.32
AP	Agricultural productivity (thousand yuan)	5.14	4.75	0.16	44.34
RD	Road density	0.08	0.04	0.01	0.28
gdp2	Share of secondary sector in GDP	0.48	0.13	0.15	0.92
gdp3	Share of tertiary sector in GDP	0.41	0.10	0.07	0.75
	2010				
NA	Non-agricultural *hukou* population (million)	1.10	2.76	0.12	33.44
U	Urban resident population (million)	1.58	4.58	0.15	49.60
A65	Night light area at 65% threshold using satellite F18 (km^2)	485.00	1978.08	32.94	24706.03
A50	Night light area at 50% threshold using satellite F18 (km^2)	587.11	2325.99	2.37	30320.72
GDP	Gross domestic product (billion yuan)	107.56	395.33	4.03	4442.01
AP	Agricultural productivity (thousand yuan)	19.68	42.60	0.91	631.29
RD	Road density	0.13	0.06	0.05	0.82
gdp2	Share of secondary sector in GDP	0.52	0.12	0.10	0.86
gdp3	Share of tertiary sector in GDP	0.42	0.11	0.12	0.79

Note: Number of observations is 221 (except for variable A65 where it is 203).

Sources: NBS (2001, 2003, 2011, 2012) and Gibson et al (2014).

Appendix Table 2

**Adding Covariates Does not Change the Result that Urban Area Expansion
is Related to Growth in Resident Population but not to Growth in Registered Population**

	Dependent variable: Δln(Urban Area)			
	Area at 50% Luminosity Threshold		Area at 65% Luminosity Threshold	
	(1)	(2)	(3)	(4)
Δln(GDP)	0.019	-0.087	-0.175	-0.277
	(0.124)	(0.123)	(0.127)	(0.127)**
Δln(Non-agricult *hukou*)	-0.175		-0.086	
	(0.136)		(0.137)	
Δln(Urban residents)		0.432		0.417
		(0.187)**		(0.193)**
Δln(AP)	0.143	0.081	0.252	0.206
	(0.064)**	(0.066)	(0.063)***	(0.064)***
Δln(RD)	-0.072	-0.064	0.145	0.161
	(0.074)	(0.073)	(0.078)*	(0.077)**
Δgdp2	1.578	1.584	3.006	3.161
	(0.650)**	(0.645)**	(0.694)***	(0.688)***
Δgdp3	0.863	0.681	2.187	2.208
	(0.672)	(0.666)	(0.697)***	(0.689)***
Constant	1.036	1.107	1.118	1.186
	(0.152)***	(0.151)***	(0.153)***	(0.152)***
Observations	221	221	203	203
Adjusted R^2	0.036	0.052	0.100	0.120
Zero slopes *F*-test	2.36**	3.01***	4.75***	5.57***
Cox-Pesaran stat	-6.77***		-12.41***	
	H_0:(1) / H_1:(2)		H_0:(1) / H_1:(4)	
Cox-Pesaran stat	-0.86		0.05	
	H_0:(2) / H_1:(1)		H_0:(2) / H_1:(3)	

Note: See Appendix Table 1 for the definitions of variables and Table 2 for further notes.

Appendix Table 3

Details on the 94 Papers Summarized in Table 1

Author	Journal	Year
Auffhammer, M., & Wolfram, C. D.	The American Economic Review	2014
Desmet, K., & Rossi-Hansberg, E.	The American Economic Review	2013
Song, Z., Storesletten, K., & Zilibotti, F.	The American Economic Review	2011
Faber, B.	The Review of Economic Studies	2014
Anderson, S., & Ray, D.	The Review of Economic Studies	2010
Au, C., & Henderson, J. V.	The Review of Economic Studies	2006
Jia, R.	The Review of Economics and Statistics	2014
Edlund, L., Li, H., Yi, J., & Zhang, J.	The Review of Economics and Statistics	2013
Emran, M. S., & Hou, Z.	The Review of Economics and Statistics	2013
Liu, X., Lovely, M. E., & Ondrich, J.	The Review of Economics and Statistics	2010
Hering, L., & Poncet, S.	The Review of Economics and Statistics	2010
Holz, C. A.	The Review of Economics and Statistics	2009
Li, H., & Zhang, J.	The Review of Economics and Statistics	2007
Wu, X., & Perloff, J. M.	The Review of Economics and Statistics	2005
Lee, S., & Malin, B. A.	Journal of Development Economics	2013
Wang, J.	Journal of Development Economics	2013
Liao, P.	Journal of Development Economics	2013
Jarreau, J., & Poncet, S.	Journal of Development Economics	2012
Fleisher, B., Li, H., & Zhao, M. Q.	Journal of Development Economics	2010
Qin, D., & Song, H.	Journal of Development Economics	2009
Qiao, B., Martinez-Vazquez, J., & Xu, Y.	Journal of Development Economics	2008
Whalley, J., & Zhang, S.	Journal of Development Economics	2007
Ravallion, M., & Chen, S.	Journal of Development Economics	2007

Appendix Table 3, continued

Au, C., & Henderson, J. V.	Journal of Development Economics	2006
Elliott, R. J. R., & Zhou, Y.	World Development	2015
Ke, S.	World Development	2015
Zhang, Y.	World Development	2014
Appletona, S., Songa, L., & Xia, Q.	World Development	2014
Shi, H., & Huang, S.	World Development	2014
Poncet, S., & Waldemar, F. S.	World Development	2013
Li, C., & Gibson, J.	World Development	2013
Wu, A. M., & Wang, W.	World Development	2013
Brehm, S.	World Development	2013
Andersson, F. N., Edgerton, D. L., & Opper, S.	World Development	2013
Ouyang, Y., & Pinstrup-Andersen, P.	World Development	2012
Jiang, S., Lu, M., & Sato, H.	World Development	2012
Ho, C. Y., Ho, W. Y. A., & Li, D.	World Development	2010
Appleton, S., Song, L., & Xia, Q.	World Development	2010
Knight, J., & Gunatilaka, R.	World Development	2010
Uchimura, H., & Jütting, J. P.	World Development	2009
Appleton, S., & Song, L.	World Development	2008
Holz, C. A.	World Development	2008
Felipe, J., Laviña, E., & Fan, E. X.	World Development	2008
Tobin, D.	World Development	2005
Banister, J., & Zhang, X.	World Development	2005
Zhang, H., Zhang, H., & Zhang, J.	Journal of Comparative Economics	2015
Herrmann-Pillath, C., Libman, A., & Yu, X.	Journal of Comparative Economics	2014

Appendix Table 3, continued

Meng, X., Shen, K., & Xue, S.	Journal of Comparative Economics	2013
Fan, S., Li, L., & Zhang, X.	Journal of Comparative Economics	2012
Zhang, J., Wang, L., & Wang, S.	Journal of Comparative Economics	2012
Ho, C. Y.	Journal of Comparative Economics	2012
Chi, W.	Journal of Comparative Economics	2012
Feng, J., He, L., & Sato, H.	Journal of Comparative Economics	2011
Du, J., He, Q., & Rui, O. M.	Journal of Comparative Economics	2011
Jin, Y., Li, H., & Wu, B.	Journal of Comparative Economics	2011
Hornstein, A. S.	Journal of Comparative Economics	2011
Wei, Z., & Hao, R.	Journal of Comparative Economics	2010
Chen, A., & Groenewold, N.	Journal of Comparative Economics	2010
Cai, F., & Wang, M.	Journal of Comparative Economics	2010
Bloom, D. E., Canning, D., Hu, L., Liu, Y., Mahal, A., & Yip, W.	Journal of Comparative Economics	2010
Montalvo, J. G., & Ravallion, M.	Journal of Comparative Economics	2010
Démurger, S., Gurgand, M., Li, S., & Yue, X.	Journal of Comparative Economics	2009
Ding, S., & Knight, J.	Journal of Comparative Economics	2009
Guariglia, A., & Poncet, S.	Journal of Comparative Economics	2008
Chi, W., & Li, B.	Journal of Comparative Economics	2008
Ran, J., Voon, J. P., & Li, G.	Journal of Comparative Economics	2007
Yao, S., & Wei, K.	Journal of Comparative Economics	2007
Zhang, X.	Journal of Comparative Economics	2006
Li, H., & Zhu, Y.	Journal of Comparative Economics	2006
Wan, G., Lu, M., & Chen, Z.	Journal of Comparative Economics	2006
Zhang, J., Zhao, Y., Park, A., & Song, X.	Journal of Comparative Economics	2005

Appendix Table 3, continued

Meng, X., Gregory, R., & Wang, Y.	Journal of Comparative Economics	2005
Du, Y., Park, A., & Wang, S.	Journal of Comparative Economics	2005
Appleton, S., Song, L., & Xia, Q.	Journal of Comparative Economics	2005
Yang, D. T.	Journal of Comparative Economics	2005
Tsui, K. Y.	Journal of Comparative Economics	2005
Jiang, M., & Xu, L. C.	Journal of Comparative Economics	2005
Liu, Z.	Journal of Comparative Economics	2005
Li, H., & Li, Z.	Journal of Urban Economics	2013
Bosker, M., Brakman, S., Garretsen, H., & Schramm, M.	Journal of Urban Economics	2012
Deng, X., Huang, J., Rozelle, S., & Uchida, E.	Journal of Urban Economics	2008
Liu, Z.	Journal of Urban Economics	2007
Du, J., & Peiser, R. B.	Regional Science and Urban Economics	2014
Zheng, S., Kahn, M. E., Sun, W., & Luo, D.	Regional Science and Urban Economics	2014
Magnani, E., & Zhu, R.	Regional Science and Urban Economics	2012
Roberts, M., Deichmann, U., Fingleton, B., & Shi, T.	Regional Science and Urban Economics	2012
Fu, Y., & Gabriel, S. A.	Regional Science and Urban Economics	2012
De Sousa, J., & Poncet, S.	Regional Science and Urban Economics	2011
Zheng, S., Kahn, M. E., & Liu, H.	Regional Science and Urban Economics	2010
Poncet, S.	Regional Science and Urban Economics	2006
Anderson, G., & Ge, Y.	Regional Science and Urban Economics	2005
Ten Raa, T., & Pan, H.	Regional Science and Urban Economics	2005
Liu, Z.	Journal of Economic Geography	2013
Zheng, S., Wang, R., Glaeser, E. L., & Kahn, M. E.	Journal of Economic Geography	2010