Title: Growing rich without growing old: the impact of internal migration in China

Abstract

In 2017, about 10.6% of the total population in China were aged 65 or above, making it an "aging" society. The elderly dependency ratio (EDR) which is the number of the elderly per 100 working-age population was 14.8, a huge increase from 1970 when it was 6.7. The speed and magnitude of the aging trend remains a serious threat to China's sustainable growth. However, EDR exhibits wide and unusual spatial variation within the nation. In this study, we investigate the spatial pattern of EDR across 31 provinces in China in 2000 and 2010, based on a decomposition analysis. The analysis helps to attribute the EDR change to four factors: working-age migration, working-age mortality, population momentum, and the growth of elderly population. It is found that the impacts of internal migration offset or even reverse the regional differentials in fertility and mortality, thus leading to an unusual aging pattern in China. More developed provinces along the east coast attract young workers which has reduced the EDR despite persistent low fertility; whereas less developed provinces see young workers outflow, increasing the EDR despite the relatively high fertility rate. This explains why we observe a reversal of the positive relationship between the EDR and the GDP per capita that is seen in international comparisons. To some extent, we might say that some provinces are "growing old before growing rich", while other provinces are growing rich without growing old. The related social and policy implications are discussed.

Keywords: aging, China, elderly dependency ratio, internal migration, provinces

Growing rich without growing old: the impact of internal migration in China

Introduction

Changes in the population age distribution result from the interactions of three factors: births, deaths, and migration. At the national level, the decline of fertility and mortality are major proximate causes for the changing demographics in China with a 1.4 billion population. International migration, while involving large numbers in absolute terms, has a relatively minor impact (Vaupel and Yi 1991).

Over the past three decades, demographic changes have been dramatic in China. In 1979, the one-child policy was introduced. At that time, the proportion of the elderly (aged 65 and above) in the total population was 4.5% and it more than doubled to 9.6% in 2015, within the 7%−14% range attracting the formal designation of an aging society (United Nations 2015a). The pace of China's population ageing is unprecedented. For instance, it took France 115 years (from 1865 to 1980) for the elderly population to rise from 7% to 14%. In contrast, it will take China only 26 years to see the same change (from 2000 to 2026) (Kinsella and He 2009; Yip et al. 2006). By 2035, its proportion of elderly is expected to reach 21.3%, signifying that China will become a super-aged society (United Nations 2015a). The magnitude and speed of the population ageing will impose great challenges on China to maintain sustainable development in the coming decades and its possible implications to the world economy cannot be underestimated.

Recently, China announced the relaxation of its one-child policy but the impact on fertility is very limited. Internal migration in China plays a more dominant role in shaping regional demographic patterns and trends (Jones 2016a). More developed regions tend to have lower fertility, lower population growth and more severe aging, in line with international trends. However, selective migration can mitigate or even reverse this pattern. China's floating population (i.e., those people residing in a location different from their born province or *hukou* for at least six months) rose from 79 million in 2000 to 253 million in 2014 (Duan et al. 2013) and is expected to reach 291 million in 2020

(NHFPC 2015). The movements and destinations of these migrants have had a significant impact on the population structure of China at the provincial level. Jones (2016b) has pointed out that in China, now geographical differences in aging “appear to be affected much more by patterns of migration than by differences in fertility and mortality”.

This study investigates China’s aging trends at the provincial level. Throughout, the elderly dependency ratio (“EDR”) is used to measure population aging, being the ratio of the elderly population (aged 65 and above) to the working-age population (aged 15-64). The plan of the paper is as follows. We first look at the relationship between EDR, total fertility rate (TFR), and GDP per capita, and compare patterns for China with the rest of the world, uncovering a previously unknown anomaly in China. Heuristic arguments suggest that this could be caused by internal migration. Second, a decomposition analysis is performed to quantify the contribution of four factors to the changes of EDR between 2000 and 2010. The four factors are the migration of working-age population, mortality of the working-age population, population momentum, the growth of elderly population. This allows us to directly assess the impact of internal migration on EDR. Finally, related social and policy implications of the divergent aging trajectories across provinces are discussed.

Recent anomaly in the relationship among EDR, TFR, and GDP per capita

In the course of economic development, mortality typically declines, life expectancy (LE) increases, fertility decreases, and the population starts to age. It seems that population aging “is the inevitable final stage of the global demographic transition, part and parcel of low fertility and long life” (Lee 2003). Therefore, if GDP per capita is an indicator of a country’s economic development, we expect a positive relationship of GDP per capita with LE and EDR, and a negative relationship of GDP per capita with TFR and mortality, as well as a negative relationship of TFR with EDR and LE.

By using data from China’s National Bureau of Statistics and World Bank, the relationships among EDR, TFR, LE, and GDP per capita are assessed for the world and China in years 2000 and 2010. Specifically, the correlation coefficients are calculated for the 31 provinces in China and for countries with similar level of GDP per capita in the world. As shown in Table 1, at the world level, the correlation coefficients are quite consistent at the two time points and all have the expected sign, as indicated above. For China in 2000, the correlations are consistent with the world pattern. However, it is interesting to note that in 2010, the relationship of EDR with both TFR and GDP evaporates, while the correlation coefficient with LE is also reduced. This has not been previously noted in the literature.

Table 1 here

These relationships are further visualized in Figure 1. In the left plot, the world data displays the well-established negative relationship between TFR and EDR, with a similar trend and level of TFR for years 2000 and 2010. It also shows a negative relationship for China in 2000, although the levels of TFR are much lower (probably due to 30 years of one-child policy). However, in 2010 the negative relationship disappears, even turning slightly positive. In the right plot, the world data shows a standard positive relationship between GDP per capita and EDR, meaning that the more developed the country/region, the higher the EDR, the older the population (United Nations 2015b). A similar relationship can be observed for China in 2000. However, in 2010, the positive relationship for the world became stronger, while for China the correlation completely disappears. Again, this has not been previously observed in the literature.

Figure 1 here

The relationships observed at the world level are very consistent with findings in the existing literature (Bryant 2007). But the exceptional changes in the pattern of China over the period 2000-2010 deserve more attention. In the introduction, it is pointed out that migration flows within China are extremely large and are potentially much more potent drivers of demographics than fertility or mortality, especially in the short term. Consequently, migration flows may change the general patterns described above. As a region develops, it attracts young productive workers from less developed regions. Net migration moves working age-population from provinces with lower GDP per capita to those with higher GDP per capita for job opportunities; thus, provinces with higher GDP per capita may see economic growth accelerate even more than it otherwise would and the influx of working-age population will cause EDR to decrease, or at least increase less than it otherwise would. In contrast, in the region where out-migration takes place, the economy may grow slower than it otherwise would while the EDR may increase more than it otherwise would.

For the remainder of the paper, we investigate this unique pattern in China and assess the underlying factors, especially the impact of internal migration on population aging across different provinces and how this is related to spatial differences in economic development.

Accelerators and Decelerators of Population Aging

Population aging is often driven by declines in fertility as well as improvement in mortality and health status in the long term but, in the short term, so-called population momentum and migration may also play an important role. These driving factors are described here.

Fertility. Fertility transition from high to low levels imposes a long-term impact on aging. First, the continuous reduction of fertility leads to a decrease in the size of younger cohorts, thus increasing the relative size of the working-age and the elderly population (Kim and Schoen 1997). This in turn has an immediate depressing impact on both the child dependency ratio and the total dependency ratio (Kapteyn 2010). However, the decline in the younger population will make for a reduced workforce when these younger cohorts enter working age. Second, high fertility in the early period of the transition creates a swelling of the mid-period working-age population. In the short term, this drives down the EDR and creates a demographic window of opportunity. But when this working-age population enters old age, the EDR will dramatically increase. By this time, the increasing elderly population cannot be offset by the younger population that has resulted from the prolonged low fertility. This pattern can be seen in many high-income developed countries and regions. In China, the TFR fell from six children per woman in the 1960s to a replacement level (2.1 per woman) in the early 1990s and has since resumed its decline to sub-replacement levels (1.5 per woman). Such dramatic fertility decline is closely related to the one-child policy and the rapid economic development in China.

Mortality. Reduced mortality and increased life expectancy, especially in combination with reduced fertility, obviously leads to long term increase in the EDR. Lower mortality in the late working age-group means that more people progress to the elderly age-group. Lower mortality in the elderly age-group means that they survive for longer. Lower infant mortality also drives lower fertility, as the improved survival of infants reduces replacement births. In China, life expectancy for men and women in 1960 was 42 and 45 years, respectively; currently they have increased to 75 and 78 years, respectively. (World Bank, 2016). Over the period of 2000-2010, the age-standardized mortality rate in China had decreased by 19% for the under-70 age-group and by 15% for the 50-69 age-group (Norheim et al. 2015). Consequently, more people survive to age 65, resulting in a significant increase in the number of the elderly.

Population momentum. At a given point of time, the existing age-distribution has direct short-term implications for the EDR. If the working-age is defined at 15-64 then, ignoring mortality, the change in working-age population between the two years will equal the number of 14-year-olds (entrants) minus the number of 64-year-olds (drop-outs). This is the so-called impact of population momentum (Kim and Schoen 1997; Vaupel and Yi 1991), and is particularly pertinent for developed economies where the baby-boom generation are just reaching old age. Jones (2016b) has argued that some cities and provinces in China may very soon see their population momentum approach the turning point, from positive to negative, because they had prolonged ultra-low fertility due to the one-child policy and the much larger pre-policy cohorts will become elderly in the decades to come. As this negative momentum fully manifests itself in the near future, population aging in China will be unique and unparalleled, both in terms of the speed of aging and the size of the elderly population (Chen and Liu 2009; Zeng and

George 2000).

Migration. Unlike fertility and mortality, migration into or out of a region can have an immediate impact on the population age structure. Specifically, working-age migration will reduce the EDR in the host regions while increase it in the sending regions. Over the past two decades, rapid economic growth and urbanization in China are closely related to large-scale internal migration. The age composition of migrants is often heavily biased towards the young and working-age population, so in-migration serves as a decelerator of EDR, postponing or slowing down the population aging in some provinces along the east coast and in a few special economic zones, while out-migration serves as an accelerator, speeding up the aging process in some interior provinces (Zheng and Yang, 2016). Ananta and Arifin (2009; 2016) have described the interplay among migration, aging, and economic development, and put forward three possible patterns: a "slowed aging process in rich economies", where in-migration slows down the pace of aging but does not reverse the aging trend; a "deferred aging process in rich economies", where the population age structure still remains young because of in-migration; and an "accelerated aging process in low-income economies", where out-migration accentuates aging.

In sum, the existing literature identifies the above four driving forces behind population aging in China. No studies have tried to quantify empirically the impacts of all four forces together at the provincial level. This study aims to fill this gap using a proposed decomposition analysis.

Data and Method

Data Sources

The data used for our analyses are the population by 5-year age group (with age ranging from 0 up to 85 and above) in the years 2000 and 2010 for each of 31 provinces in China (excluding Taiwan, Hong Kong, and Macau), extracted from the 2000 and 2010 population censuses of China. The data are directly and publicly available from the two reports for each province: *Tabulation on the 2000 Population Census* and *Tabulation on* *the 2010 Population Census*. The data allows us to calculate EDR for each province at two time points. Rather than the *hukou population* (i.e., the *de jure* population), the resident population (i.e., the *de facto* population) is used.

Figure 2 shows a spatial map of EDR for each province in China in the years 2000 and 2010. In 2000, the EDRs of the 31 provinces were almost equally split either side of 10 (elders per 100 working-age persons) with 16 provinces below the value and 15 above. The five provinces with the highest EDRs in 2000 were Shanghai (15.02), Jiangsu (12.36), Zhejiang (12.22), Shandong (11.43), and Chongqing (11.42). The five provinces with the lowest EDRs were Qinghai (6.65), Ningxia (6.66), Xinjiang (6.86), Heilongjiang (7.36), and Tibet (7.42). Ten years later in 2010, the EDRs in 25 provinces were above 10.00 and only six provinces had EDRs less than 10.00. Those were Tibet (7.22), Qinghai (8.66), Ningxia (8.85), Xinjiang (8.87), Guangdong (8.90), and Inner Mongolia (9.96). The number of provinces with EDRs larger than 12.00 has increased from three in 2000 to 11 in 2010.

Figures 2 and 3 here

Figure 3 shows the ratio of the EDR in 2010 to the EDR in 2000. Most of these ratios are much larger than one, meaning that population in these regions are more aged than a decade ago. The EDRs in nine provinces experienced a dramatic increase – by more than 30%. These provinces were located in the north, southwest, and northwest of China (including Qinghai, Hubei, Jilin, Ningxia, Sichuan, Heilongjiang, Guizhou, Chongqing, and Gansu). In particular, in Gansu province, within the 10 years, the EDR rose from 7.67 to 11.18, by about 46%. However, the EDRs of five provinces decreased, namely, Shanghai, Tianjin, Tibet, Beijing, and Zhejiang. Particularly in Shanghai, the EDR dropped by 17%, from 15.0 in 2000 to 12.5 in 2010. Apart from Tibet which will be discussed later, the other provinces are either in the Bohai Economic Rim or in the Yangtze River Delta which have offered many job opportunities due to its rapid economic and industrial development.

Direct information on provincial migration is not available. Besides, our analysis requires age-specific 10-year mortality rates for each province, specifically for the 5-54 and 55+ age-groups, as explained below. To estimate these rates, the number of deaths by age group is needed and also obtained from the two census reports for the 31 provinces.

Method

Our method is based on decomposing the proportional change of EDR into different factors. These factors have meaningful interpretations and allows us to attribute changes in EDR to different dynamic sources.

Let n_A^t denote the number of people in age group A=[L,U] (i.e. age ranging from L to U) at time *t*. With this notation, EDR is the ratio of the elderly population $n_{[65,120]}^t$ to the working age population $n_{[15,64]}^t$, supposing 120 is an absolute limit on human lifespan. Now n_A^{t+T}/n_A^t measures the proportional growth of the age group A over T years. It is pertinent to look at the age-group A−T =[L−T,U−T] who will move into the [L,U] age-group after T years. Let $n_{A-T,s}^t$ denote those of the n_{A-T}^t who survive into the age-group A at time *t*+T. This cannot be directly observed, however it can be calculated from

$$n_{A-T,s}^t = n_{A-T}^t \times (1 - m_{A-T}^t) \qquad (1)$$

where m_{A-T} is the T-year mortality rate of age-group A−T, which can be estimated from age specific mortality rates. Furthermore, we factorize the growth of the age group A into three terms, as show in Eq. (2).

$$\frac{n_A^{t+T}}{n_A^t} = \frac{n_A^{t+T}}{n_{A-T,s}^t} \times \frac{n_{A-T,s}^t}{n_{A-T}^t} \times \frac{n_{A-T}^t}{n_A^t} \qquad (2)$$

The first term would equal 1 without migration (if we assume L>T so that fertility has no impact). It is greater or less than one as net migration is positive or negative. The second term equals the survival rate over T years, that is $(1 - m_{A-T}^t)$. The third term depends on the population structure at time T and the potential groups of people who enter or leave age group A, illustrated in Eq. (3).

$$\frac{n_{A-T}^t}{n_A^t} = 1 + \frac{n_{[L-T,L]}^t - n_{[U-T,U]}^t}{n_{([L,U])}^t} \qquad (3)$$

So it is larger or smaller than one as the number $n_{[L-T,L]}^t$ who will enter the age group A is larger or smaller than the number $n_{[U-T,U]}^t$ who will leave.

Now, these equations will be applied to decompose the change in the EDR over 2000-2010.

$$\frac{EDR^{2010}}{EDR^{2000}} = \frac{n_{65+}^{2010}/n_{(15,64)}^{2010}}{n_{65+}^{2000}/n_{(15,64)}^{2000}} = \frac{n_{\mathrm{OLD}}^{2000+10}}{n_{\mathrm{OLD}}^{2000}} \bigg/ \frac{n_{\mathrm{WORK}}^{2000+10}}{n_{\mathrm{WORK}}^{2000}} \qquad (4)$$

As shown in Eq. (4), the numerator and denominator are ratios of the general form which we have just been considering with A=OLD and A=WORK respectively. We could apply the previous factorization method to both terms, yielding 6 factors, however for reasons mentioned later we will only apply it to the working age range [15-64]. Thus, the change ratio of EDR is decomposed into four interpretable factors (see Eq. (5))

$$\frac{EDR^{2010}}{EDR^{2000}} = \frac{n_{5-54,s}^{2000}}{n_{15-64}^{2010}} \times \frac{n_{5-54}^{2000}}{n_{5-54,s}^{2000}} \times \frac{n_{15-64}^{2000}}{n_{5-54}^{2000}} \times \frac{n_{65+}^{2010}}{n_{65+}^{2000}} \qquad (5)$$

The first term $n_{5-54,s}^{2000}/\, n_{15-64}^{2010}$ is the ratio of the population aged 5-54 in 2000 who will survive to age 15-64 ten years later to the working-age population in 2010. Without migration this ratio would be one, and is less/greater than one when there is inward/outward net migration. Therefore, this ratio measures the impact of working-age migration on EDR.

The second term, $n_{5-54}^{2000}/n_{5-54,s}^{2000}$ can be simplified into the reciprocal of the 10-year survival rate $(1 - m_{5-54})$ of the 5-54 group in our earlier notation. So it will always be greater than one because loss of potential working age population will always make the EDR higher. Therefore, this term measures the impact of working-age mortality.

The third term $n_{15-64}^{2000}/n_{5-54}^{2000}$ can be expressed in terms of three age-groups: the 15-54 age group in 2000 who will still be of working age in 2010; the 55-64 age group who will leave the working age (the older group) and the 5-14 age group (the younger group) who will enter working age. The ratio can be further expressed as the following:

$$\frac{n_{15-64}^{2000}}{n_{5-54}^{2000}} = \frac{n_{15-64}^{2000}}{n_{15-54}^{2000} + (n_{5-14}^{2000} - n_{55-64}^{2000})} \quad (6)$$

This ratio will be less than one if the younger group outnumber the older. It depends on the age distribution of the existing population. Therefore, this term measures the impact of the population momentum.

The fourth term $(n_{65+}^{2010}/n_{65+}^{2000})$ measures the direct growth of the elderly population over 2000-2010. Actually, this is determined by the population structure in year 2000 (i.e. the momentum of aging), mortality of the 55+ age-group as well as net migration. It is possible to break this into three factors analogous to the three terms above, but our present focus will be on the working age factorization, since elderly migration is not a major driver of EDR patterns. Indeed, our calculations (not presented) indicate that this elderly ratio is mainly driven by provincial differences in momentum (i.e. the numbers in the 55-64 age-group) rather than differences in elderly mortality or migration.

In sum, our factorization reveals the role of internal migration, working age mortality, population momentum, and the changing size of the elderly population in determining the trend in EDR. This helps us to identify the driving forces for aging in each province, and also enhances our understanding of population dynamics in China.

Results

Decomposition of Changes in the EDR in the Period 2000-2010

Table 2 shows the impacts of the four factors on the change of EDR in Columns 3 to 6. The product of these columns gives the change of the EDR over the period 2000-2010 (Column 2). Column 8 shows the synthetic EDR in 2010, which is estimated under the assumption that there was no net migration among the provinces over 2000-2010.

Table 2 here

Many of the migration factors are less than one. Especially for Shanghai, Tianjin, Beijing, Zhejiang, and Guangdong, EDR is strongly suppressed by migration. In Shanghai and Beijing, in-migration has suppressed the EDR by 32.4% and 33.6%, respectively. If there was no net in-migration, the EDR in 2010 for Shanghai and Beijing would have risen to 18.4 and 15.9, rather than decreased to 12.5 and 10.5. *Without inflow of the young population, these two highly-developed cities would have become the oldest places in China in 2010.* In Tianjin, Zhejiang, and Guangdong, in-migration also pulled down the EDR by 26.4%, 15.3% and 13.4%, respectively. Without in-migration, the EDR of these provinces would have increased to 14.18, 14.23, and 10.28, rather than the observed 10.43, 12.05, and 8.90. These results imply that the large influx of labor migrants have reversed the aging trend in these provinces.

However, there is also a group of provinces where migration has sped up population aging. In Henan, Guangxi, Anhui, Hubei, Sichuan, Guizhou, Chongqing, net out-migration has made a significant contribution to the increase of the EDR. For example, in Guizhou, the migration itself raised the EDR by 16%; if there was no migration, the increase of EDR would have been much smaller, reaching 11.3 instead of 13.2. In Chongqing, out-migration accelerated the population ageing, which has increased the EDR by 12% and made the city the oldest place in China in 2010. Without outflow of the young population, the EDR would be 14.6 rather than 16.5.

Population momentum is currently less than one in every province, because the number aged 5-14 exceeds the number aged 55-64 (see Eq. (4)). However, in the near future population momentum will exceed one and begin to contribute to ageing, as baby boomers move towards the end of their working age. Provinces with the least favorable (i.e. largest) population momentum are Shanghai, Tianjin, Beijing, and Zhejiang, which are all highly developed regions. Indeed, the momentum factor is strongly positively correlated with GDP.

The major driver of EDR however is the elderly population itself. Due to increase of life expectancy, the number of the elderly has gone up across all the provinces in China. Particularly, in places like Xinjiang, Ningxia and Gansu, the elderly population has been escalating at an astonishing speed. This value of this factor ranges from 1.21 to 1.64 (Column 6).

Finally, the impact of working-age mortality on the EDR is very minor. For most of the 31 provinces, mortality in ages 5-54 in the period 2000-2010 pushed up the EDR only about 1% to 3% at most.

Figure 4 visualizes the impacts of migration, momentum and the number of elderly on EDR for provinces classified into four levels of EDR change. Four of the five provinces where EDR decreased, namely Beijing, Tianjin, Shanghai, and Zhejiang are all located in the key economic regions of the Bohai Economic Rim in the north, the Yangtze River Delta in the east, and the Pearl River Delta in the south. All these regions have been the economic powerhouse of China’s development in the period 2000-2010.

The fifth province is Tibet but the decreased EDR here is largely due to the population momentum. Figures 4 (c) and (d) show that in areas where the EDR rose rapidly during the period 2000-2010, not only were there increase of the elderly population but also out-migration that accelerated the aging process. Most of these are the neighboring provinces of the key economic regions, while some are in the middle and western part of China. They are the main labor suppliers to the more economically prosperous regions. It can be seen clearly in this figure that the increase in the number of elderly is an important driver of population aging in all the provinces of China.

Figure 4 here

Getting Old before Getting Rich: An Unbalanced Spatial Pattern

In contrast with high-income western countries, China has completed the first demographic transition at a relatively low level of social and economic development (Cai and Wang 2009). Currently, "getting old before getting rich" has become a matter of concern in China (Wu et al. 2007). Figure 5 (a) shows the relationship between GDP per capita and the EDR at the provincial level for the years 2000 and 2010. In 2000, the association between the two is positive. Provinces with higher GDP per capita often have higher EDR, meaning that the population is older in richer areas. However, the trend line flattened in 2010 (as already noted in Section 2). This is driven by provinces such as Chongqing, Sichuan, Anhui, Guangxi, Guizhou, and Hunan (top left of the plot), whose EDR increased by 25−45% despite having low GDP per capita. At the same time, the EDRs of Shanghai, Beijing, Tianjin and Shanghai reduced while their GDP per capita grew massively. Subsequently, the gap of GDP per capita has widened substantially between 2000 and 2010. This imbalanced spatial pattern indicates that some provinces in China are very likely to *"grow old before growing rich",* whereas the others which are being benefited by the inland migration would *"grow rich without growing old".*

Figure 5 (b) shows the counterfactual EDR (Table 2, Column 8) calculated assuming no migration. The positive relationship between GDP per capita and EDR in 2010 re-appears. We have thus attributed the disappearance of the standard positive correlation between EDR and GDP to migration.

Figure 5 here

Conclusion

In this paper, we have identified the disappearance of the usual relationship of EDR with TFR and GDP per capita in China between 2000 and 2010, and we have attributed this reversal to internal migration based on our decomposition analysis. The internal migration has moderated aging in the richer provinces while accelerated aging in the poorer provinces. The latter grow old before growing rich while the former grow rich without growing old. It has widened the income disparity among provinces in China. The benefits of overall economic growth in China have been concentrated in a small number of provinces.

Spatially, it is revealed that provinces located in the key economic regions such as the Bohai Economic Rim in the north, the Yangtze River Delta in the east, and the Pearl River Delta in the south, either had smaller increases or even decreases of the EDR, which was mainly due to in-migration. And the influence of in-migration in the Yangtze River Delta was comparable or even stronger than that of the Pearl River Delta (see Table 2, Column 3). This is consistent with the findings by Liang et al. (2014), which indicated that there was a shift in the migrant destination from the Pearl River Delta to the Yangtze River Delta over the first decade of the twenty-first century. However, provinces surrounding the key economic regions or in the interior part of China had larger increases in their EDRs, which were caused by out-migration. This study has thus provided the empirical evidence to demonstrate how internal migration has dominated population dynamics, especially population aging at the provincial level of China (Gu 2014).

Furthermore, it is discovered that the relationship between regional economic development and population aging has changed over the period 2000-2010. In 2000, the age structure of China's population was much older in more developed areas, and much younger in less developed areas. However, by 2010, that positive relationship no longer existed. In less developed areas, the population was even aging faster, whereas in more developed areas, the population was aging much slower or even getting younger. This implies that the argument "getting old before getting rich" does not hold for the entire China. Internal migration has played a crucial moderating role in the relationship between economic development and population aging across different provinces. Therefore, in the near future, China will not only face the challenges that come with rapid aging at the national level; the country will also have to close the economic gaps between the sending and host provinces. Thus, it is important for the provinces that have benefited from net in-migration to contribute some fair share of human capital to the provinces that have been negatively affected by the net out-migration. Meanwhile, scholars have also noticed that inter-provincial return migration, especially among migrants with higher education, is rising rapidly, which might help to reduce the income and occupational inequality between the eastern and western regions, and between the coastal and interior areas (Chunyu et al. 2013; Liang et al. 2014).

Apart from the regional imbalance in development and income inequality, the differences in wages and social welfare between migrant workers and local people have also always been of great concern. The household registration system (*hukou*) needs to be revisited as it has been a barrier for migrants and their family members to fully participate in daily activities. It still remains an important factor in determining one's wage and social benefits, especially in the major cities (Chan 2010). Furthermore, the social cost of large-scale internal migration on millions of families has not been fully accounted for. On the individual level, the migrants might be financially better off. However, the left-behind children, lonely elderly, and rising divorce rates due to long spatial separation, have become urgent social issues that need to be addressed. Economic growth cannot be sustainable with a huge hidden social cost. The family support system in modern China has been weakened and it has a substantial impact on the long-term development. In terms of the economic benefit from internal migration, some regions may gain more, but others less, and some may even lose out.

Government policy should be developed to address the growth imbalance and special compensations should be provided to those provinces which have contributed to the net migration. But the most important thing is to ensure that suitable measures are in place to deal with the rapidly changing demographics both at the national and regional levels, so that the flow of internal migration can be directed and regulated to produce the desirable outcome with the aim of improving the overall well-being of the people in China. It should also ensure that potential negative impacts of massive internal migration are managed properly to achieve sustainable growth (Sha et al., 2016).

There are several limitations in this study, however. Although the decomposition analysis has enabled identification of the proximate demographic factors of changes in the EDR, this study has not yet empirically linked those demographic factors with the socioeconomic drivers (urbanization, industrialization, etc.). Even so, the present analysis can still help reflect the rapid socioeconomic changes underlying China's population dynamics. Nonetheless, this study mainly focuses on inter-provincial migration, and has not paid much attention to intra-provincial migration. Liang et al (2014) have observed that over the period 2000-2010, intra-provincial migration was growing, indicating that the aging pattern even within an individual province would become more complicated and divergent than in the past. Clearly, the present decomposition method could be used to further investigate the impacts of intra-provincial migration, with access to population data at the city or county level. Moreover, migration of the elderly population has also not been specifically estimated in this study. Although elderly migrants still account for a very small proportion in the total floating population in China, about 7.2% in 2015 (NHFPC 2016), the rising movement of the elderly population will also affect the regional aging trend. Thus, this calls for further examination and more research on the well-being of these elderly migrants.

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Table 1 correlation coefficients among EDR, TFR, LE, GDP

	World 2000	World 2010	China 2000	China 2010
EDR→TFR	-0.66***	-0.73***	-0.41**	+0.10
GDP→TFR	-0.46**	-0.46**	-0.70***	-0.67***
LE→TFR	-0.66***	-0.69***	-0.81***	-0.54***
GDP→EDR	0.48**	0.39**	0.57***	-0.003
LE→EDR	0.47***	0.50**	0.70***	0.33*
GDP→LE	0.35**	0.40*	0.75***	0.79***

Note: *p<0.05, **p<0.01, ***p<0.001; GDP per capita of the 31 provinces in China ranged from US$700 to US$7000 in 2000 and from US$2000 to US$15000 in 2010.

Table 2 The decomposition result of changes in elder dependency ratio between 2000 and 2010 (descending order according to the change ratio of EDR)

region	EDR 2010/ EDR 2000	working-age migration	working-age mortality	population momentum	growth of elderly	EDR2010	EDR2010*
Shanghai	0.830	0.676	1.012	0.978	1.240	12.46	18.44
Tianjin	0.928	0.736	1.014	0.934	1.331	10.43	14.18
Tibet	0.974	0.956	1.034	0.801	1.230	7.22	7.56
Beijing	0.976	0.664	1.014	0.969	1.495	10.54	15.87
Zhejiang	0.986	0.847	1.018	0.923	1.240	12.05	14.23
Guangdong	1.005	0.866	1.015	0.850	1.347	8.90	10.28
Shanxi	1.080	0.956	1.018	0.843	1.316	10.06	10.52
Fujian	1.083	0.981	1.017	0.850	1.277	10.30	10.50
Hainan	1.092	0.958	1.015	0.818	1.373	11.18	11.68
Hebei	1.095	0.982	1.018	0.869	1.260	10.99	11.20
Henan	1.116	1.085	1.018	0.833	1.212	11.83	10.90
Jiangsu	1.156	0.947	1.017	0.907	1.325	14.30	15.10
Shandong	1.157	0.984	1.018	0.895	1.290	13.23	13.45
Jiangxi	1.167	1.017	1.019	0.841	1.338	10.78	10.60
Yunnan	1.187	0.996	1.026	0.855	1.359	10.64	10.68
Guangxi	1.218	1.099	1.019	0.839	1.297	13.38	12.18
Liaoning	1.244	0.960	1.019	0.930	1.368	13.17	13.72
Shaanxi	1.244	0.983	1.020	0.848	1.463	11.11	11.30
Anhui	1.252	1.074	1.017	0.843	1.358	14.20	13.22
Hunan	1.268	1.040	1.020	0.880	1.358	13.46	12.94
Inner Mongolia	1.283	0.977	1.020	0.885	1.454	9.65	9.87
Xinjiang	1.292	0.926	1.020	0.835	1.640	8.87	9.58
Hubei	1.302	1.096	1.018	0.856	1.362	11.80	10.76
Qinghai	1.303	1.005	1.022	0.846	1.500	8.66	8.62
Jilin	1.307	0.998	1.020	0.904	1.421	10.53	10.55
Ningxia	1.328	0.963	1.017	0.827	1.641	8.85	9.19
Sichuan	1.403	1.083	1.024	0.895	1.414	15.19	14.03
Heilongjiang	1.410	0.967	1.020	0.908	1.575	10.38	10.73
Guizhou	1.412	1.162	1.027	0.822	1.439	13.19	11.35
Chongqing	1.440	1.123	1.024	0.905	1.383	16.45	14.64
Gansu	1.458	1.058	1.020	0.839	1.610	11.18	10.57

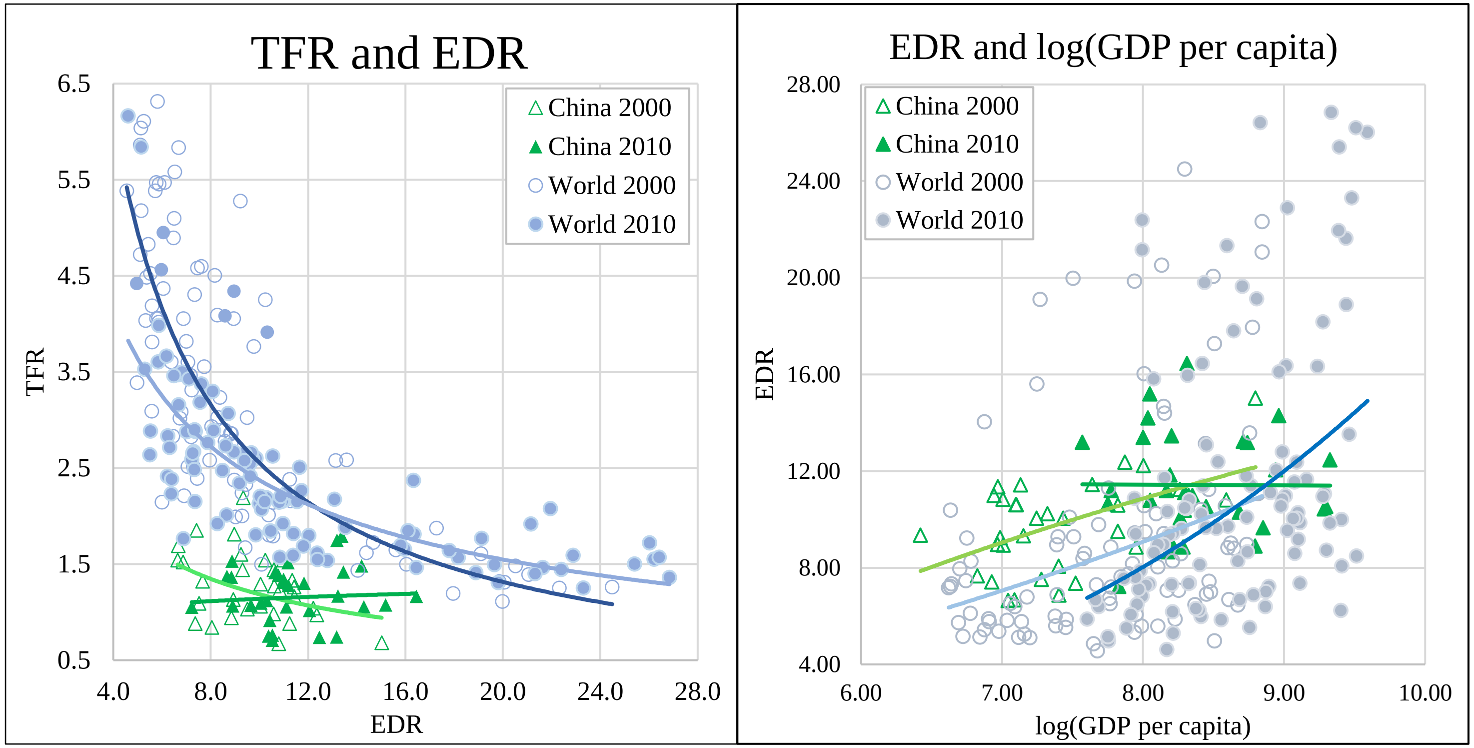

Fig. 1 the relationship among EDR, TFR, and GDP in the world and China.

Note: China data is for all 31 provinces; world data is for countries with similar levels of GDP per capita

Elderly dependency ratio in 2000 and 2010, by province

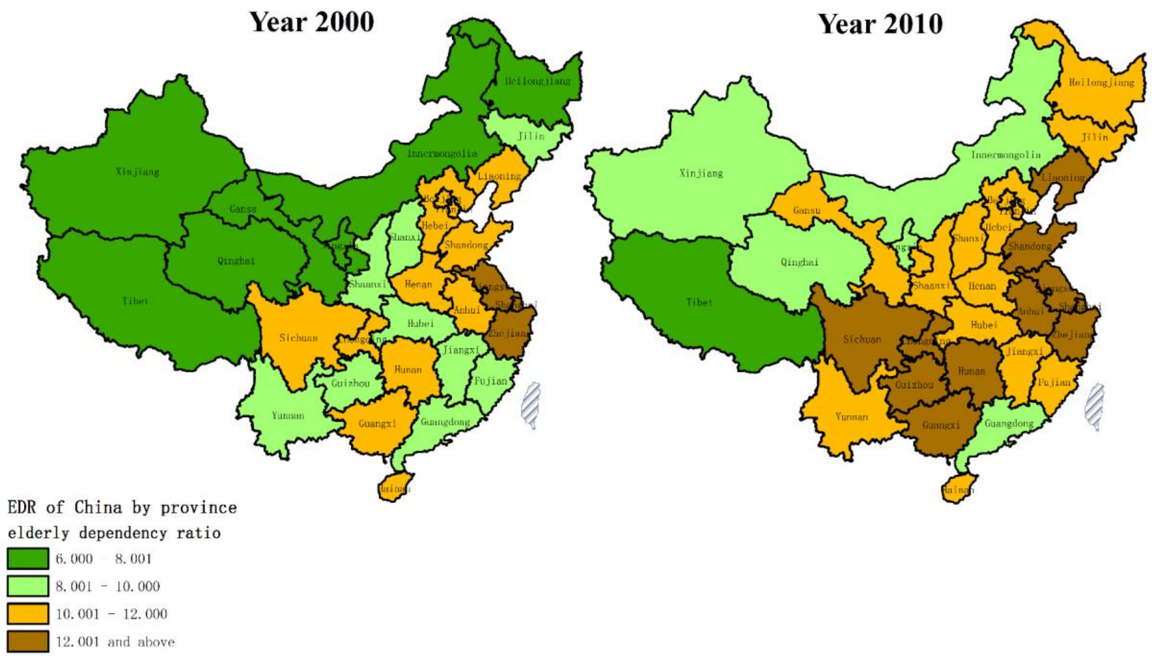

Fig. 2 Elderly dependency ratios for each province in China in 2000 and 2010

Source: The 2000 and 2010 Population Census of the People's Republic of China

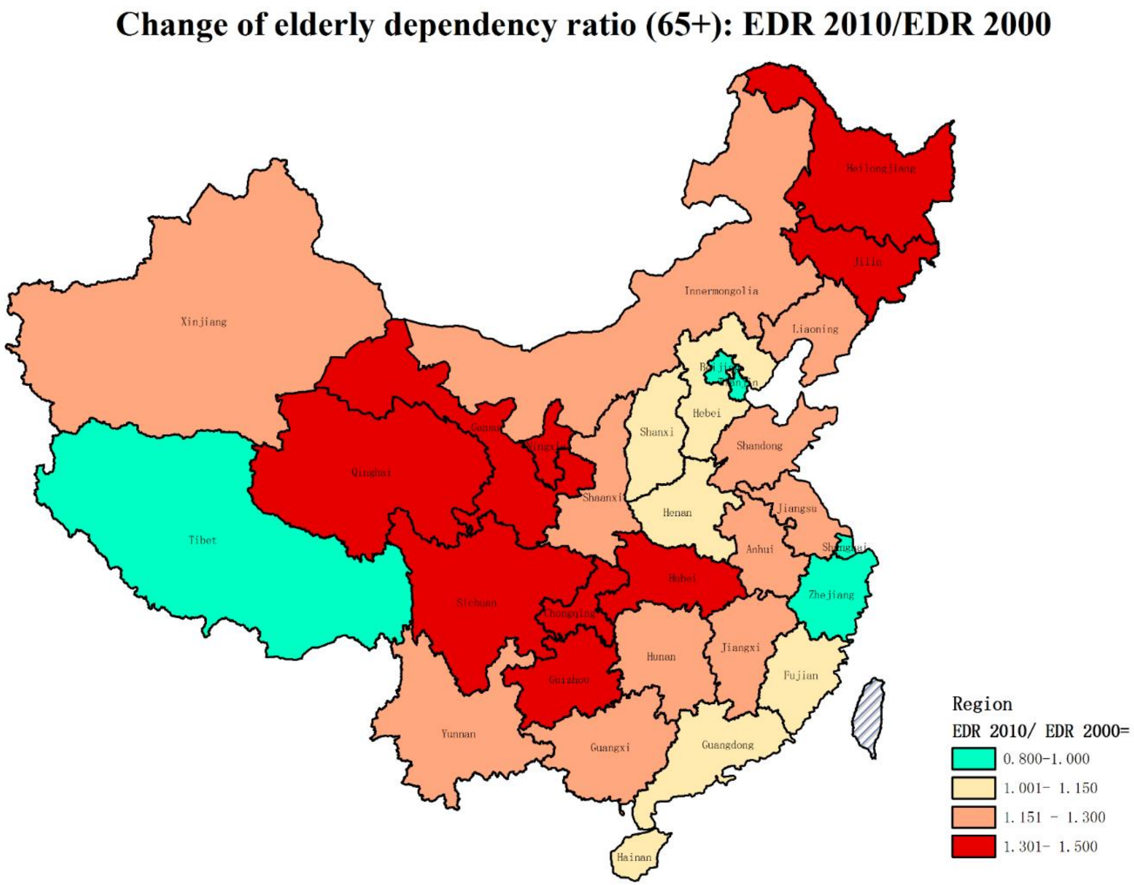

Fig. 3 Changes in the elderly dependency ratios over 2000-2010 for each province
Source: The 2000 and 2010 Population Census of the People's Republic of China

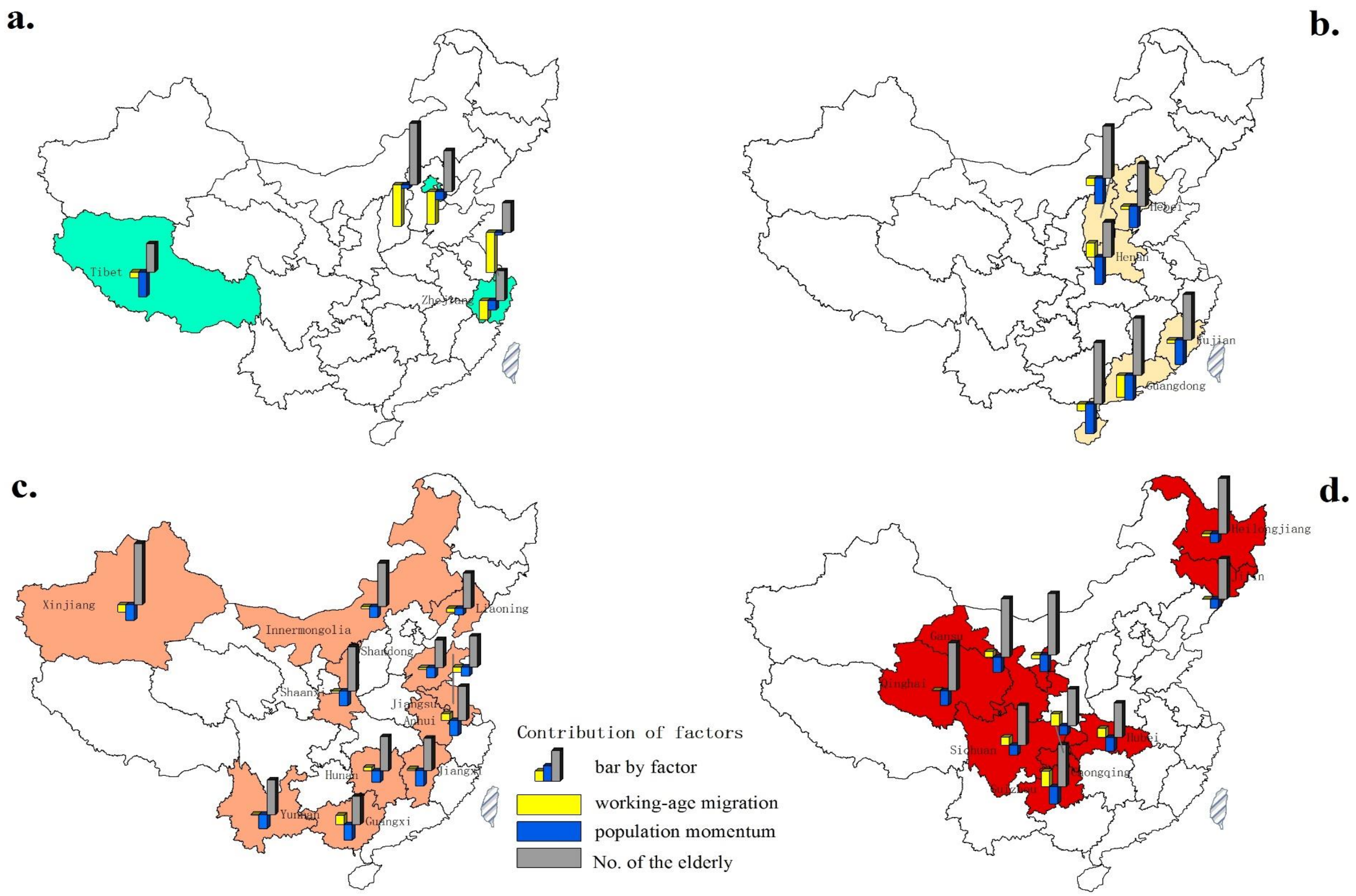

Fig. 4 The contribution of working-age migration, population momentum, number of elderly to changes in EDR between 2000-2010

Note: the change ratio of EDR is in the range of 0.80-1.00 in (a), of 1.00-1.15 in (b), of 1.15-1.30 in (c), and 1.30-1.50 in (d).

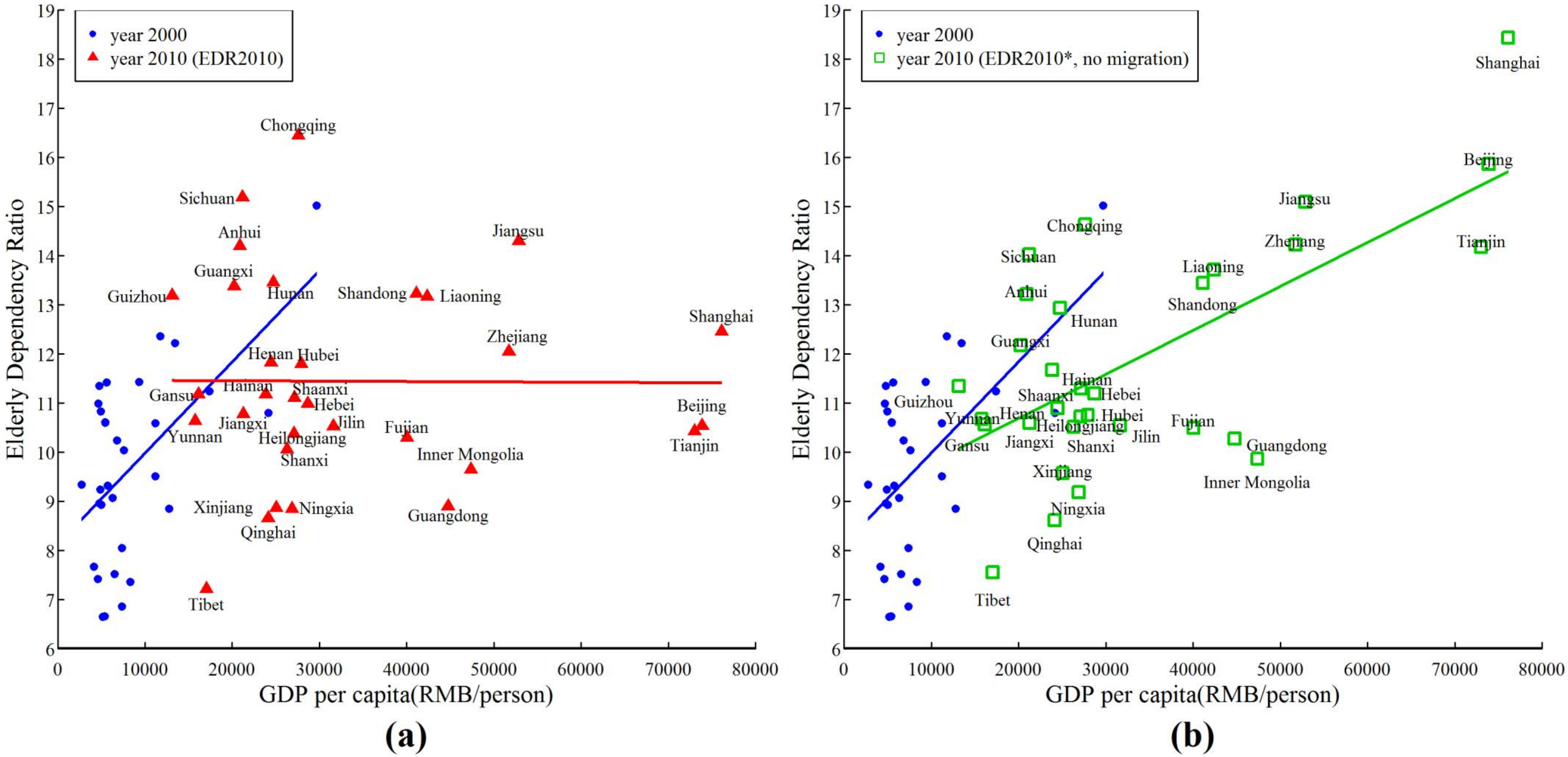

Fig. 5 the relationship of GDP per capita with the actual EDRs in (a) and the synthetic EDRs in (b)