Two scenarios on Chinese population dynamics based on a multiregional projection model

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Abstract

Migration between Chinese provinces is changing the face of the country. We present the results of a set of multiregional projections for the Chinese population according to the model of A. Rogers (1995). The population is divided by age, gender and province, based on data of the 1990 and 2000 censuses. We make some assumptions to account for birth underreporting and for missing cross-tabulations. We develop two scenarios covering the 2000-2020 time span: in the first, migration rates are constant; in the second, they double throughout 20 years. The second scenario is not unlikely, given the government's growing tolerance of migrant workers, and given that propensity to interprovincial migration could be much higher (such as, for example, in the USA). In Scenario 1, migration peaks in 2005 and then slows down because of population ageing. In Scenario 2, migration increases at a slower and slower pace across the whole projection horizon. Migration has important effects at the provincial level. In most provinces, the effect of migration is as large or larger than that of natural growth. In the three independent metropolises (Shanghai, Beijing and Tianjin) migration is by far the largest factor of population growth, making up for a very low fertility and reducing the dependency ratio; rural provinces like Hunan, on the other hand, lose working-age population to outmigration.

Since the death of Mao Zedong thirty years ago, China has undertaken many important steps in the direction of a less controlled society: migration is no exception. While there are still significant constraints to the freedom of movement of the Chinese population, in the last ten years we have seen the emergence of a dramatic expansion of the phenomenon of internal migration.

In this paper we carry out projections of the Chinese population at the provincial level.[1] The projections range from 2000 to 2020 and they are, to the best of the author's knowledge, the only regional-scale population projections updated with the data of the 2000 census.

Knowing precisely the size and the composition of the population of each province is crucial to the Chinese policymaker, both for decision-making and for planning. At a glance, the relative importance of migration in determining size and composition of each province's population is such that migration forecasts cannot be treated as an adjustment to natural growth forecasts; rather, they must be fully integrated in the model. Hence the decision to adopt Andrei Rogers's multiregional model, which allows for the projection of migration with a specific origin and destination.

Rogers's model requires an enormous quantity of data. To this purpose, we utilized every possible piece of information from the tabulations of the 2000 census, and where information was missing, we estimated it in the most neutral way.

We carried out the projections for 20 years only, believing that it is unreasonable to push farther into the future for a society that is changing so rapidly. The most unpredictable and inexactly reported data are those on fertility rates. In 2020, today's infants will be 20-year-olds, the age when migration is most likely to happen – and we have no precise idea of how many they are.

Unwilling to make assumptions on the future policies of the Chinese government, we estimated two scenarios with different propensity to migrate. In the first, all rates are kept fixed, to simulate the absence of changes in policy. In the second scenario, migration rates double linearly over the 20 years, to simulate further liberalization.

The two scenarios do not differ much in qualitative terms, in that the effects on population size and structure are the same, just magnified in the second scenario. What differs – and is, in a way, surprising – is that in the first scenario

[1] Provinces are the largest administrative units in the People's Republic of China.

the total number of migrants reaches its peak in 2005-2010 and then declines, even though the overall size of the Chinese population keeps increasing. Migration behavior is strongly related to young age, and population ageing acts as a brake to the otherwise increasing phenomenon. In the second scenario, however, the doubling of the rates is enough to offset the ageing brake, and the total number of migrants keeps growing through the whole projection time span.

It is important to take these results with a grain of salt. Migration rates might change differently from what we assumed: they could decline, or they could more than double in the next 15 years. These results are useful for the policymaker, however, because they give at least an idea of the magnitude of the changes that China is undergoing and will undergo in the future. The census 2010 will give us a fair idea of the precision of these estimates.

Data and model

The multiregional model

We carry out the projections according to Roger's multiregional model (1995). The population is broken down in several categories, and each category is a cell of the population vector. The model requires a large quantity of data, depending also on the number of characteristics accounted for. A simple model, accounting only for the regions of origin and destination, would require much less detailed data than an origin-destination-age-sex model. In fact, given the relative richness of the Census 2000 tabulations we can, with some adjustments, project a population that is divided into 2 genders, 31 provinces, and 17 age groups (0-4, 5-10, …, 75-79, 80+): a total of 1,054 categories (2 x 31 x 17).

In the time unit (5 years, in our case) the population will undergo one transition. The transformation occurs by multiplying our 1,054-cell vector by a square matrix of the same size (1,054 x 1,054). The first line of the matrix has, in correspondence with the female population, the fertility rates for each age group. All other cells represent transition probabilities. In other words, the number in the cell *(i,j)* of the matrix represents the probability that an individual in the i^{th} category before the transition will be in the j^{th} category after the transition.

For our model, therefore, we need to estimate the size of the population in

each of the 1,054 categories and the transition rate for those transitions that may actually happen.[2]

Population data

The census tabulations do not report the population breakdown by age, province and gender simultaneously. At the national level, they report the full age-sex distribution. At the provincial level, the tabulations provide only three large age groups (0-14, 15-64 and 65+). Using the technique of Iterative Proportional Fitting[3] (IPF) we fitted the national distribution to the regional totals, so as to have a complete distribution.

The IPF algorithm is very useful to complete a table of which we have the row and column totals. After filling the table with an approximate distribution, the algorithm fits it to the known row and columns totals. A very good approximation of the 2000 population is the 1990 population, reported by Chesnais and Sun (2000), broken down by age, sex and region. We projected this distribution 10 years later with no adjustment, thus putting the former 0-4 years old people in the place of the new 10-14 years old people, and so on. The first two missing age groups have been filled by births on the basis of the latest birth rates by the National Bureau of Statistics (NBS, 1990-1998).

In performing this adjustment, we realized that the 10-14 years old population is larger in absolute size than the corresponding 0-4 years old age group in 1990. This is most probably due to the underestimation of births, as a difference of 9 million people (without accounting for the effect of mortality) can neither be reasonably imputed to immigration from abroad[4] nor to death underestimation (Li and Sun, 2003). In China's case, unreported deaths are specifically searched for before every census, and the public registries are updated (Banister, 1987). We will deal with this problem below, while estimating mortality rates.

Fertility rates

Age-specific fertility rates are available at the national level for the whole 1990-2000 period. The 2000 Census reports only the births by age of mother for 1999, and the rates are probably unreliable because of the birth

[2] In fact, most of the matrix's cells are 0. It is impossible for a man to become a woman, for an individual to become younger, or to become 10 years older within 5 years; an individual can either be 5 years older and alive in any of the 31 provinces, or dead.

[3] For a detailed explanation of the technique, see Schoen and Jonsson (2003).

[4] Especially in the case of China, which reported only 22,000 international immigrants between 1995 and 2000

underreporting individuated in the previous section. Fortunately, the U.S. Census Bureau reports both age-specific fertility rates and the sex ratio at birth for all years between 1990 and 2000. The simple mean value of the years between 1995 and 2000 has been used for the projections, to prevent yearly fluctuations to influence the projections' result.

Notice that fertility is less important than mortality to the purposes of this analysis, because the newborn babies of the first projection period (2000-2005) will be 15-19 years old in the last period (2015-2020), i.e. not yet in the age where migration is most likely to happen. The national-level birth rates have been adapted to the single regions.[5]

Mortality rates

Mortality revealed greater difficulties. As we said, the population figures of the first two age groups are heavily underestimated, and therefore the data are not valid for estimating the intercensal probability of dying. The same problem, to a much lesser extent, shows up in older age groups, probably because of unreported migration.

Birth underreporting and undercounting in general are a common problem in developing countries. The UN (2002) report a method to assess with reasonable precision the mortality rates in such cases. The mortality schedule is adapted to a Brass General Model schedule starting from the approximated life expectancy. Having a national-level mortality schedule, we applied it backwards to the 2000 cohorts, to determine birth underreporting in 1990.

Of course, birth underreporting might flaw the 2000 census data too, which looks realistic because of the unnaturally low fertility rates of the last years (1995-2000). Moreover, a 1,81% underestimation is officially admitted but the age distribution of such underestimation has never been released. For China, 1,81% means 23 million people.

With the adjusted figures for 1990, and the estimated mortality and fertility rates, we were able to determine the possible size and distribution of underestimation in the 2000 census (about 3%, mainly in the first two age groups).

The provincial population figures are adjusted proportionally to the national figures: repeating 31 times the above procedure would not give much more

[5] ADJASFR, a spreadsheet by the U.S. Census Bureau, adjusts a given fertility schedule to a target number of births. Births are known from the Census 2000 data. For further details, see Population Analysis System on http://www.census.gov/ipc/www/.

precise estimates, and would be very time-consuming.

Finally, with coherent figures for the 1990 and 2000 population, the national age-specific death rates are adapted to the single provinces.[6]

Migration rates

The 2000 census reports with good precision all the migration flows of the 1995-2000 period, cross-tabulated by origin and destination. Unfortunately, data on the destination of migration flows are not cross-tabulated with data on the age composition of migrants. Age-gender data are available, however, and we merged the two partial distributions into a joint distribution, assuming that every single flow follows the national age distribution. We think that this assumption is not able to influence the results significantly, given the relatively short projection period.

Having the size of the age-sex groups at provincial level, we estimated the age-sex-destination specific migration probabilities for every region by the occurrence/exposure method, i.e. by dividing the flows by the total population in the origin region in the same category.

We projected two different scenarios, because fixed propensities to migration may be an unsatisfying approach. An increase in the overall propensity to migrate is highly probable because of the government's progressively increasing tolerance towards migrants. Moreover, the present propensity to interprovincial migration is one-fifth of the propensity to interstate migration of the USA, and thus there is large room for an increase.

The first scenario keeps fixed the propensities to migration, which is anyway useful. Making 1 any calculated migration rate, the value will be 1 in all successive transitions (i.e. 2000-2005, 2005-2010, 2010-2015, 2015-2020). The second scenario assumes that propensity to migrate increases by 100% during four 5-year periods. Making 1 the estimated propensity to migrate of the 1995-2000 period, that of the 2005-2010 period is 1,25 and so on up to 2 in the 2015-2020 period.

The projection is carried out by successively multiplying the population vector by the 1,054 x 1,054 transition matrix, and (in Scenario 2) increasing all rates at every step. Results are presented in the next section.

[6] ADJMX, a spreadsheet by the U.S. Census Bureau, adapts a given mortality schedule to a desired number of deaths. The number of deaths is known at the provincial level.

Results

Total population and age structure

Both scenarios yield practically the same results in terms of population size, as internal migration influences fertility marginally and international migration is not included in the model.

China's population grows at a slower and slower pace, descending from 3,7% in 2000-2005 to 1,9% in 2015-2020. The dependency ratio, calculated as (number of people under 15 + number of people over 65) / (number of people aged 15-65), is smaller in 2020 than in 2000; on the other hand, the population is older than before, and the percentage of people over 65 on the total population has grown from 6,3% to 10,4% (see Figure 1 and Figure 2).

These results are not surprising – they roughly coincide with all other projections. More interesting are the results specifically sought through the multiregional approach: a description of the future migration and of the population at the provincial level.

Overall figures of migration

The overall number of migrants in each five-year period is the first surprise. In Scenario 1 the figure increases in the first year and decreases in the second, and therefore the most massive wave of migration (at least in absolute terms) should be in place at the time we are writing. In Scenario 2, with increasing propensity to migration, the number of migrants increases constantly but at an ever slower pace (see Figure 4). Maintaining the same curve, we could imagine that the peak will be reached around the middle of the century with about 70 million migrants in five years. The overall migration rate is in the first Scenario constantly decreasing and in the second constantly increasing. Why does migration stop growing (in Scenario 1) or slow down (in Scenario 2)? The phenomenon is mainly due to the ageing of the Chinese population and the subsequent decrease of people in their 20's and 30's, the ages where individuals have the highest probability of migrating.

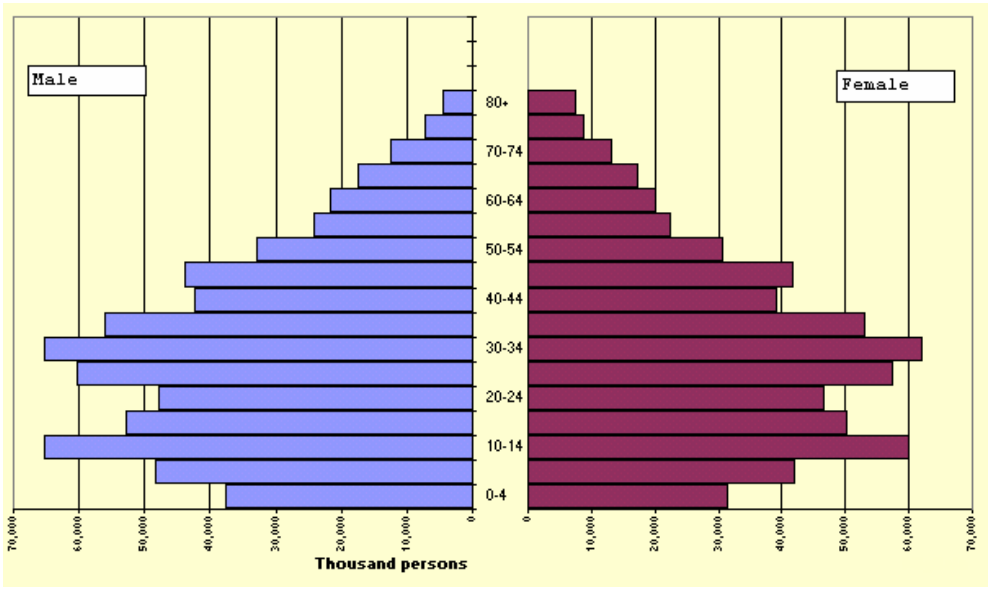

Figure 1: age-sex pyramid for China, 2000

Source: 2000 Census tabulations.

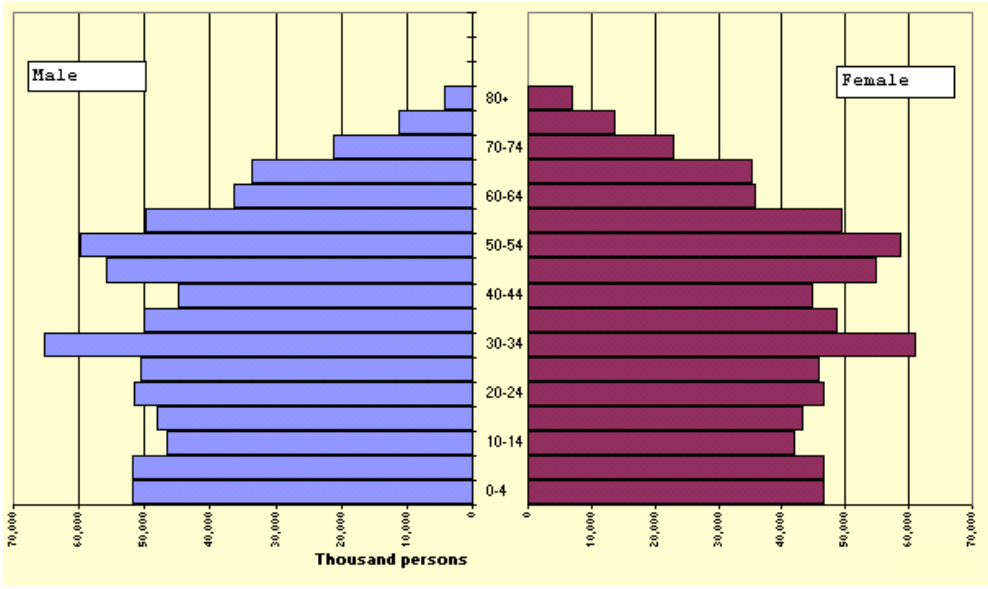

Figure 2: age pyramid of China for 2020 – Scenario 1

Source: own projection.

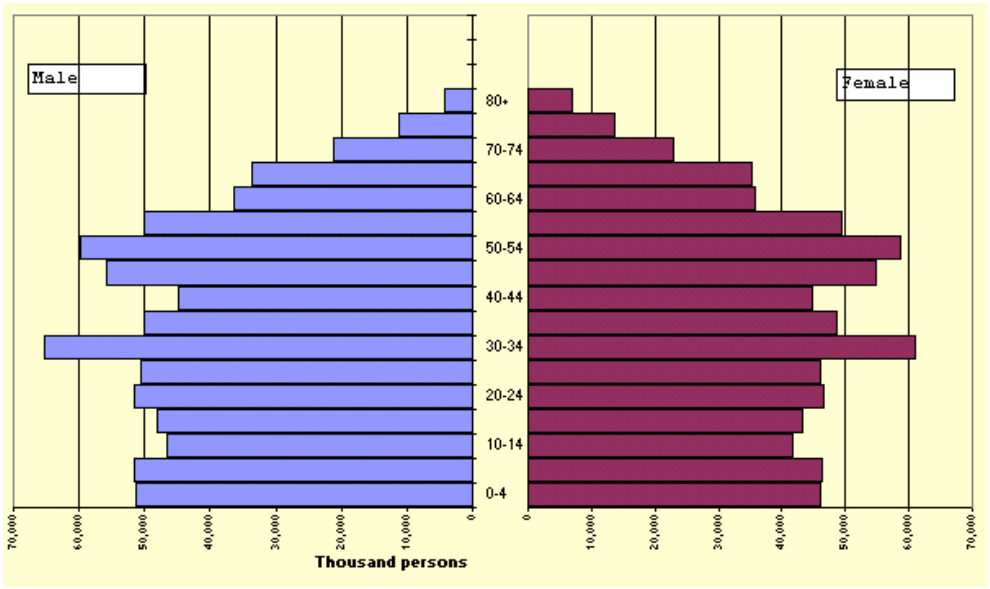

Figure 3: age pyramid for China, 2020 - Scenario 2

Source: own projection.

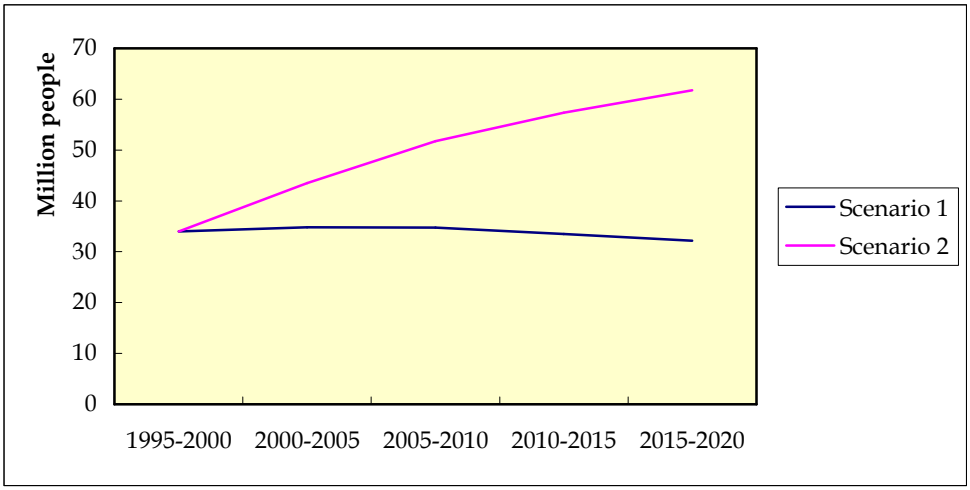

Figure 4: overall number of internal migrants, 1995-2020

Source: Census 2000 and own projection.

Major flows

The multiregional model provides fairly precise estimates at a much more detailed level. The following flow maps represents the flows of over 750,000 people during the whole 20 year period in Scenario 1 and 2. The two maps are fairly similar, since in Scenario 2 all rates are inflated the same way. Also, in 20 years the higher rates of migration of Scenario 2 do not have the time to change the face of the country so much as to change themselves.

The results are surprising once again. Migration influences to a great extent the evolution of each provincial population. In some cases, even with the minimal propensity to migrate of Scenario 1, migration plays a crucial role. In the case of the three metropolises, where natural growth was around zero, inmigration makes up a growth varying between 1.1% and 2.6% on a yearly basis (Scenario 1).

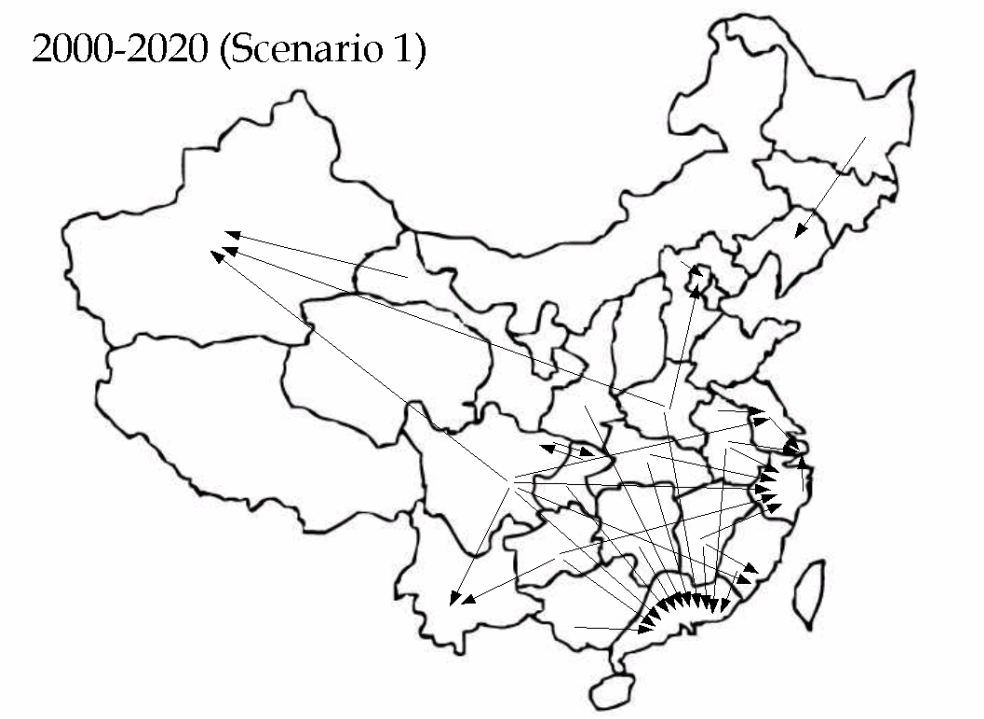

Figure 5: migration flows over 750,000 persons for 2000-2020 – Scenario 1

Source: own projection.

In Scenario 2 the growth of metropolises reaches a level between 1.6 and 4.2%. Other provinces will experience booming growth rates under the joint effect of intense inmigration and sustained fertility. This is the case for Guangdong (4.0 to 5.6%) and Xinjiang (2.5 to 3.2%), and to a lesser extent Zhejiang and Jiangsu. Finally, there are also provinces where net migration outbalanced natural growth, transforming growth into decline. They are Anhui, Jiangxi, Hunan, Sichuan and in the second Scenario also Guizhou.

Table 1 presents the relative contribution to population growth of natural growth and migration for all provinces under both scenarios.

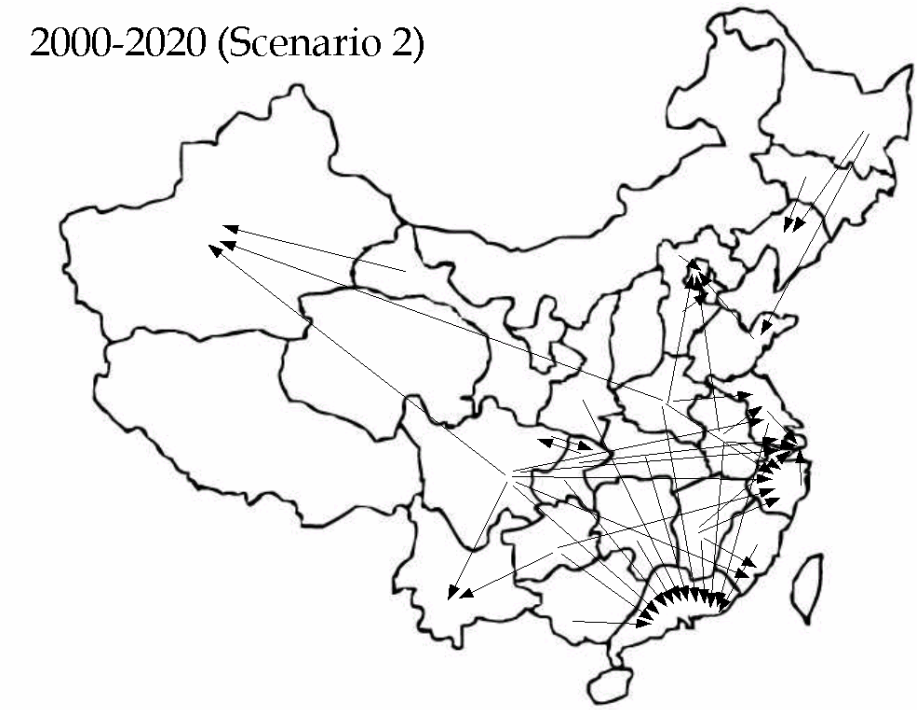

Figure 6: migration flows over 750,000 persons for 2000-2020 – Scenario 2

Source: own projection

Province	Scenario 1			Scenario 2		
	net migration	natural growth	overall growth	net migration	natural growth	overall growth
Beijing	2,61%	-0,05%	2,57%	4,13%	0,07%	4,19%
Tianjin	0,81%	0,27%	1,09%	1,29%	0,33%	1,63%
Hebei	-0,04%	0,67%	0,62%	-0,07%	0,66%	0,59%
Shanxi	0,01%	1,01%	1,02%	0,01%	1,01%	1,02%
Inner Mongolia	-0,09%	0,62%	0,53%	-0,15%	0,61%	0,46%
Liaoning	0,18%	-0,07%	0,12%	0,29%	-0,06%	0,23%
Jilin	-0,18%	0,04%	-0,14%	-0,28%	0,03%	-0,24%
Heilongjiang	-0,31%	0,31%	0,00%	-0,49%	0,30%	-0,20%
Shanghai	2,52%	-0,31%	2,22%	3,97%	-0,23%	3,74%
Jiangsu	0,20%	0,21%	0,41%	0,31%	0,22%	0,53%
Zhejiang	0,78%	0,30%	1,08%	1,17%	0,35%	1,53%
Anhui	-0,89%	0,65%	-0,24%	-1,37%	0,56%	-0,80%
Fujian	0,41%	0,45%	0,86%	0,61%	0,47%	1,08%
Jiangxi	-1,16%	0,66%	-0,50%	-1,76%	0,56%	-1,19%
Shandong	0,01%	0,35%	0,36%	0,01%	0,35%	0,36%
Henan	-0,43%	0,69%	0,26%	-0,67%	0,64%	-0,03%
Hubei	-0,51%	0,37%	-0,14%	-0,80%	0,33%	-0,47%
Hunan	-0,84%	0,24%	-0,60%	-1,28%	0,18%	-1,10%
Guangdong	2,53%	1,45%	3,98%	3,92%	1,68%	5,60%
Guangxi	-0,73%	0,84%	0,11%	-1,13%	0,76%	-0,37%
Hainan	0,19%	1,48%	1,67%	0,29%	1,50%	1,79%
Chongqing	-0,41%	0,11%	-0,30%	-0,64%	0,08%	-0,56%
Sichuan	-0,89%	0,29%	-0,60%	-1,35%	0,21%	-1,14%
Guizhou	-0,63%	1,39%	0,75%	-1,01%	1,30%	0,30%
Yunnan	0,14%	1,12%	1,26%	0,21%	1,13%	1,35%
Tibet	0,20%	2,02%	2,22%	0,28%	2,05%	2,33%
Shaanxi	-0,18%	0,69%	0,51%	-0,29%	0,67%	0,38%
Gansu	-0,33%	0,91%	0,58%	-0,52%	0,87%	0,35%
Qinghai	-0,23%	1,30%	1,07%	-0,38%	1,28%	0,90%
Ningxia	0,12%	1,35%	1,47%	0,18%	1,37%	1,55%
Xinjiang	0,98%	1,53%	2,51%	1,51%	1,65%	3,16%

Table 1: Factors of population growth of Chinese provinces, 2000-2020

Average 1-year rates. Source: own projection.

Detailed analysis of three selected provinces

In the light of the considerations above, it is legitimate to ask whether such massive flows determined some variation in the age structure of single regions, and which other effects are to be expected in both "exporters" and "importers" of migrants. We analyse here three provinces (Guangdong, Shanghai and Hunan) by comparing their age structure as of the 1990 Census with that of 2020 (both Scenario 1 and Scenario 2). The three provinces have been chosen as representative of three very different phenomena. We choose 1990 and not 2000 because 1990 can be considered the beginning of the so-called "age of migration" (Liang, 2001).

Guangdong

Guangdong is the recipient of the greatest absolute flow of migrants and it also has a relatively strong natural growth rate. The projected population for 2020 will be between 160 and 190 million people, starting from the current value of about 89 million (see Figure 7).

This figures are calculated using the usual assumption that propensity to migration either remains fixed or doubles, but the difference is not large: and it is in fact the difference between the two projected net migration figures, 44.9 and 69.5 million people. Even though this is theoretically possible, it is also probable that in the specific case of Guangdong the government will adopt some measures trying to prevent migrants from settling down in the already crowded Cantonese cities.

As for the age structure, in 1990 it had a typical pyramid shape (Figure 8). By 2020 the structure is transformed (Figure 9-10). As we can see, in the second pyramid the 30-34 age group's size is double of the corresponding age group (0-4) in 1990. This has been primarily caused by migration with no doubt. Therefore, migration serves here (in the short and middle run) to inflate the productive segments of the population, keeping the dependency rate low. It must be remembered, anyway, that these people will age in the long run[7].

[7] Here most economists will think about Keynes' famous statement: in the long run, all of us will be dead. True, but most of us will have to go through retirement before reaching that point.

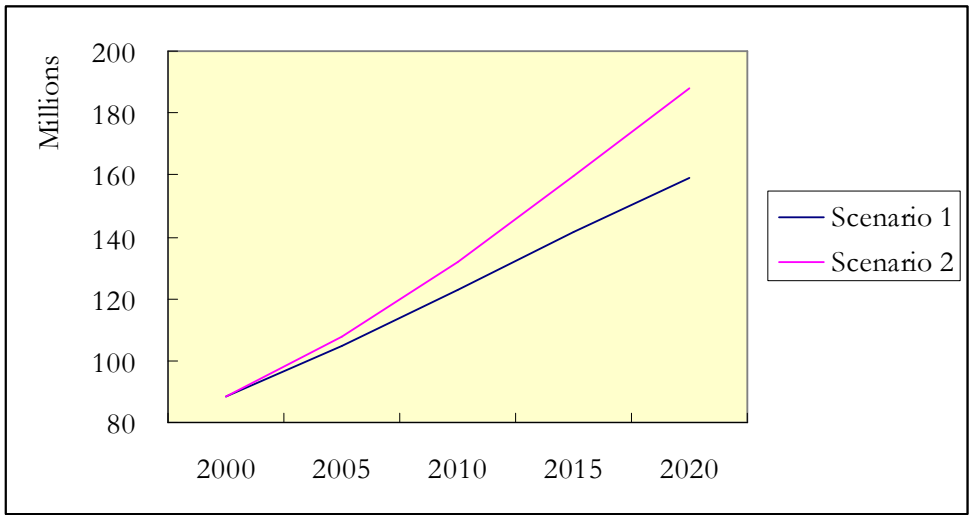

Figure 7: Population of Guangdong, Scenario 1 and 2

Source: own projection.

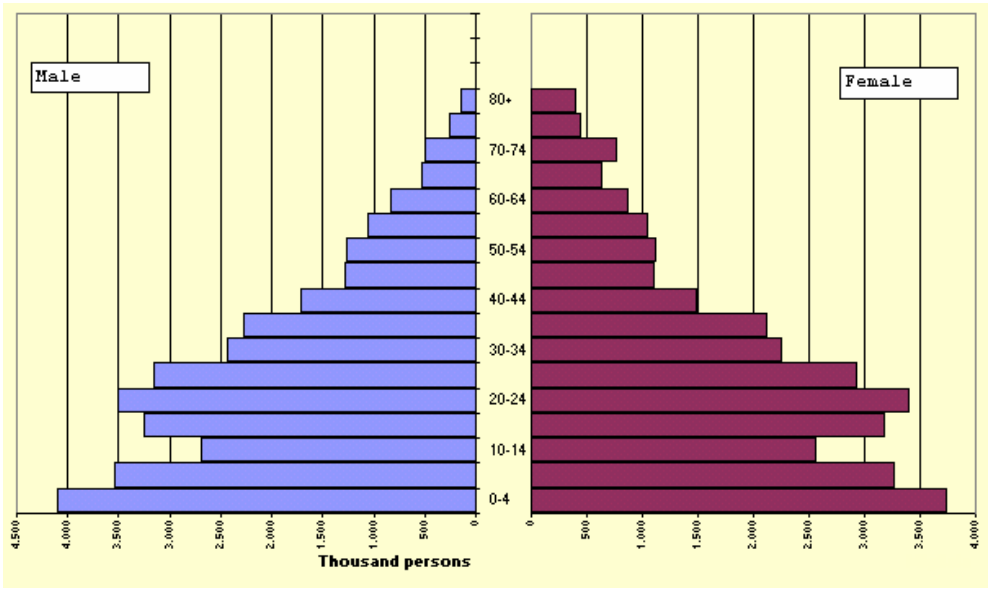

Figure 8: Age pyramid of Guangdong, 1990

Source: 1990 Census, adjusted.

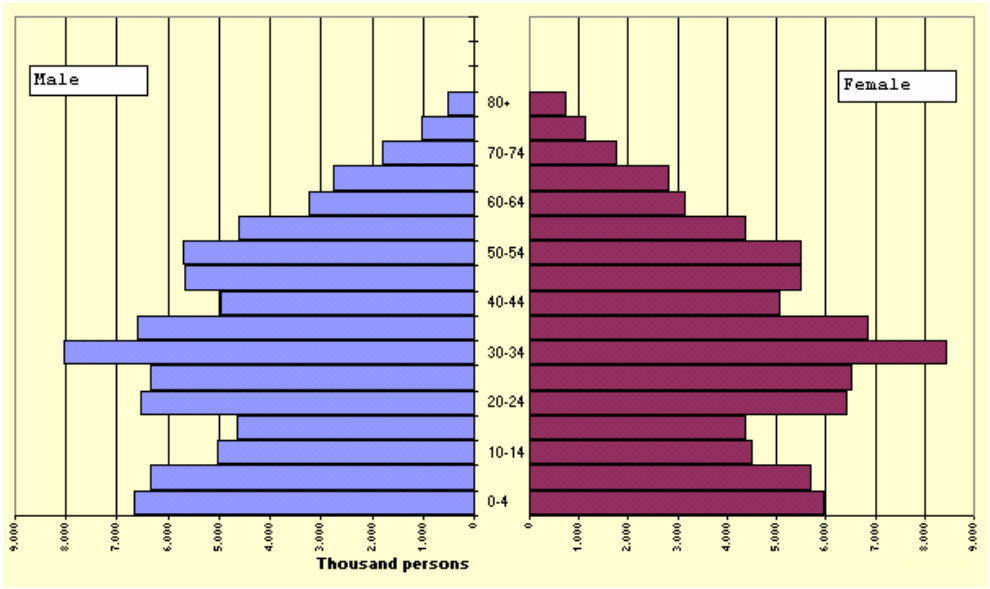

Figure 9: Age pyramid of Guangdong, 2020 – Scenario 1

Source: own projection.

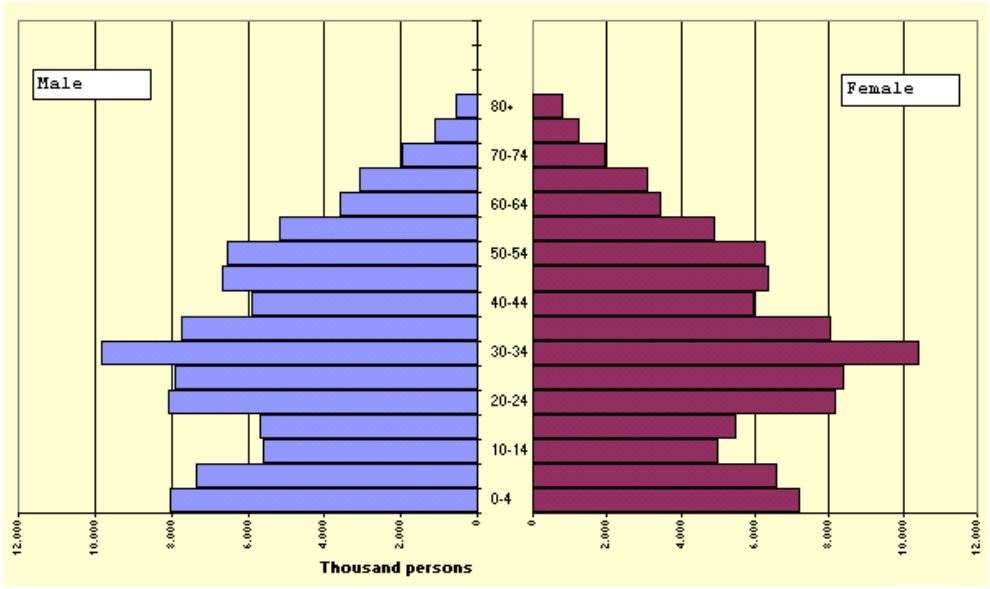

Figure 10: Age-sex pyramid of Guangdong, 2020 - Scenario 2

Source: own projection

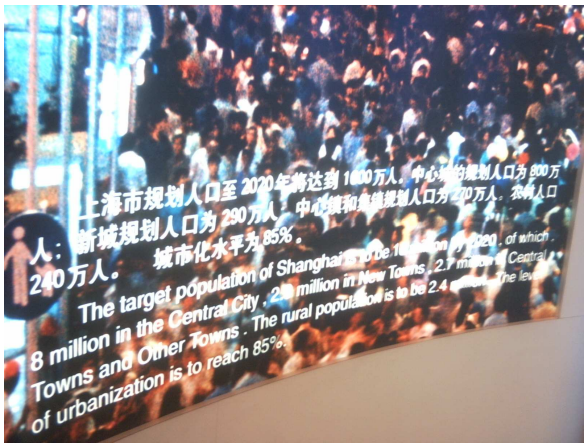

Figure 11: 2020 population target for Shanghai

Source: own photo at Shanghai Expo in People's Square, October 2003.

"The target population of Shanghai is to be 16 million by 2020, of which 8 million in the Central City, 2.9 million in New Towns, 2.7 million in Central Towns and New Towns. The rural population is to be 2.4 million. The level of urbanization is to reach 85%."

Shanghai

While Guangdong does not need to lower its already low dependency rate, Shanghai is already coping with an ageing population. Shanghai's population is almost totally non-agricultural, and it presents fertility rates among the lowest in China (if not the lowest).

The city experienced inmigration, with alternate intensity, through the whole history of the People's Republic of China. Its age structure is very similar to that of European developed countries. We see once again a very large population increase in the projection period, exclusively due to migration (from 16.5 in 2000 to 23.8-28.8 million in 2020, see Figures 12 through 14). The younger age of incoming migrants will balance the ageing of Shanghai's population. The city proper of Shanghai is populated at present day by "only" 11 million individuals. One could imagine that a large part of the new 7-12 million individuals would find a place either in the central city or in the satellite towns. However, we are reasonably sure that this will not happen, and Shanghai's 2020 population will be older than projected. The target for Shanghai Municipality in 2020 is neither 23.8 nor 28.8 million persons, rather 16 million, which is the present figure (see Figure 11). Even though the objective is more than ambitious, new policies will try to redirect migration to elsewhere: by easing migration to smaller urban centres, the relative attractiveness of Shanghai and other metropolises will be reduced.

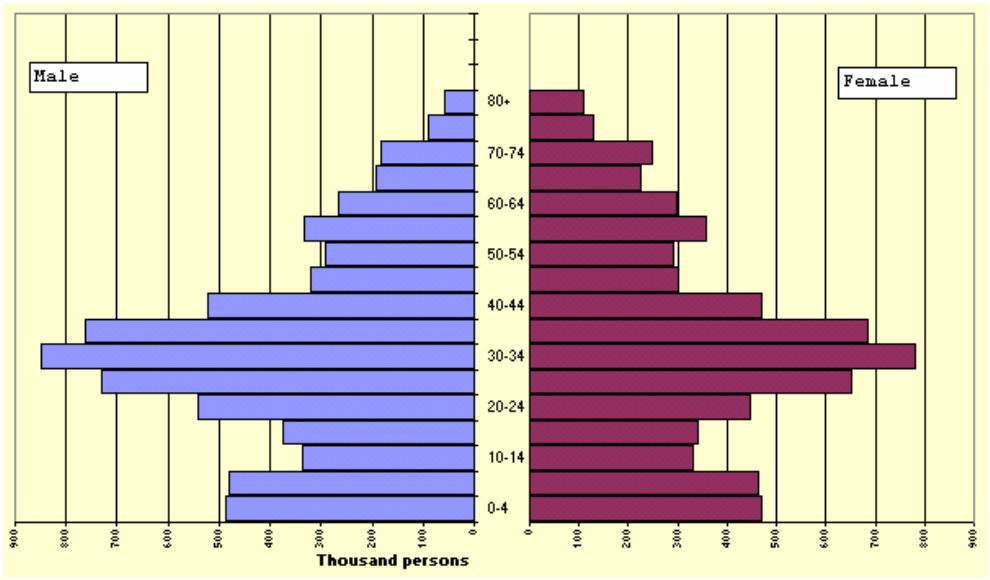

Figure 12: Age pyramid of Shanghai, 1990

Source: 1990 Census, adjusted.

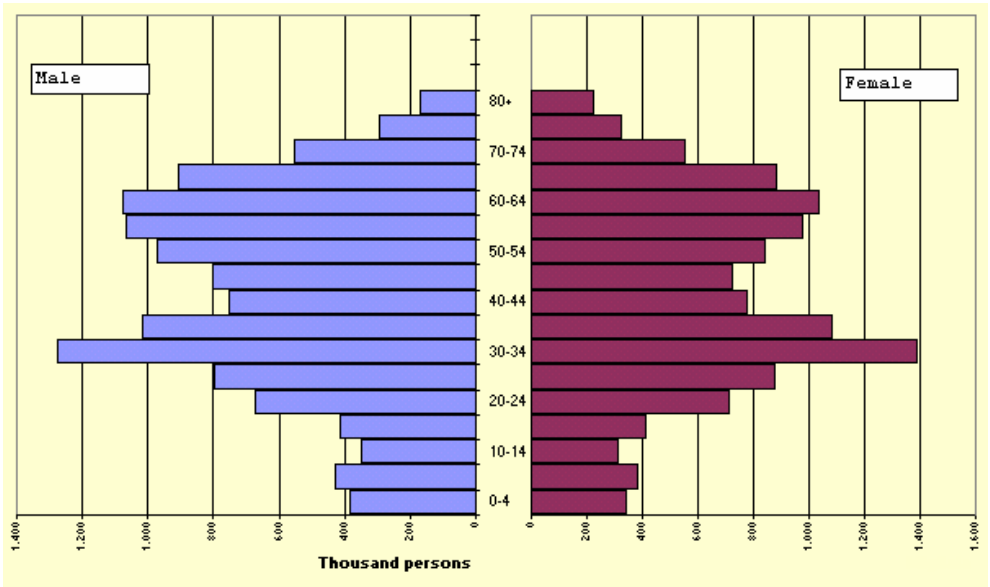

Figure 13: Age pyramid of Shanghai, 2020 – Scenario 1

Source: own projection.

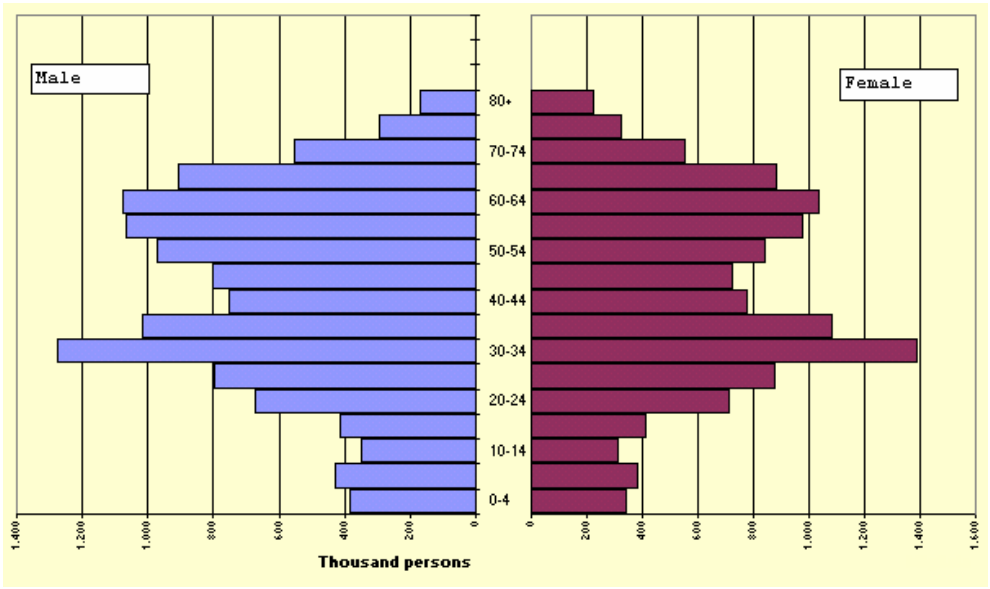

Figure 14: Age-sex pyramid for Shanghai, 2020 - Scenario 2

Source: own projection

Hunan

Hunan has been analysed in depth because it shows the signs of the opposite phenomenon: it is a "provider" of migrants and has a declining population. Every year many young males and females leave the province heading to the coastal industrial areas. The effect is a general impoverishment of the province's human capital and also an increase in the dependency ratio, as people in working ages are much more likely to migrate than elderly or children.

As in Guangdong, we see from the figures the same trend: from a proper pyramid in 1990 to a structure with decreased mortality in 2020. The big difference from Guangdong is that the pattern of missing 20- and 30-year-old people is clearly recognizable, especially comparing the pyramid of Scenario 1 with that of Scenario 2: the age groups starting with 20, 25 and 30 are visibly smaller.

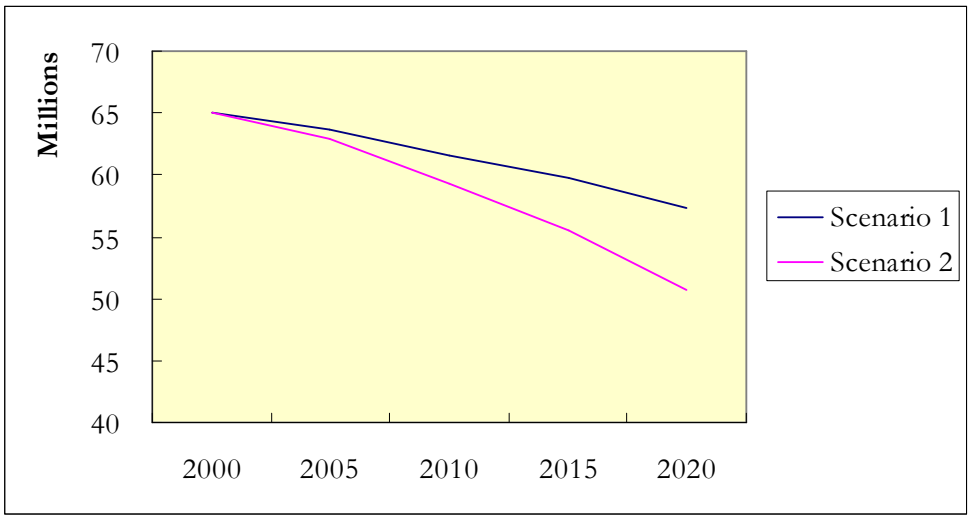

Figure 15: Population of Hunan, 2000-2020

Source: own projection.

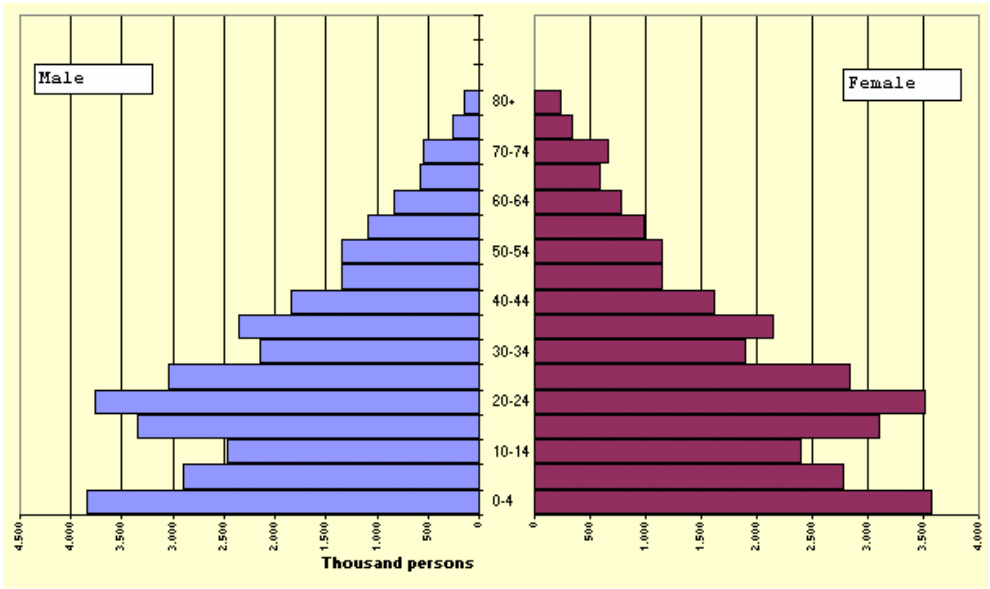

Figure 16: Age pyramid of Hunan, 1990

Source: 1990 Census, adjusted.

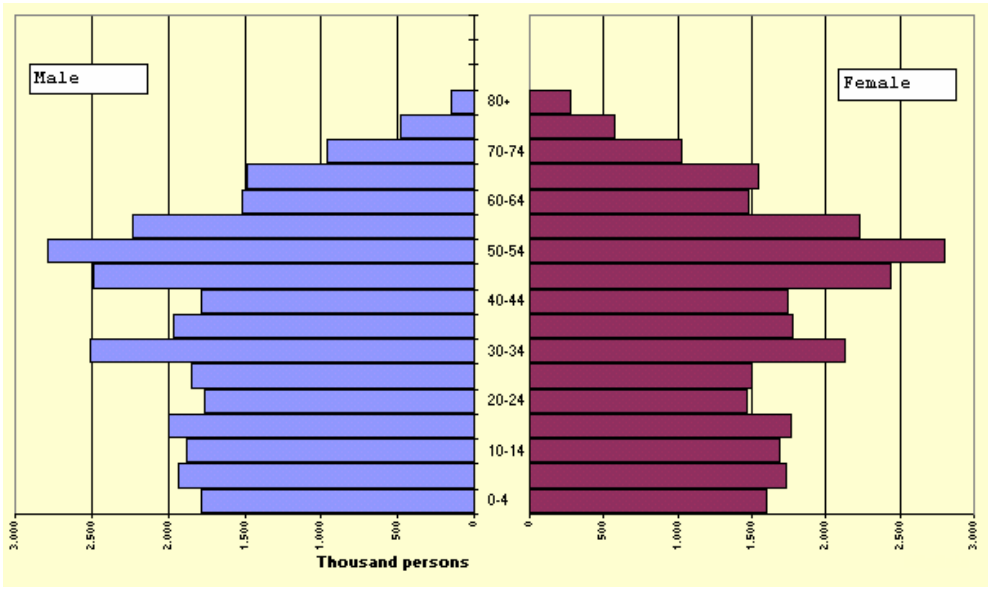

Figure 17: Age pyramid of Hunan, 2020 - Scenario 1

Source: own projection.

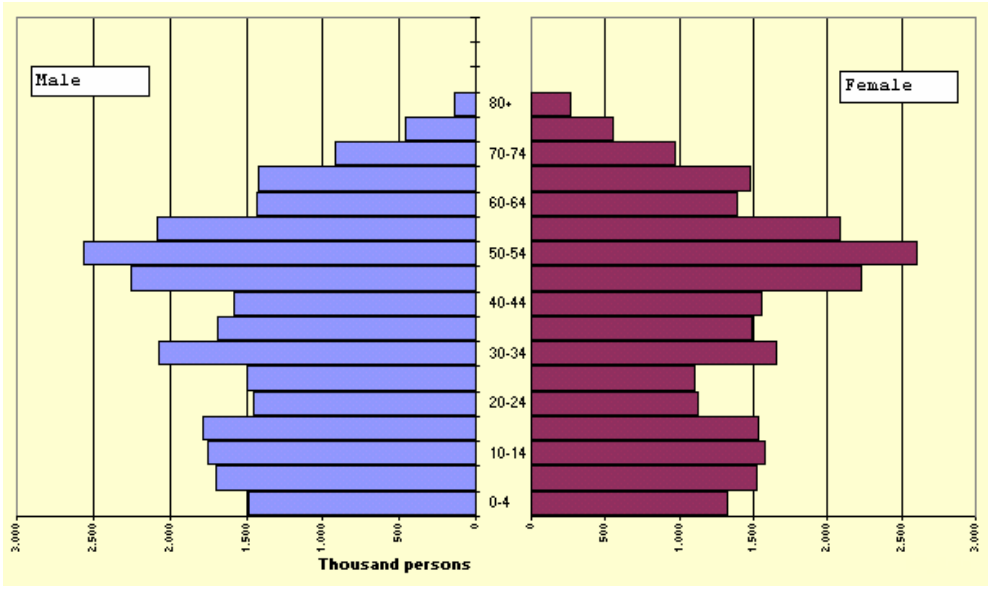

Figure 18: Age pyramid of Hunan, 2020 - Scenario 2

Source: own projection.

Conclusion

In this paper we projected the current population of China forward to 2020, building two different scenarios based on a multiregional model. Both scenarios help understand local-level and national level trends, and are a good starting point for a study of future Chinese migration.

Migration increases in both Scenarios during the first 5-year period. Starting from the second period, in Scenario 1 the ageing population will function as a brake to migration, thus inverting the trend. In Scenario 2, by definition, the propensity to migrate grows, and population ageing is enough only to slow down the growth of the number of migrants.

We analysed the effects of migration on the age structure of the population through a set of three examples. The analysis showed that migration alters significantly a normal age pyramid. Migration, on average, raises the dependency ratio of the origin province while lowering that of the destination.

These projections are also rich of valuable information for policymakers. At present day, laws and institutions are designed to limit migration, but at the same time they are obliged to tolerate it, which is a source of inefficiency and confusion. Migration in the future could create problems such as overcrowding, excessive pressure on resources and infrastructure; on the other hand, it also has the potential to ease population ageing.

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