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ORIGINAL ARTICLE

Dynamics and implications of the age profiles of inter-provincial migration in China

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Abstract
This research examines the shifts in age profiles among migrants in China, utilizing microdata derived from four national censuses and two 1% population sample surveys conducted since 1990. Our findings indicate: (1) there has been a surge in age-specific migration intensity across all age groups over the past two decades; (2) the age profiles of the flow floating population differ from both the entire and the residual migrant populations; and (3) the age profiles of China's flow floating population exhibit a blend of Asian and Western patterns—a prevalence among individuals in their early 20s, typical of Asian patterns, and a broad range of ages post-peak, indicative of Western patterns. Consequently, we propose that future population projections prioritize the flow floating population over the traditionally employed entire floating population. Furthermore, recognizing heterogeneity is critical for accurately understanding migrants in China, necessitating a comprehensive migration policy that safeguards the rights and welfare of these individuals.

Keywords Flow floating population · Age-specific migration rate · Census · China

1 Background

Migration serves as a pivotal demographic mechanism. The age patterns of individuals relocating to and from a region significantly sculpt its demographic attributes, particularly the age structure. Compared to birth and death, migration is frequently the key driver of short-term demographic shifts (Rogers, 1979). The inflow and outflow of people directly modify an area's age and gender composition, especially in smaller locales. Furthermore, migration can reformulate a region's ethnic, cultural,

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and socioeconomic makeup, often impacting local economic conditions (Johnson et al., 2013).

According to China's household registration standard, the Seventh National Census revealed that the floating population had surged to 375.8 million in 2020, representing a 69.73% increase (approximately 154.39 million) from 2010. The crude migration rate, which denotes the proportion of migrants in the total population, rose from 16.53% in 2010 to 26.62% in 2020 (Cheng & Duan, 2021; Wang, 2021). Evidently, migration has emerged as a profoundly significant phenomenon in China's contemporary population and socioeconomic development. It is intricately intertwined with economic structural adjustments, transformations, and shifts in regional economic patterns that have unfolded over the past three decades (Liu & Chen, 2021).

Long-established migration patterns in China are beginning to show signs of change and the emergence of new trends (Zhou, 2021). Key areas of evolution include the dispersion and distance traversed by migrants, the proportion of intra- and inter-provincial migrants, and the causes instigating these migrations. Consequently, the question arises: What have the age profiles in inter-provincial migration during the past two decades been? Furthermore, what can alterations in this trend reveal to us?

The focus on age profiles in relation to inter-provincial migration within this article is motivated by a twofold rationale. Firstly, despite the plethora of scholarly works on migration in China, both from cross-sectional and longitudinal perspectives, the age profiles—or age patterns—have not been sufficiently scrutinized. Secondly, the age pattern serves as a fundamental parameter in population projection. This is especially the case with the cohort-component method, a method heavily employed to assemble national-level population projections (Siegel & Swanson, 2004). The overall level of the age-specific migration rate—reflected by the curve's position within a coordinate system—along with its corresponding age profile exhibited by the curve's shape, necessitate preliminary estimations for population projections, thereby influencing the resultant projections.

To address the identified research lacuna, this article concentrates on the dynamic progression and consequences of age profiles within China's inter-provincial migration, from the spectrum of demographic research and population projections. We delve into and elucidate if and how the age profiles have varied throughout different years and adjusted over time, in response to the considerable increments in the migrant population size and the rising migration rate, drawing upon data derived from consecutive 10-year population censuses and mini-censuses from 1990 onwards. We also engage in discourse on the employment of age profiles within population projections, and the repercussions these shifts provoke within a larger societal context. Exploring these matters is of practical relevance as the age profile serves not only to grasp the basic characteristics and age selection of migrants in China but also lays the groundwork for prospective investigations in related fields, particularly within the realm of population projections.

The structure of this paper is as follows: following an overview of the relevant literature in Sects. 2, 3 probes into matters related to terms and definitions in the context of China's societal backdrop. In Sect. 4, we delineate the changes in age

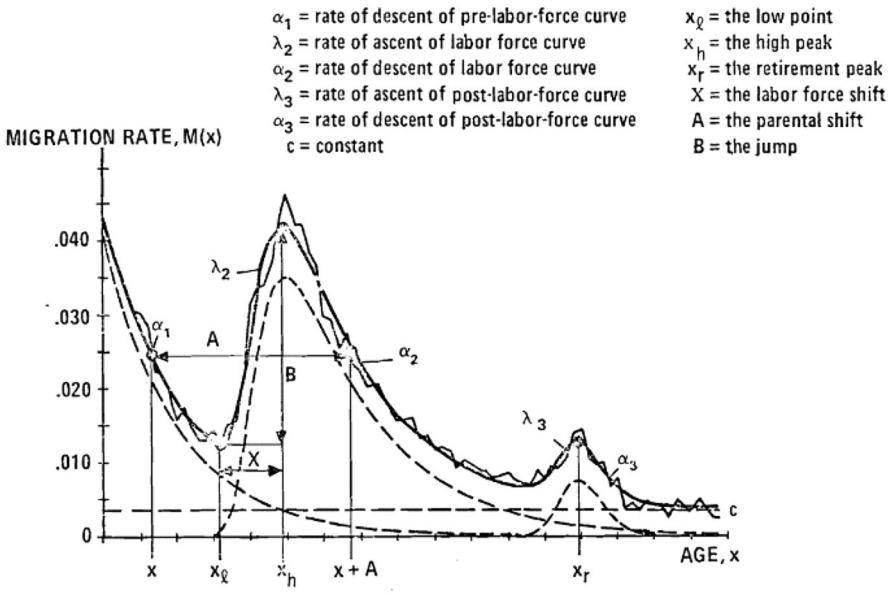

Fig. 1 The age-specific migration model proposed by Rogers and Castro (1979). Graph taken from (Castro & Rogers, 1979)

profiles, succeeded by a discourse on its societal significance tied to the alterations in age profiles.

2 Literature review

Ever since Rogers and Castro's (1979), hereafter referred to as the "Rogers-Castro model", introduction of mathematical models for unravelling the age profiles of migration, the model has found extensive use, as depicted in Fig. 1. The model stimulated a slew of studies (Castro & Rogers, 1979; Rogers, 1988; Rogers & Castro, 1979), making the age profiles of migration and its regularity two of the main concerns of migration researchers (Pazul & White, 1981). As Fig. 1 highlights, the initially high migration rates among children gradually dwindle from birth till the age of $X_{\downarrow}$. Subsequent to this stage, the age-specific migration rate reveals a sharp incline, peaking at age X_h, followed by a slow decay. The emergence of an additional peak at X_r corresponds with retirement. This archetypal migration profile can be fit using a multi-exponential model, highly favored in the field (Zandy et al., 2018), albeit simpler linear estimation methods sufficing for most applications (Rogers et al., 2005). The application of this model extends to various countries, including Japan, the Republic of Korea, Thailand (Kawabe, 1990), China (Yan, 2004), and Australia, as well as Britain (Rees et al., 2000).

The field of cross-national migration analysis suffers from a lack of standards in the computation of comparable measures of migration activity (Rees et al., 2000). Globally accepted measurements exist for mortality and fertility analysis, such as life expectancies and total fertility, but there are no sets of comparable cross-national measures of internal migration activity despite many comparative studies (Long, 1991; Nam et al., 1990; Rees & Kupiszewski, 1999). To bridge this research gap, various indices have been proposed in a series of studies (Bell et al., 2002; Bernard et al., 2014a; Rees et al., 2000). Bernard et al. (2014a) proffered more coherent measures centered on the migration intensity rate of change, namely, Intensity at peak, Age at peak, Breadth of peak, UMRC, MDRC, and Asymmetry. The majority of inter-country variance in migration age profiles is encapsulated by the age and intensity of peak migration, and applying these two indicators to 25 countries unveils sizeable regional differences.

Another perspective elucidates consistent migration regularities in age profiles by aligning the profiles with life course, facilitating the explanation of cross-national differentials. This concept gained traction when Castro and Rogers (1983) posed the question, "What the Age Composition of Migrants Can Tell Us?" By disaggregating migrants into dependent and independent groups, it was observed that the age profiles of migrants are susceptible to relative alterations in dependency levels, natural increase rates, and mobility. Furthermore, family connections among migrants are mirrored in their aggregate age profiles (Castro & Rogers, 1983). Bernard et al. (2014b) evaluated the association between migration age profiles and the age structure of four pivotal life course transitions—education completion, labor force entry, union formation, and first childbearing. A global sample of countries was considered, with a comparative analysis of the transition to adulthood in Australia and Great Britain. Additionally, the peaks in student migration (Wilson, 2010), along with the variations brought about by gender, distance, and marital status in elderly migration (Rogers, 1988) were also examined.

Age-specific migration rates consistently exhibit a remarkably uniform age profile, a trend that appears to be universal and timeless (Rogers, 1988). Despite this consistency, significant variations exist among nations regarding the ages at which migration peaks, particularly concerning working-age individuals (Rogers & Castro, 1981). While these regularities remain, recent cross-national studies have unveiled systematic variations in migration profiles, especially among young adults (Bernard et al., 2014b). For instance, Bell and Muhidin (2009) highlighted that migration within Asian countries is predominantly among individuals in their early 20s, while in Latin America, migration peaks later, in the late 20s, and is more widely dispersed across the age spectrum. Similarly, Ishikawa (2001) demonstrated that migration in Sweden is more concentrated among young adults than in Canada or Japan. Furthermore, age-specific migration patterns within large, geographically contiguous areas exhibit spatial clustering (Johnson et al., 2013).

In China, numerous studies have concentrated on the mathematical modeling of age-specific mobility (Hu & Li, 1998; Hu & Liu, 1997; Yan, 2004; Yang, 1992a, 1992b). These investigations have utilized data sourced from a 1% population sample survey in 1987 (Yang, 1992a), the 4th National Population Census in 1990 (Hu & Li, 1998; Hu & Liu, 1997), and the 5th National Population Census in 2000 (Yan,

2004). Their analytical approaches primarily adhere to the concepts proposed by Rogers and Castro (1979), employing either an urban–rural classification or migration reasons and education levels to segment the population and discern migration patterns amongst various subpopulations separately. The findings consistently indicate that China's age-specific mobility model resembles the Rogers model, thereby affirming its applicability to the Chinese context (Yan, 2004).

Prior research on China's age-specific migration rates has significantly focused on the age-specific patterns of rural–urban migration (Wang & Yuan, 2007). For instance, Wang (2004) scrutinized data from the censuses of 1982, 1990, and 2000 and estimated and interpreted the alterations in the age patterns of rural–urban and urban–rural migration by gender between 1990 and 2000. There are differentials in age-specific migration rates between origin and destination areas and substantial regional variations in age patterns have also been observed between the rural-to-urban and urban-to-rural migrants (Wang, 1994, 1995).

The age-specific migration rate, encompassing both level and pattern, serves as a vital metric to aid in population projections concerning closely related societal issues, particularly given the escalating migration intensity in recent decades. This rate is convenient for projecting populations of a single urban area or an entire province. The precision of the age-specific migration rate also influences the accuracy of population size and structure estimates (Meng & Jiang, 2018). It equally affects the precision of estimates regarding various socioeconomic development indicators and the pertinence of assessments of diverse socioeconomic developments, such as pension (Liu et al., 2008; Wang, 2011), industrial structure alterations (Lu et al., 2019), and public facility provisions (He et al., 2009). Such migration patterns hold significant implications for individuals, institutions, and both the rural and urban communities, as well as for formulating policies and practices promoting sustainable community development (Johnson et al., 2013).

In summary, research on China's age-specific migration rates has predominantly centered on developing mathematical models, delineating specific pattern traits, and subsequent applications. Nonetheless, there is a dearth of studies providing a comparative analysis from a temporal perspective, which could unveil the dynamics and characteristics of the age-specific migration rate over time and discern associated societal implications. Such an analysis could also aid in predicting the future trajectory of the age-specific migration rate and furnish a more precise foundation for the development of population projection models.

3 Terms definition and data description

3.1 Terms definition

The notion of "migration" is generally confined to relatively permanent changes in residence between specifically designated political or statistical areas or between type-of-residence areas (Siegel & Swanson, 2004). Migration may be quantified in various manners, but the two most prevalent forms of data capture changes in residence as either transitions or events. Transition data are characteristic of the

information gathered in national censuses, which identify migrants by comparing their usual place of residence at the time of enumeration (t) with that at a specified earlier date (t − n)[1] (Bell et al., 2002).

However, in China, the complexities of the Household Registration System (Hukou) make measuring migration more intricate. Among census terms, elements like the place of Hukou, the place of usual residence 5 years earlier, and the place of current residence are incorporated into the census questionnaire. The difference between the usual residence 5 years ago and the current residence helps identify recent 5-year migrants, defined as the "earlier 5-year residence". Due to the Hukou, the sample identified by this definition comprises two parts: formal migrants, defined by a change in Hukou location, and individuals without Hukou changes. These two groups differ significantly in their characteristics and socio-economic behavior, despite both being classified as migrants (Zhou, 2022).

The term "floating population," unique to China and based on the Hukou system, refers to migrants who (1) have left their Hukou location without altering it; (2) have resided in the destination area for more than half a year, or have been away from their Hukou location for more than half a year despite residing in the destination for less than half a year; and (3) have moved across township or administrative street, as defined by the National Bureau of Statistics. The criteria include Hukou, time, and administrative boundaries. Generally, the number of migrants in official reports corresponds to the floating population. Given the significance of the Household Registration system (Hukou) in China, this paper will use the floating population defined by Hukou instead of formal migrants or those defined by the earlier 5-year residence.

However, the definitions employed by the censuses and sample surveys lack consistency. The 4th Census in 1990 solely incorporated information pertaining to people's Hukou (household registration) and failed to record the timings of residential changes, thereby hindering the identification of the flow floating population. The 5th Census in 2000 included a questionnaire item concerning residency change asking, "When did you begin to live in your current local township or sub-district?" The 1% Population Sample Survey in 2005, along with the 6th Census in 2010 and 7th Census in 2020, only inquired about "when individuals had left their Hukou registration place". The 1% Sample Survey in 2015 contained both these items. Clearly, the relevant question item regarding migration timing in the 4th Census centered on when respondents arrived at their current locale, while subsequent censuses and surveys focused on when respondents left their Hukou registration locale.

Regardless of the time scale, the definition does not consider the duration of stay in the current residence or the time since leaving the place of Hukou. This implies that the floating population can reside in the destination for an extended

[1] This period is usually either 1 year, as in Britain, or 5 years, as in the USA, although some nations, such as Australia and Canada, ask for place of residence at both t − 1 and t − 5, and others, such as France, have a different interval length. Transition data have several limitations, perhaps the most serious of which is the failure to identify multiple and return moves and migrants who are born or who die during the measurement period.

period (e.g., more than 10 years) or as short as half a year. Earlier research has revealed marked differences in various demographic and socio-economic characteristics between floating populations who left their Hukou location more than 5 years ago and those who left within the past 5 years. Thus, to illustrate the flow within 5 years and account for Hukou, the floating population sample in each census is divided into two segments: *the flow floating population* who left their Hukou location (or arrived at the destination) within 5 years prior to the reference time point of a given census, and *the stock floating population* who left their Hukou location more than 5 years ago.

Accordingly, to identify the flow floating population, we utilized the duration of residence at the current location (no more than 5 years) for data from the 4th census in 2000, and the time of departure from the Hukou registration locale (within 5 years) for data from all other censuses/surveys. While the principal patterns discussed in this paper are unlikely to alter significantly due to these varying definitions, it is advisable to bear these minor differences in mind when interpreting the results.

3.2 Data and formula

This research utilizes microdata from the four most recent mainland Chinese censuses (the 4th in 1990, the 5th in 2000, the 6th in 2010, and the 7th in 2020), along with two 1% population sample surveys, also termed as "mini-censuses," conducted in 2005 and 2015.

The notion of age-specific migration rate is pivotal to this paper. By definition, a rate is the ratio of the number of events occurring during a specific period divided by the average survival years of the population at risk during that period. When applied to the age-specific migration rate, it would refer to the size of the floating population of a certain age (the number of events) divided by the average survival years of the at-risk population corresponding to this floating population of the same age. However, this paper defines the flow floating population based on a migration time within a 5-year period, and the number of age-specific deaths in a population and the average survival years of a corresponding at-risk population cannot be estimated when using microdata. For simplicity, the age-specific migration rate in this paper is calculated as follows: the size of the (flow) floating population of a certain age divided by the total population of the same age. Strictly speaking, the measure obtained this way could be seen as a proportion or intensity rather than a rate.

4 Changes to the age-specific migration rate in China

In this section, we conduct a temporal comparison of the age profiles between the entire floating population and the flow floating population.

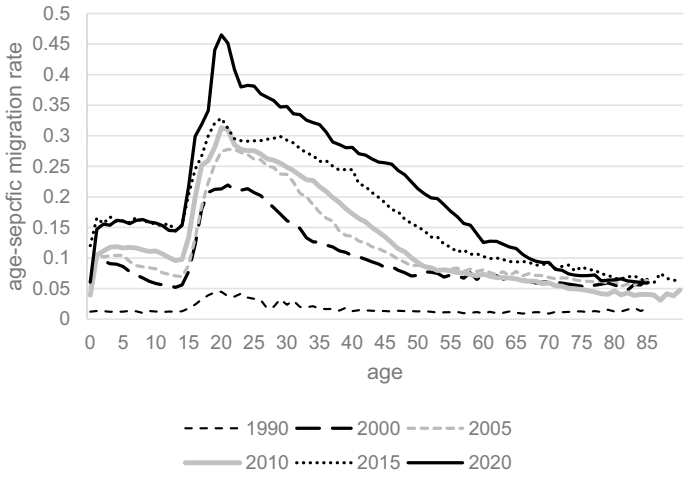

Fig. 2 Age-specific migration rates of the entire floating population in censuses/surveys

4.1 The age profiles of the entire floating population

Figure 2 depicts the age profiles of the entire floating population for specific years since 1990. Several significant changes have transpired over the years:

1. The most prominent change is that the age profiles of the entire floating population consistently have risen over time since 1990. Namely, the age profile curve generally shifted upward during the period under study. However, the rate of increase varied among different age groups.
2. There are two distinct levels for individuals under 15 years of age. Between 2000 and 2010, the age-specific migration rate of this age group saw a gradual increase but remained relatively low level, with a substantial rise occurring in 2015 and 2020. This surge may suggest an increase in migrant families bringing their children to live with them post-2010, and potentially inclusive of a rise in children born, raised, or growing up in destination areas. Despite being born and growing up in the destination, these children, like their parents, do not have the Hukou of their resident locale, thus still being considered part of the floating population.
3. The apex age of the age profiles of the entire floating population hovered around 21 years old, a figure that has remained relatively stable since 1990, while the peak rate experienced a significant increase. In 2020, it stood at 0.465, meaning 46.5% of 21-year-olds were part of the floating population, a stark contrast to the peak rate in 2000, which was merely 0.211. The highest age-specific migration rate more than doubled from 2000 to 2020, signifying the escalating spatial mobility in China.
4. Following the peak age, the rate of decline and the turning points for age-specific migration rates have varied since 1990. The shift from a rapid to a slow decrease in the migration rate occurred around age 50 in 2000, 2005, and 2010, while this

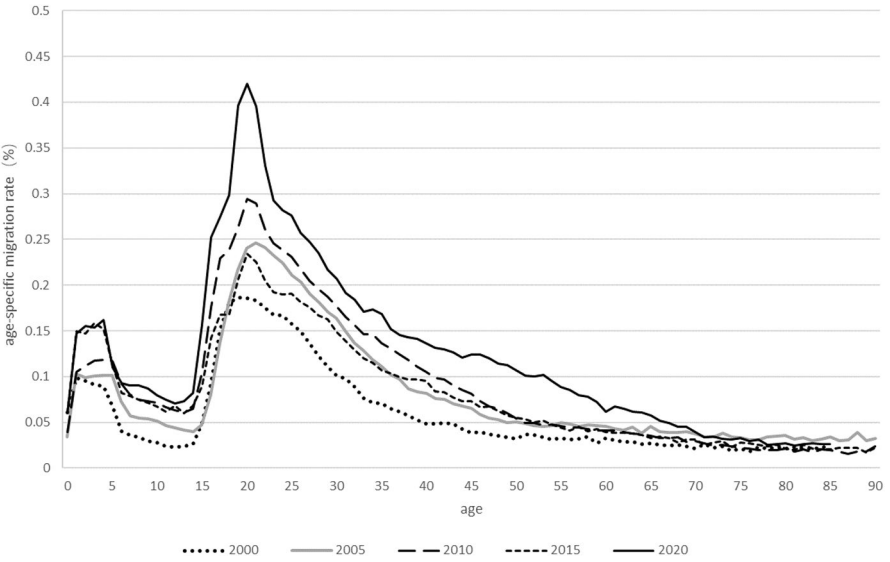

Fig. 3 Age-specific migration rates of the flow floating population in previous censuses/surveys

turning point rose to age 55 in 2015 and age 60 in 2020. This suggests that floating population members, who were previously inclined to exit the labor market and return to their place of origin at age 50, have been gradually delaying this transition in recent decades. A more significant proportion of these migrants continue to work in their destination areas into the later stages of their lives. This could be due to the aging labor force resulting from overall population aging, labor shortages in destination locales, or shifting attitudes towards work among the floating population, with migrants more willing to work longer in the destination area before retiring.

In conclusion, since 1990, the age profiles of the entire floating population in China have undergone substantial changes. Emerging trends include a gradual uptick in migration rates among school-age children (6–15 years of age), a significant increase in the peak rate, and a delay in the age at which individuals exit the migrant course. These patterns suggest that the dynamics of individual replacement within the floating population, including timing and reasons for returning to the place of origin, might have drastically altered in recent decades. Therefore, studying the internal replacement within the floating population is crucial as it can form the basis for accurately forecasting its future size and structure and support initiatives to address social security concerns that emerge when migrants return to their places of origin.

4.2 Age profiles of the flow floating population

As depicted in Fig. 3, the general trend of the age profiles of the flow floating population (with no available results for 1990 by definition) is strikingly similar to that of the entire floating population (as seen in Fig. 2):

1. The age profiles of the flow floating population demonstrate an overarching upward trajectory over the years, signifying that the age-specific migration intensity has progressively risen.
2. The peak age has remained relatively static over the years (around 23 years of age), but the peak rate has experienced an increase since 2000. For instance, the peak rate in 2020 was more than double that of 2000.
3. Although the age profiles of the flow floating population generally declined after reaching the peak, it is evident that in 2020, this decrease slowed after the age of 35. This can be observed in the expanding gap between the 2020 curve and those of the other years, a phenomenon referred to as a later post-peak turning point.
4. The age profiles for individuals between the ages of 60 and 70 in 2020 were notably higher than the corresponding rates for other years, while the migration intensity among those aged 70 and older remained largely unchanged and exceptionally low over the years. The upsurge in age-specific migration intensity for those between 60 and 70 years old occurred in tandem with the heightened rates in the working-age migrants.

The age profile of the flow floating population in China reveals regularities and differentials when compared to other countries. Generally, the age profile of China aligns with the "Rogers-Castro model", demonstrating age selectivity of migrants and is highly concentrated among individuals in their early 20s (Bernard et al., 2016; Ishikawa, 2001). Concurrently, the gradual decrease in the rate after the peak age in China suggests a progressively broader dispersion in the periods studied, resembling the profiles of Europe and Latin America where migration is more widely spread across the age range (Bell et al., 2015; Bernard et al., 2016).

On the contrary, significant differentials are evident in infancy and around the retirement age. The extremely low levels at infancy suggest that most pregnant members of the floating population tend to return to their hometowns for childbirth. Another possible explanation could be that the hukou of the newborns are not registered until the prescribed time. Furthermore, there is no peak at retirement age in China because the elderly tend not to leave their place of Hukou due to familial ties and the link between the Hukou and social welfare benefits, including medical and retirement pensions.

Therefore, the age profile of migration in China simultaneously exhibits regularity and stability over time, reflecting a blend of Asian and Western patterns with unique Chinese characteristics: a concentration in the early 20s akin to the Asian pattern, and a dispersion across a broad age range post the peak age, similar to the Western pattern (for instance, Canada) (Bernard et al., 2016; Ishikawa, 2001).

Enrollment in higher education (or education completion), labor force entry, union formation, and first childbearing are identified as four key determinants in the transition to adulthood and significant triggers of spatial mobility (Mulder, 1993). However, in China, only the first two determinants—enrollment in higher education and labor force entry—hold a significant influence on the floating population. These two factors determine the peak age and level. Concurrently, labor force entry contributes to wider dispersion, given that Working or Business, one of the 8 migration reasons in census items, constitutes approximately 73.33% of the floating population, with about 11.14% being the spouse of a floating population member (Wang, 2019). It is apparent that the life course transitions have a different effect on China's floating population when compared to other nations.

However, there were still significant differences in the age-specific migration rates between the flow floating population and the entire floating population:

1. Among children aged 0–4, the age-specific migration intensity of those less than 1 year old remained very low throughout the entire period, while minor increases were observed among children aged 1 to 4, rising from approximately 0.05 in 2000 to about 0.10 in 2015 and 2020. This group's profile significantly differs from the "Rogers–Castro model", which exhibits a decreasing trend from a high level due to family union or childbirth (Bell et al., 2015). This indicates that in China, many migrant parents prefer to have their children in their hometown, not their destination area. These parents then rejoin the floating population after caring for their baby for 2–3 years. From a life-course perspective, the motivations, or reasons for migration (or floating) in China differ from those in other countries.
2. Among school-aged children (6–15 years old), the age-specific migration intensity for the flow floating population across all censuses remained relatively low, albeit with minor increases over time, and were below those observed for the entire floating population. This low intensity suggests that new migrants who moved within 5 years prior to the census point at age 6–15, are fewer than those in the entire floating population in this age group. The difference accounts for children who grew up and have been living in their destination area for more than 5 years. Simultaneously, the need for stability during primary and middle school education keeps the migration rate of this age group relatively low. In essence, this difference between the two types of floating population is a key characteristic of the flow floating population and one of the reasons why this research focuses on the flow floating population.
3. The age profiles of the flow floating population in 2015 were lower than those in 2005 or 2010, diverging from the trend observed in the entire floating population. Figure 3 illustrates that the age-specific migration curve for 2005 falls between the two curves of 2000 and 2010. While one might anticipate the 2015 curve to rest between the 2010 and 2020 curves, it is, in fact, more aligned with the 2005 curve. This unexpected observation could suggest that migration activity within the flow floating population was relatively inactive before 2015. Alternatively, this result may be an artifact from the sampling process of the 1% Population Sample Survey in 2015. Regardless, this finding underscores the effectiveness of the flow

floating population in reflecting 5-year migration trends and necessitates caution when utilizing the 2015 sample survey data.

5 Conclusion and discussion

By drawing on microdata from four national censuses and two 1% population sample surveys conducted since 1990, this paper delineates the characteristics and shifts in the age-specific migration rate for both the entire inter-provincial floating population and its flow component in China over the previous three decades.

5.1 Conclusion

Firstly, the age profiles of the flow floating population differed in various aspects from that of the entire floating population. To begin with, only the flow floating population exhibited a concave-shaped curve for children aged 6–15. Secondly, the flow floating population had two turning points (at ages 35 and 70) following the peak age of 23, while the entire floating population had only one (at age 60). These divergent profiles with turning points not only hint at distinct patterns and social implications but also underscore the significance of the stock floating population in the destination area.

Secondly, the age-specific migration rate of the Chinese population exhibited a consistent upward trajectory across all age groups over time. However, the anticipated trend for the 2015 mini-census, where the curve would sit between those of the 6th census in 2010 and the 7th census in 2020, was unexpectedly lower than that of 2010, closely resembling the 2005 curve.

Thirdly, the age profile of flow floating population in China exhibits a blend of Asian and Western patterns: a concentration in the young 20s as characteristic of the Asian pattern and a dispersion across a broad age range post-peak age as indicative of the Western pattern. However, there was no evidence of high mobility among very young children aged 0–4, and the minor peak typically seen around the retirement age of 60 in Western societies was not present in the case of China when compared to the Rogers–Castro model.

5.2 Discussion

Our research findings offer a perspective on the age profile within an international comparative framework and provide an analytical foundation for future population research, particularly those concerning population projections. Moreover, they deepen our understanding of China's population migration and related policies.

The age profile of migration encompasses a variety of factors, including age structure, life-course transitions, development levels, and historical cultural backgrounds (Bernard et al., 2014a, 2016; Ishikawa, 2001; Warnes, 1992). An examination of the inter-provincial floating population in China reveals systematic variations in the aggregate age profile of migration, not only between countries when

compared to the Rogers-Castro model, but also across historical time points. The combined influence of these factors supports these changes in the age profile over time. Future research could explore the explanation and disaggregation of these changes within the context of international comparisons.

Furthermore, the following points are worthy of additional discussion.

Firstly, we must consider the definition of the floating population in China. This paper utilizes the term 'flow floating population', which differs from the entire floating population, to represent the newly added migratory population within the last 5 years under the Hukou system. While this definition is not internationally comparable and does not fully represent China's migration situation, it does have the advantage of highlighting the newly added, or 'flow', floating population, excluding the 'stock' component who has resided in their destination area for over 5 years and could be considered as permanent residents. Additionally, this definition captures China's unique social and institutional context. In the future, age profiles and socio-economic characteristics of three samples defined by 'flow', 'stock', and 'earlier 5-years residence' could be compared to depict different facets of migration in China.

Secondly, refining the migration parameter design in population projections. Population projections (births, deaths, or migration) typically commence with the selection of a specific age pattern. Earlier projections of the floating population predominantly relied on the entire floating population. However, our findings reveal that the age-specific migration rate of the flow floating population significantly deviates from that of the entire floating population. In contrast, the age profile of the flow floating population more accurately mirrors alterations in the size and structure of the estimated new floating population within a 5-year span, thereby enhancing projection accuracy. Most prior research has overlooked this aspect, particularly in studies concerning population migration and projections. We recommend that future population projections utilize migration parameters based on the flow floating population, as opposed to the entire floating population.

Additionally, recognizing the distinction between the entire country and each province would be beneficial. While this paper focuses on the national floating population, similar analyses can be applied to subpopulations based on various classifications. If the unit of analysis is a province or smaller administrative region, migrants can be categorized into intra- and inter-regional groups, and the age profiles for these subpopulations may vary significantly. In population projections for specific provinces, the age-specific migration rate of the floating population should be differentiated for each province to identify applicable age patterns. Therefore, further refinement of the age-specific migration rate in research and population projections at different jurisdictional levels is necessary. Moreover, investigating the potential to incorporate the age-specific migration rate into a format akin to the model life table to represent different age model types is worthwhile. More detailed subdivisions and characterizations will aid in refining migration parameters, ensuring future population projections more accurately reflect social reality.

Thirdly, the relative stability in the age profiles of the stock migrant population highlights the importance of considering heterogeneity as a fundamental aspect in understanding the floating population in China. Variations can be examined from

both flow and stock perspectives, as well as through the lens of age groups. Concerning flow and stock, only migrants possessing greater social and human capital are likely to transition from the flow to the stock. Consequently, the challenges they encounter, such as job stability, income, and social integration pathways, may differ.

Regarding age groups, the stock floating population of school age may have been born, raised, and educated in their destination areas, with limited emotional ties to their ancestral homes or their parents' origins. This necessitates increased social support and policy assurances from destination administrations to enhance their social integration and safeguard their development. For those aged 35 and above, family matters, livelihood concerns, and even elderly care issues may be the primary challenges the stock floating population faces. While addressing migrant issues holistically, it is also essential to adopt a heterogeneous perspective to comprehend and resolve the distinct problems faced by various migrant subgroups. This approach is equally applicable to the theoretical research of migration in China.

In conclusion, the preceding analysis and discussion underscore the necessity of constructing a comprehensive migration policy framework, safeguarding the rights and interests of the floating population through systematic institutional arrangements. An extensive reform of the inflexible household registration system could be a starting point, even though it may only partially address all the challenges encountered by the floating population.

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Declarations

Conflict of interest The authors declare there is no conflict of interest. The manuscript has not been published before and is not under consideration for publication elsewhere.

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