



Analyzing the impacts of cultural backgrounds on migrants' acculturation strategies in mobile phone social networks

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ARTICLE INFO

Keywords:

Mobile phone social networks
Acculturation strategies
Socioeconomic status
Cultural distance
Individualism
Collectivism

ABSTRACT

By employing a large-scale mobile phone dataset and constructing a social network with 6,351,033 nodes and 14,735,425 ties, this research empirically studies how the individualistic and collectivistic (I-C) cultural backgrounds of migrants influence their acculturation strategies under different contexts. We introduced the rice theory and developed new network-based constructs to measure their acculturation strategies, I-C cultural backgrounds, and socioeconomic status. We found that migrants with more collectivistic cultural backgrounds tend to interact more with people from their hometowns rather than locals of their host societies. Surprisingly, this relationship is contingent on cultural distance: when a migrant's cultural background is similar to the host society, this migrant tends to interact more with local friends than people from her hometown. Moreover, higher socioeconomic status is found to decrease the cultural conservatism tendencies of migrants with more collectivistic cultural backgrounds. These findings can help stakeholders to devise more refined policies to better integrate migrants with diverse backgrounds and reduce potential cultural conflicts.

1. Introduction

In recent years, large-scale migration within and across countries has brought many societal challenges, one of which is to help migrants adapt and adjust to the new culture of their host societies (a process called acculturation) (Berry, 1997). Nowadays, migrants often come from diverse cultural backgrounds and socioeconomic status (SES). Policies that fail to account for the diversity and complexity of acculturation processes involving different people, cultures, and contexts can cause serious problems such as cultural conflicts, social segregation, and inequality. Moreover, as large amounts of data about individuals' characteristics, interactions, and behaviors become available through personal computing devices such as mobile phones, existing acculturation research lacks efficient methods to process, analyze, and utilize such data. Our study combines data science methods, especially social network methods, with novel culture theories to extract insights and knowledge from a mobile phone dataset including 11,216 migrants in an eastern Chinese city. The social network constructed based on calling patterns has 6,351,033 nodes and 14,735,425 relationships. Based on

this, we aim to study how cultural backgrounds under different contexts affect migrants' acculturation strategies.

Two major acculturation strategies were proposed by Berry (1997): the first strategy concerns migrants' tendency to conserve their original culture and is called "degree of cultural conservatism," whereas the second strategy concerns their tendency to adopt the culture in their host society by interacting with the locals and is called "interaction tendency" (Erten et al., 2018). Negative interaction tendency often causes societal problems such as social segregation and mental health issues for migrants, such as stress, depression, and anxiety (Lindert et al., 2009). Therefore, it is critical to better understand the factors that may affect these two acculturation strategies under different contexts.

In particular, the cultural background of a migrant's original society is suggested to have long-lasting effects on acculturation strategies (Berry, 1997). Cultures are typically divided into two dimensions: **individualistic and collectivistic (I-C) cultural orientations** (Hofstede, 1984). Our study focuses on analyzing the impacts of individualistic and collectivistic (I-C) cultural orientations of migrants' original societies (i.e., **migrants' I-C cultural backgrounds**) on their

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acculturation strategies. A major empirical challenge is to model and measure migrants' I-C cultural backgrounds at a large scale, while previous research mainly relies on small-scale questionnaires or surveys to obtain migrants' personal I-C orientations. To address this, our study adopted the rice theory (Talhelm et al., 2014), which suggests that people who are born in rice-farming regions like southern China have more collectivistic cultural orientations since paddy rice often requires more cooperation, and such orientations were passed on across generations. Therefore, we measure a migrant's I-C cultural background using the percentage of cultivated land devoted to rice paddies in the birthplace of that migrant.

Another challenge is that existing research often adopted a univariate vision perspective to study the predictors of migrants' acculturation strategies like I-C cultural backgrounds and other contextual factors but failed to consider the interplay between these predictors. For instance, migrants with more collectivistic cultural backgrounds were found to rely on collective coping strategies through soliciting assistance from family members (Kuo, 2013; Yeh et al., 2001). Thus, they may rely more on social connections and resources from their original societies when experiencing acculturation stress. However, with higher **socioeconomic status** (i.e., socioeconomic opportunities and social privileges), these collectivistic migrants may have better resources in their host societies, such as occupational prestige (Berry et al., 2006a), and thereby become less dependent on their original societies. Therefore, understanding the interplay of these predictors can provide useful insights for assisting policy-making for migrants with disparate cultural and socioeconomic backgrounds.

To summarize, this study aims to answer the following research questions: (1) How do migrants' I-C cultural backgrounds affect their acculturation strategies? (2) How do contextual factors like migrants' socioeconomic status and cultural distance moderate the impacts of I-C cultural backgrounds on acculturation strategies? We leverage the birthplace information and calling patterns of about 382,000 mobile phone users in a large Chinese telecommunication dataset to construct novel measures for migrants' acculturation strategies, I-C cultural backgrounds, socioeconomic status, and cultural distance. Based on the rice theory (Talhelm et al., 2014), we developed an instrumental variable and then empirically examined the causal impacts of 11,216 migrants' I-C cultural backgrounds on their acculturation strategies under different situations of socioeconomic status and cultural distance. Our empirical analysis found that migrants with more collectivistic cultural backgrounds are more likely to call people in their hometowns (cultural conservatism), while migrants with more individualistic backgrounds call more local friends in their host city. Surprisingly, this relationship is contingent on cultural distance: when the cultural backgrounds of a migrant's original and host society are similar, migrants with more collectivistic backgrounds tend to interact more with local friends than people from their hometown. Moreover, higher socioeconomic status is found to decrease the cultural conservatism tendencies of migrants with more collectivistic cultural backgrounds. Based on previous acculturation research, we propose these moderating effects can be attributed to the reason that migrants with different cultural backgrounds handle acculturation stress differently depending on the level of stress (cultural distance) and available resources (socioeconomic resources). The contributions of this paper are threefold. First, to the best of our knowledge, we are the first to introduce the rice theory to acculturation research. The resulting I-C cultural background construct and the instrumental variable we developed not only allow us to study its causal impacts on migrants' acculturation strategies but also provide an effective means to study how I-C cultural orientations may influence various human behaviors based on large-scale data analytics rather than traditional small-scale survey-based methods. Second, analyzing the interplay between I-C cultural backgrounds and contextual factors like SES helps stakeholders better understand how migrants' strategies are formed under different situations. Thus, more refined and targeted policies can be developed to facilitate desirable acculturation outcomes. Third, the

measure we developed for SES provides a network-based approach to capture individuals' socioeconomic status using mobile phone data, which has become increasingly common in empirical data analytics.

2. Theoretical background

2.1. Acculturation strategies and cultural background

Acculturation is the process by which migrants who were brought up in one cultural context adapt to a new culture through intercultural contact (Berry, 1997). Due to potential conflicts between the original and host societies, migrants must develop strategies to manage acculturative stress. Two major acculturation strategies emerge: cultural conservatism, which involves retaining a migrant's original culture, and interaction tendency, which reflects the level of adoption of the host society's culture. Different acculturation strategies can lead to varied outcomes. A substantial body of literature seeks to understand the consequences of different acculturation strategies, such as adjustment levels (Stogianni et al., 2021), health outcomes (Ma & Xia, 2021; Yue et al., 2021), life satisfaction (Yoo, 2021), and adaptation (Tatarko et al., 2020). However, the factors driving the systematic differences in acculturation strategies among different migrant groups remain unclear.

Previous studies on group-level acculturation strategies have primarily focused on identifying the most preferred strategy for specific migrant groups (Cao et al., 2017; Yijälä & Jasinskaja-Lahti, 2010; Zhang et al., 2011), conducting inter-group comparisons among various ethnic groups (Lalonde & Cameron, 1993; Migliorini et al., 2015; Neto, 2002), and exploring intergenerational differences (Berry & Hou, 2021; Kunst & Sam, 2014). These studies often limit their samples to particular groups such as children (Guerra et al., 2019), adolescents (Kumi-Yeboah et al., 2020), or international students (Krsmanovic, 2020; Xing et al., 2020). While confirming that different acculturation strategies may dominate in various migrant groups, these studies lack a comprehensive understanding of the distinct characteristics of different migrant groups and the systematic factors driving their diverse acculturation strategies, such as the cultural characteristics of their original societies. As outlined by Berry (1997), there is a significant need to study how migrants' original cultural backgrounds shape their post-migration behaviors, a topic largely overlooked in previous research. In the existing literature, migrants with different cultural backgrounds are often simply distinguished by their ethnicity or country of origin. To our knowledge, there is no literature that empirically examines the impact of migrants' cultural backgrounds on their acculturation strategies.

Moreover, most previous studies on acculturation strategies have focused on the cognitive or affective aspects, such as attitudes toward heritage and host cultures or willingness to contact locals (Xu et al., 2023). There is little literature focusing on migrants' behavioral aspects of acculturation strategies (Kreienkamp et al., 2024). Behavioral measures that have been studied include civic participation (Ay Kesgin, 2024), interethnic marriage (Song, 2009), and media consumption (Shoemaker et al., 1985). Although these studies provide valuable insights into migrants' behaviors in the host society, they often fail to capture the interaction tendencies toward both the host society and migrants' hometowns. In contrast, we leverage a unique mobile phone dataset to directly measure migrants' calling behaviors, specifically their tendencies to call home or contact individuals in the host society. As Kreienkamp et al. (2024) pointed out, understanding contacts during acculturation is crucial. The selective choice of contacts with individuals from their original culture or the host society reflects different acculturation strategies, which may lead to varied acculturation outcomes. Our extensive mobile phone records data provide an objective measure to assess migrants' actual calling behaviors.

Lastly, the causal relationship has rarely been established in previous acculturation studies (Kunst, 2021). We aim to complement existing research by establishing this causal relationship between migrants' cultural backgrounds and their acculturation strategies, thereby

providing a deeper understanding of the dynamics of migrants' acculturation processes.

2.2. Individualistic and collectivistic cultural background

Two widely studied cultural characteristics, individualistic and collectivistic orientation in migrants' original societies (i.e., I-C cultural background), need to be examined mainly for two reasons. First, I-C cultural orientation is often considered as an important source of the behavioral differences between the East and the West (Talhelm et al., 2014). Thus, it is a critical research perspective for cross-cultural studies. Second, I-C cultural background is linked with individuals' preferences in coping with stress (Kuo, 2011), which conceptually would affect migrants' acculturation strategies. Despite these reasons, previous research mainly focused on the impacts of migrants' personal I-C cultural tendencies rather than their original cultural backgrounds. For example, Dona and Berry (1994) surveyed 101 Central American refugees living in Toronto and tried to link personal I-C orientation with their acculturation strategies but failed to identify a significant relationship.

Moreover, previous acculturation research has predominantly relied on questionnaires and surveys to study individual-level I-C cultural orientation. These direct assessment methods, however, only reflect explicit aspects of culture that individuals are aware of. In reality, cultural practices are deeply woven into the everyday life of migrant groups and thus may not be adequately captured at the individual level (Oyserman et al., 2002). Thus, acculturation research that focuses on analyzing individual-level I-C cultural orientation and other features, such as gender (Berry et al., 2006b; Cao et al., 2017), length of residence (Pham & Harris, 2001), language proficiencies (Cao et al., 2017), education (Pham & Harris, 2001), and personalities (Schmitz & Schmitz, 2022) is not enough. The systematic influence of migrants' I-C cultural backgrounds on migrants' acculturation strategies is overlooked. Addressing this issue may have more practical significance, as it can provide a better policy lens toward migrant groups with different I-C cultural backgrounds.

To address this, we developed a new measure based on the rice theory to measure migrants' I-C cultural backgrounds. This theory suggests that southern Chinese with rice-farming history are more collectivistic than northern Chinese with wheat-farming history. This is derived from the subsistence theory that two of the most common subsistence crops—rice and wheat—are vastly different in the requirements of labor and irrigation, which then transformed into two distinct cultural orientations in rice and wheat regions, given the different levels of collaboration required by farming those two crops (Talhelm et al., 2014). Thus, a migrant's I-C cultural background can be measured by the percentage of farmland devoted to rice paddy in her hometown.

2.3. The interaction between contextual factors and I-C cultural background

Besides migrants' I-C cultural background, acculturation strategies also depend on various contextual factors. Berry (1997) suggests that individuals may appraise the meaning of their acculturation experiences differently in different situations. However, previous research often takes a univariate perspective to study these contextual factors and overlooks the interaction between these factors and migrants' I-C backgrounds. For example, some migrants may be exposed to greater acculturative difficulties due to greater cultural differences between their hometowns and the host society. Overlooking the diversity and complexity of the contextual factors of migrants' acculturation may lead to a biased understanding of their behaviors after migration. In this study, we focus on two critical contextual factors that may moderate the relationship between I-C cultural background and acculturation strategies: socioeconomic status (SES) and cultural distance.

2.3.1. Socioeconomic status

Socioeconomic status is defined as the social and economic opportunities and privileges an individual has within a society. Thus, it is closely related to the potential coping resources a migrant can leverage in the host society (Hobfoll, 2001). During the acculturation process, migrants often adopt coping strategies to deal with acculturative stress, given available resources (Berry, 1997). Migrants with different cultural backgrounds also delimit the nature and the range of resources differently (Wong, 1993). Thus, the relationship between a migrant's I-C background and acculturation strategies may be moderated by SES.

Previous studies usually focused on studying the impact of specific types of coping resources, such as education experience (Pham & Harris, 2001), language proficiency (Cao et al., 2017), and occupational prestige (Berry et al., 2006a). However, SES should encompass the opportunities and privileges available to individuals from various social and economic perspectives within the society (Association, 2018), especially through their social networks. Thus, a more comprehensive SES measure is needed to more accurately capture the aggregate coping resources a migrant can obtain in the host society.

To address this, our novel network-based SES measure draws insights from two streams of studies. First, Campbell et al. (1986) proposed a "networks as resources" argument, suggesting that social resources are often embedded in one's social networks. Thus, network-based measures, to a large extent, can effectively represent SES as the aggregate social and economic resources (Luo et al., 2017). Second, previous research found that an individual's economic status is associated with their spatial choices of residence (Clark & Ware, 1997; Sager, 2012). Residential segregation will deteriorate the disadvantaged situation of some minority groups since little local resources can be outsourced from the surrounding environment (Massey et al., 1987). In addition, previous migration studies also found that migrants from different residential locations or migrant enclaves exhibit differences in wage levels (Shen, 2017), economic integration (Zou & Deng, 2020), social integration (Yang, Zhou, & Jin, 2020), or varying degrees of segregation (Zhang et al., 2024). These differences may be attributed to the differences in opportunities for building intergroup connections and social ties in the host city (Shen, 2017), emphasizing the importance of considering migrants' surrounding communities in their acculturation process. Thus, locational information is also a crucial factor in understanding migrants' acculturation, as it effectively captures the resources in the host society accessible to migrants.

One unique feature of our dataset is the temporal-spatial information, enabling us to assess the residential locations of migrants and the associated resources embedded in those geographic areas, as reflected by the social networks of their neighbors. By employing advanced data analytics methods, we construct a more comprehensive SES measure to address the limitations of previous studies discussed above. We further use this measure as a situational factor to examine how varying levels of local resources accessible to migrants influence their acculturation process and the corresponding acculturation strategies.

2.3.2. Cultural distance

Moreover, migrants' acculturative stress-coping strategies are contingent on cultural distance, which is defined as the divergence in language, religion, and general norms between the culture of a migrant's original and host society (Berry, 1997). Cultural distance is a proxy for measuring acculturative difficulties (Ward & Searle, 1991), representing the extent of potential cultural conflicts and required adjustments during the acculturation process (Berry, 1997). It heavily influences the stress appraisal process, as well as the resulting stress-coping schema and acculturation strategies. For example, when cultural distance is small, it is easier for a migrant to change her behavior in order to "fit" into the culture of the host society. Thus, the acculturative stress is lower. However, when cultural distance is more extensive, cultural conflicts may induce more acculturative stress and social difficulties (Ward & Searle, 1991), and thereby may cause the migrant to change

their coping strategies (Berry, 1997).

However, little research has explored the interaction between cultural distance and I-C cultural background in shaping migrants' acculturation strategies. Previous literature instead emphasized the direct relationship between cultural distance and migrants' acculturation outcomes, such as adjustment and adaptation. For example, Demes and Geeraert (2014) found that sociocultural and psychological adaptation were negatively associated with perceived cultural distance. Galchenko and Van De Vijver (2007) reported that Chinese and North Korean migrants perceived the largest cultural distance and lowest adjustment levels, whereas migrants from the former USSR and Africa perceived the smallest cultural distance and highest adjustment levels. Mai and Wang (2022) found that situational differences such as economic development, cultural differences, and population size between hometowns and receiving cities can influence integration outcomes. In particular, cultural distance may negatively impact migrants' social integration into the host city. Regarding the moderating effect of cultural distance, to our knowledge, only English et al. (2021) found that the relationship between host and international support with anxiety can be moderated by cultural distance, which has not addressed acculturation strategies as well.

Therefore, we differentiate ourselves from previous studies by treating cultural distance as a situational factor that leads to different levels of acculturative stress in the acculturation process. Migrants from varying individualism-collectivism (I-C) cultural backgrounds may experience and manage acculturative stress differently, leading to diverse acculturation strategies. We aim to investigate the heterogeneous effects of migrants' I-C cultural backgrounds on their acculturation strategies across different levels of cultural distance.

2.4. Summary

To address the issues discussed in previous subsections, we propose a conceptual research framework, as shown in Fig. 1.

3. Hypotheses

3.1. Impacts of individualistic and collectivistic cultural background

Previous research found that migrants' I-C cultural backgrounds have long-lasting impacts on their behaviors even if they leave their hometowns and enter a new cultural environment. More specifically, people from collectivistic-oriented cultural backgrounds tend to have interdependent self-construal, while people from individualistic-oriented

cultural backgrounds are more likely to have independent self-construal (Triandis et al., 1988). The interdependent self-construal is linked with the cultural conservatism acculturation strategy, while independent self-construal is linked with the interaction tendency acculturation strategy. This conceptual link between I-C cultural background and acculturation strategies is also confirmed by Ryder et al. (2000) through the questionnaire. Thus, we develop the following hypotheses:

H1a. Migrants with collectivistic cultural backgrounds have a stronger degree of cultural conservatism.

H1b. Migrants with collectivistic cultural backgrounds have a weaker degree of interaction tendency.

3.2. The interaction between contextual factors and I-C cultural background

3.2.1. Socioeconomic status (SES)

We proposed that higher SES in the host society can moderate the relationship between migrants' I-C cultural backgrounds and their acculturation strategies. Migrants with collectivistic cultural backgrounds prefer to seek support from their ingroup members (e.g., family members) (Yeh et al., 2001). In the acculturation process, migrants with higher SES in the host society usually can obtain immediate support from their surrounding environments. Thus, acculturative difficulties and stress can be more easily ameliorated, and the need to seek support from additional resources is low. Therefore, for migrants with collectivistic backgrounds, if they have higher SES, their aforementioned needs to seek help from ingroup members will be reduced. Moreover, higher SES enables a migrant to be more residentially integrated into the local communities. Such spatial proximity with locals can facilitate closer relationships, thus increasing a migrant's interaction tendency.

We thus hypothesize SES weakens the positive relationship between cultural conservatism and collectivistic background, as the higher need for support from ingroup members from migrants with collectivistic backgrounds is reduced when they have access to coping resources in the host society, which are represented by higher SES. Meanwhile, their lower interaction tendencies are also mitigated by higher SES since abundant resources in the host society can help them to make more local friends. Thus, we develop the following hypotheses:

H2a. The positive relationship between migrants' collectivistic cultural backgrounds and cultural conservatism is weakened by the higher socioeconomic status.

H2b. The negative relationship between migrants' collectivistic cultural backgrounds and interaction tendencies will be weakened by the higher socioeconomic status.

3.2.2. Cultural distance

We suggest that the relationship between migrants' I-C cultural background and acculturation strategies is also contingent on cultural distance. Berry (1997) suggests that when there are few cultural conflicts, the migrants only experience relatively low acculturation stress, and the need to leverage external resources is low. In the meanwhile, migrants with different I-C cultural backgrounds may perceive and handle varying levels of acculturative stress in different ways. Chun et al. (2006) suggested that individuals with individualistic and collectivistic cultural backgrounds may differ in three ways: First, the collectivistic person is more sensitive to the social context (Markus & Kitayama, 1991). Second, people with collectivistic backgrounds will adjust themselves to fit in the new environment under acculturative stress (Chun et al., 2006). Third, people with collectivistic backgrounds usually have the goal of maintaining the harmony of the surrounding environment (Chun et al., 2006; Wong, 1993). Therefore, we hypothesize that when the cultural distance is small, migrants with collectivistic backgrounds may be more attentive to cultural differences and will adjust their behaviors accordingly. Compared with migrants with

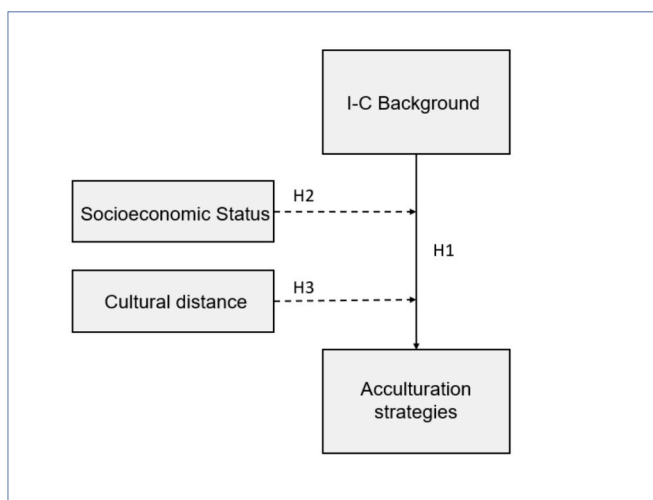


Fig. 1. Conceptual framework: effects of I-C cultural background on acculturation strategies.

individualistic backgrounds, they may interact more with locals to maintain the “harmony” in their surrounding environment.

However, when the cultural differences between a migrant’s original and host society are so large that the cultural conflicts exceed the migrant’s capacity to acculturate, acculturative stress will intensify (Berry, 1997). To cope with these adverse events, migrants with collectivistic backgrounds prefer seeking support from their ingroup members (Wong, 1993). Moreover, collectivism is also linked to avoidance coping strategies, which indicates the preference to orient away from a threat (Kuo, 2013). In the context of this study, this is shown as avoiding conflictual situations by reducing interactions with locals, exhibiting a lower interaction tendency. Thus, we propose the following hypotheses:

H3a. When the cultural distance is small between the original and host society, migrants with collectivistic cultural backgrounds have stronger interaction tendencies and weaker cultural conservatism.

H3b. When the cultural distance is large between the original and host society, migrants with collectivistic backgrounds have stronger cultural conservatism and weaker interaction tendencies.

4. Empirical design

4.1. Data

Our empirical analysis utilized three data sources. Firstly, we used a telecommunication dataset with anonymized user information from a city in eastern China located at the boundary between northern and southern China. This dataset comprises the complete call records for users of a major Chinese mobile service provider in February 2012. The original dataset includes 76,907,842 call records initiated by the 382,779 registered users. For each registered user, the county of their birthplace is encoded with an area code. We identified 11,216 migrants born outside the host city and later migrated there, with a length of residence exceeding six months. Each migrant had at least one call record during the month under study. The dataset includes the following details for each call: the anonymized mobile phone number that initiated the call, the anonymized called number, the duration of the call, the nearest cell tower where the call was initiated, and the area code where the called number was registered. All user information in this dataset is anonymized.

The second dataset contains county-level information about the percentage of cultivated land devoted to rice paddies in China. This data was used to measure the individualistic and collectivistic cultural background of migrants from different counties. Fig. 2 shows the percentage of land devoted to rice paddies in each county across China. Provided by the authors of Talhelm et al. (2014), this dataset was obtained from the statistical yearbook (State Statistical Bureau, 1996) using rice statistics when it first became available on the Chinese Bureau of Statistics website. The assumption is that I-C cultural orientation is more likely to be associated with how rice or wheat was farmed traditionally in different regions rather than statistics affected by recent advances in irrigation and mechanization in China (Talhelm et al., 2014).

The third data source is the Chinese dialect tree diagram based on the Chinese Dialect Dictionary (Baohua & Miyata, 2020). Using this diagram, we can calculate the dialect distance. The details about constructed measures are discussed in the next section (Figs. 3 and 4).

The lines in the figure represent the call volume between provinces, with the size of the nodes also determined by call volume. The layout is based on a force-directed algorithm. The color of the nodes indicates the farmland devoted to rice paddies in each province, with deeper red colors representing a higher percentage of rice farming.

4.2. Measures

4.2.1. Dependent variable: acculturation strategies

As mentioned before, two major acculturation strategies are exam-

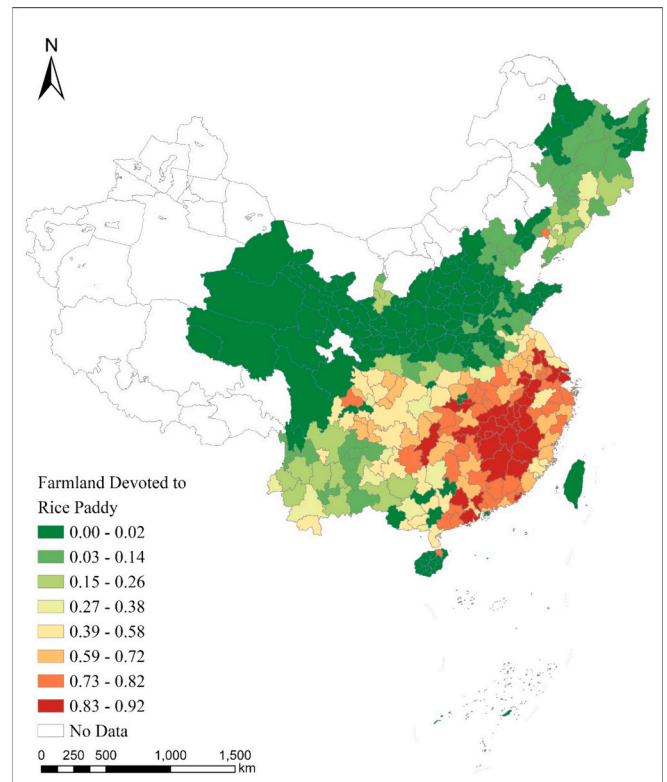


Fig. 2. The percentage of land devoted to rice paddy in each county across China.

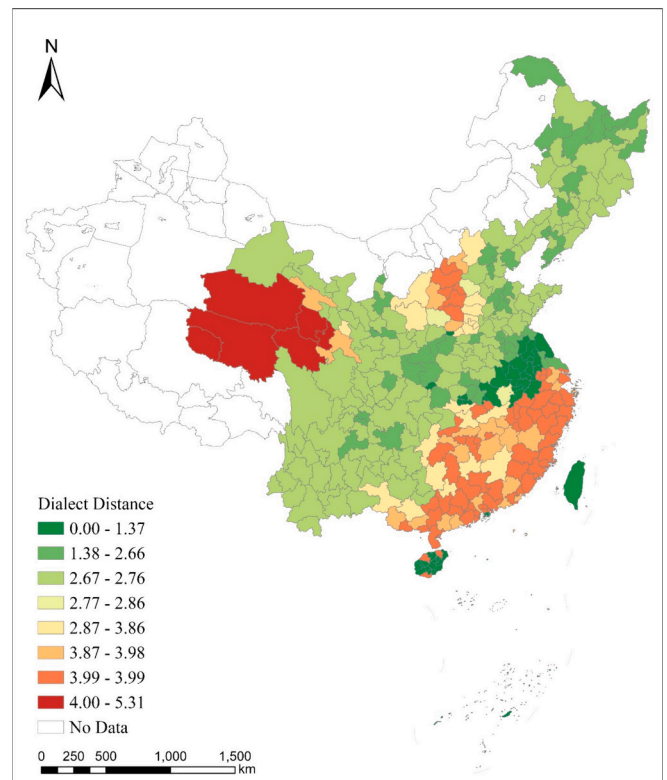


Fig. 3. Distribution of weighted dialect distance from the host city.

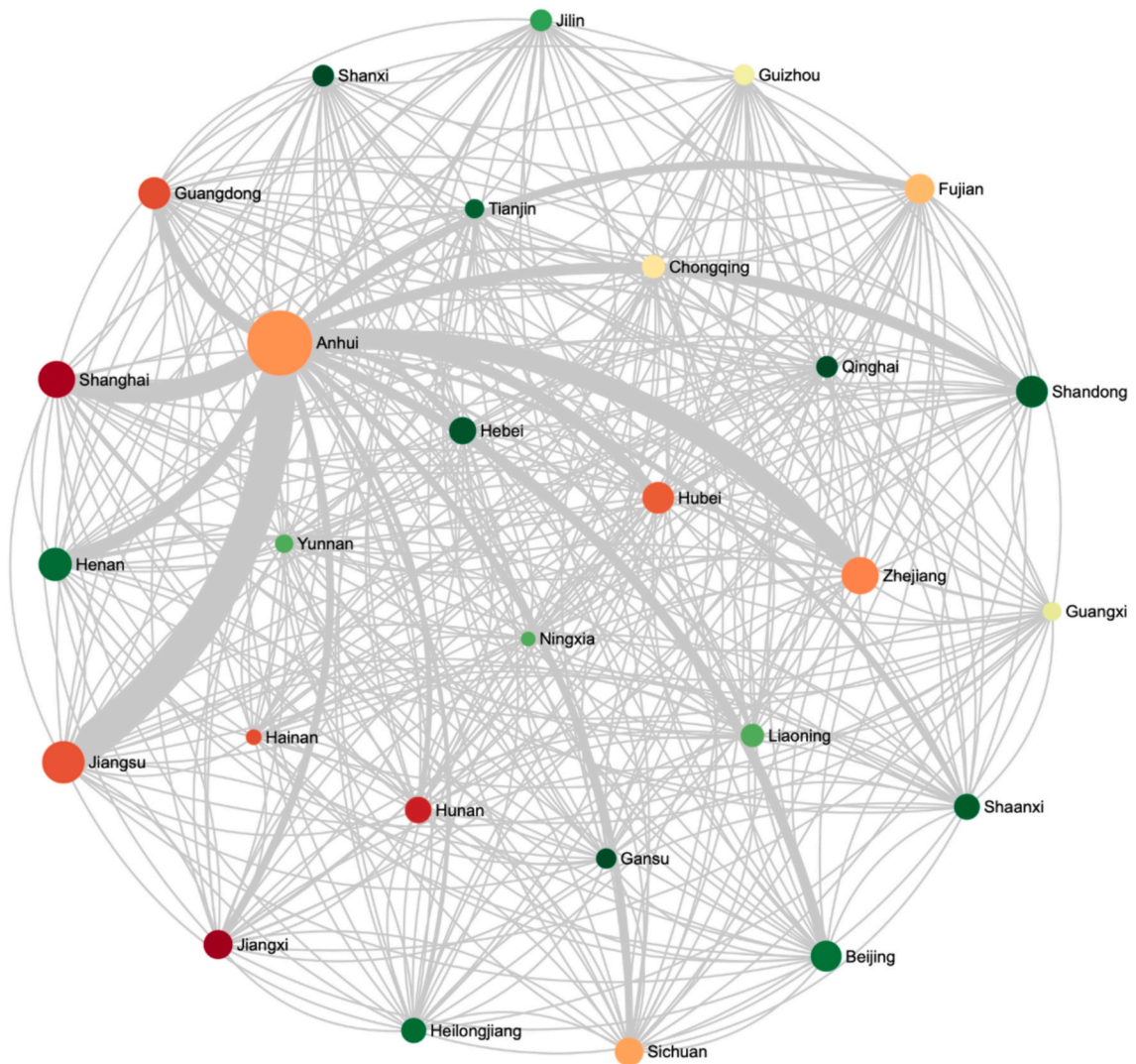


Fig. 4. Calling network among different provinces.

ined: cultural conservatism and interaction tendency. Previous research found that individuals with stronger interaction tendencies often attempt to develop stronger social ties with people of the dominant culture in the host society (Piontkowski et al., 2000). Thus, it is valid to infer migrants' acculturation tendencies from their social ties. We only consider the records that the migrant initiated and match the records with the migrant's birthplace. If the number called is registered in the migrant's birthplace, we count it as a home call. If the called number is registered in the host city, we count it as a local call. We then constructed the following two measures of acculturation strategies for a migrant i :

$$\text{Cultural Conservatism}_i = \frac{h_i}{a_i} \tag{1}$$

$$\text{Interaction Tendency}_i = \frac{l_i}{a_i} \tag{2}$$

where h_i represents the number of contacts registered in i 's hometown, l_i represents the number of contacts registered in i 's host city, and a_i represents the total number of i 's contacts.

4.2.2. Independent variable: I-C cultural background

Based on the rice theory (Talhelm et al., 2014), we use the percentage of cultivated land devoted to rice paddies in a county in 1996 to measure the individualistic and collectivistic backgrounds of migrants from this county. If this measure is high for a region, then the cultural background of migrants from this region is more collectivistic-oriented. On the other hand, if this measure is low, then the cultural background of migrants from this region is more individualistic-oriented.

4.2.3. Moderating variables: socioeconomic status and cultural distance

4.2.3.1. *Socioeconomic status.* We constructed a large social network using the call records in the telecommunication dataset. To accurately infer social network structure through mobile phone data, we removed calls involving non-human numbers, which were identified as those with a degree greater than 200. The rationale is that an average person can only maintain a certain number of social relationships mainly due to resource and time constraints (Stiller & Dunbar, 2007). After this filtering process, we constructed a social network of 6,351,033 nodes and 14,735,425 relationships. This complete network includes both registered and anonymous users.

We measured migrants's socioeconomic status as the average collective influence (CI) score of the residents in their residential location. We first identified each migrant's residential location using the cell towers as location identifiers. We defined a migrant's residential cell tower as the one most frequently used during non-working hours—between 8:00 p.m. and 7:00 a.m. from Monday to Friday, as well as throughout Saturday and Sunday. We excluded records of migrants who did not make calls during these non-working hours. Second, we calculated the CI score of each node in the complete network we constructed before. The CI score is derived from the theory of influence maximization in complex networks (Morone & Makse, 2015). This measure has been found to be highly correlated with an individual's socioeconomic status (Luo et al., 2017). The CI score of a node i is calculated as follows:

$$CI(i) = (k_i - 1) \sum_{j \in \partial Ball(i,l)} (k_j - 1) \tag{3}$$

where k_i is the degree of the node i . The $\partial Ball(i, l)$ is the set of nodes that are l steps away from the node i in the network. j includes all nodes that are in $\partial Ball(i, l)$. k_j is the degree of the node j . Then i 's CI score is the sum of the degree of all nodes with distance l from i multiplied by the number of i 's friends. Our study sets l equals to 2 for simplicity.

Third, we calculate the average CI score of a migrant's neighbors in the same residential cell tower to measure the SES of that migrant. A migrant i will have a list of neighbors (i.e., nodes that are in i 's residential cell towers). We use the average CI of i 's neighbors to reflect i 's SES in the host society. It is calculated as follows:

$$SES_i = \log \left(\frac{\sum_{j=1}^J CI(j)}{J} \right) \tag{4}$$

where J is the total number of neighbors in the i 's residential cell tower. $CI(j)$ is the CI score of the neighbor node j .

4.2.3.2. Cultural (dialect) distance. We use dialect distance between two regions as a proxy for cultural distance. Previous research also used dialect distance to measure cultural distance in studying cultural closeness and economic exchange in Germany (Falck et al., 2012). Dialect distance in our study is derived from the Dialect tree diagram based on the Chinese Dialect Dictionary (Baohua & Miyata, 2020) and Atlas of Chinese Language (Rong et al., 1987).

Following Yuyun et al. (2015), we first divided the Chinese dialects into three levels: dialect region, dialect segment, and dialect unit. Each county in China is assigned to a specific dialect unit. The absolute cultural distance between a migrant's original and host county (society) is calculated as follows: if two counties belong to the same dialect unit, the dialect distance is 0. If two counties belong to different dialect units of the same dialect segment, the dialect distance is 1. If two counties belong to different dialect segments of the same dialect area, the dialect distance is 2. If two counties belong to different dialect areas, the dialect distance is 3.

Secondly, the absolute dialect distance is weighted with the proportion of the population that belongs to two counties. This weighted measure captures the mobility of the population across different cities. The weighted cultural (dialect) distance between city A and city B is calculated as follows:

$$d(A, B) = \sum_{i=1}^I \sum_{j=1}^J S_{Ai} * S_{Bj} * d_{ij} \tag{5}$$

where S_{Ai} is the proportion of population of city A who were from county i . S_{Bj} is the proportion of population of city B from county j . d_{ij} is the absolute dialect distance between county i and county j . In this formula,

S_{Ai} (S_{Bj}) is the likelihood of an individual who resides in city A(B) but is originally from county i (j).

4.2.4. Control variables

We controlled for important personal traits such as gender, age, and length of residence. The length of residence was measured by calculating the total number of months from the start date of a migrant's mobile phone plan registration to February 2012, as most migrants register with a local operator when they first move to a new city. Additionally, we constructed two dummy variables to indicate whether the migrants are from a rural or suburban area.

4.2.5. Summary statistics

Table 1 summarizes the statistics of the 11,216 migrants. The average percentage of cultivated land devoted to rice paddies across different counties is 0.43, which suggests our sample is balanced between migrants with collectivistic and individualistic cultural backgrounds.

4.3. Empirical model

Our empirical analysis employed the following model specification to examine the impacts of I-C cultural background on migrants' acculturation strategies (H1):

$$CultureConservatism_i = \beta_0 + \beta_1 RicePercent_i + \chi Control_i \tag{6}$$

$$InteractionTendency_i = \beta_0 + \beta_1 RicePercent_i + \chi Control_i \tag{7}$$

To examine H2, we interacted *RicePercent* with *SES* and added it to the regression model. For H3, we grouped migrants based on different cultural (dialect) distance between their birthplaces and the host city and conducted regression analysis using the above empirical model.

4.3.1. Instrumental variable: rice suitability score

To address the possible endogeneity issues due to confounding factors in our study, we constructed an instrumental variable (IV) to help identify the causal impacts of migrants' I-C cultural backgrounds on their acculturation strategies. In our study, this IV needs to be correlated with migrant i 's I-C cultural background. At the same time, it cannot be related to two acculturation strategy variables: *CultureConservatism_i* and *InteractionTendency_i*, except through its effects on i 's I-C cultural background.

Inspired by Talhelm et al. (2014), we adopted the rice suitability score of the migrant i 's birthplace as the instrumental variable for our analysis. The rice suitability score is an index provided by the United Nations Food and Agriculture Organization's Global Agroecological Zones database (FAO, 2010). This index estimates an environmental suitability z-score of each province in China for growing wetland rice based on complex models that include solely environmental factors such as temperature, evaporation, and humidity. Based on the rice theory, the

Table 1
Summary statistics.

Variable	# of observations	Mean	Std. dev.	Min	Max
<i>Cultural Conservatism</i>	11,216	0.1089	0.1854	0	1
<i>Interaction Tendency</i>	11,216	0.6644	0.2571	0	1
<i>Rice Percent</i>	11,216	0.4283	0.3445	0	0.9200
<i>Dialect Distance</i>	11,216	2.8403	0.9942	0	5.3111
<i>SES</i>	10,748	12.5276	2.9840	0	15.1888
<i>Is rural</i>	11,216	0.0945	0.2925	0	1
<i>Is suburban</i>	11,216	0.0308	0.1729	0	1
<i>Is male</i>	11,216	0.7190	0.449	0	1
<i>Age</i>	11,216	34.7463	9.3484	17	88
<i>Length of Residence</i>	11,216	17.0910	7.7731	0	38

differences in individualistic and collectivistic cultural orientations across different regions originated from their choices in rice and wheat cultivation (Talhelm et al., 2014). The rice theory assumes that environmental factors determine the selection of growing rice or wheat. Thus, conceptually, the rice suitability score should not affect a migrant's acculturation strategies except through the I-C cultural background of her birthplace (measured by the percentage of land devoted to rice paddies). Therefore, the rice suitability score can be used as an instrumental variable to identify the causal impacts of migrants' I-C cultural background on acculturation strategies. Table 2 summarizes the first-stage results and shows that a region's rice suitability score is significantly associated with its percentage of land devoted to rice paddies.

5. Results

5.1. The causal impacts of I-C cultural background

Table 3 presents the results of both 2SLS and OLS regressions with robust standard errors. The results of the OLS regression in columns 2 and 4 indicate a positive and significant relationship between migrants' cultural conservatism and Rice Percent—the percentage of rice paddies in their birthplaces, as well as a negative and significant relationship between migrants' interaction tendencies and Rice Percent. Moreover, the second-stage results of 2SLS regressions in columns 1 and 3, using IV, show similar results. These results suggest a causal relationship between migrants' I-C cultural backgrounds and acculturation strategies. Specifically, migrants with a more collectivistic-oriented cultural background (i.e., higher Rice Percent) tend to interact more with people from their hometowns (i.e., exhibit more cultural conservatism) and are less likely to interact with locals in the host city (i.e., exhibit less interaction tendency). Thus, both H1a and H1b are supported.

5.2. The moderating effect of SES

Table 4 shows that SES is negatively associated with cultural conservatism and positively associated with interaction tendency in both the OLS and 2SLS results. These results may be explained by the fact that migrants with higher SES are often better equipped to integrate with the abundant resources available to them.

For the moderating effects, column 1 and column 2 show that the positive relationship between the percentage of rice paddies in migrants' birthplaces and cultural conservatism is weakened by higher SES because the coefficient of the interaction term $RicePercent \times SES$ is significantly negative, supporting H2a. This result suggests that if migrants with more collectivistic cultural backgrounds have abundant local resources, their reliance on social support from ingroup members in their hometowns decreases. These results are also held in 2SLS regression.

However, in columns 3 and 4, the interaction term is not significant for both OLS and 2SLS results. Thus, H2b is not supported. This suggests that for migrants with more collectivistic cultural backgrounds, their

Table 2
First-stage regression results.

Variable	(1)	(2)
Rice Suitability	0.0112*** (0.0001)	0.0112*** (0.0001)
Other Covariates	No	Yes
Robust F-statistics	25,841**	25,080.7*

Note: This table includes 11,216 observations from 27 provinces. Other covariates are indicators of age, gender, length of residence, urban-rural status, and dialect distance.

*** p-Value < .01.

** p-Value < .05.

* p-Value < .1.

interaction tendencies are not influenced by SES.

5.3. The moderating effects of cultural distance

We also proposed that the relationship between migrants' I-C cultural backgrounds and acculturation strategies depends on the cultural distance between their birthplaces and the host society. Since dialect distance is not a continuous measure, following (Agrawal & Goldfarb, 2008), we group migrants based on the absolute value of dialect distance. As shown by Yuyun et al. (2015), Chinese dialects are categorized into three levels: region, segment, and unit. In their studies, each county in China is assigned to a dialect unit. The dialect distance between two counties is determined as follows: if the two counties belong to the same dialect unit, the dialect distance is 0; if the two counties belong to different dialect units of the same dialect segment, the dialect distance is 1; if the two counties belong to different dialect segments of the same dialect area, the dialect distance is 2; if the two counties belong to different dialect areas, the dialect distance is 3. Thus, following this logic, we divided the sample into four groups such that if the dialect distance is below 1, the cultural difference is minimal. If the dialect distance is between 1 and 2, the cultural difference is moderately low. If the dialect distance is between 2 and 3, the cultural difference is moderately high. If the dialect distance is over 3, the cultural difference is high. In Section 6.1, the robustness check section, we also test an alternative method for dividing the sample, and the results exhibit a similar pattern.

As shown in Table 5, both the OLS and 2SLS results indicate that the relationship between acculturation strategies and I-C background is contingent on dialect distance. When the dialect distance is small, migrants with more collectivistic cultural backgrounds have fewer contacts from their hometown but more local contacts in the host society, supporting H3a. Conversely, when the dialect distance is large, migrants with more collectivistic backgrounds show stronger cultural conservatism and lower interaction tendency. Therefore, H3b is supported. Our results also indicate that when dialect distance is moderate, migrants with collectivistic cultural backgrounds show a greater reduction in their interaction tendencies with locals. However, no significant relationship was found for their cultural conservatism. These results indicate an asymmetric effect of cultural distance on migrants' cultural conservatism and interaction tendencies.

The results suggest that migrants with collectivistic cultural backgrounds tend to adjust and integrate with the host society when acculturation challenges are minimal. However, when the cultural differences between migrants' hometowns and the host society are significant, leading to cultural conflicts that exceed the migrants' capacity to adapt quickly, acculturative stress intensifies. To cope with these adverse events, migrants with collectivistic backgrounds prefer to seek support from their in-group members, which thus leads to increased cultural conservatism tendencies.

6. Robustness check

6.1. Alternative method for dividing samples based on cultural distance

To complement the results in Table 5, we also divided the sample into four groups based on their dialect distance percentiles: the top 25%, 25%–50%, 50%–75%, and greater than 75% to ensure the consistency of our findings. We re-ran the regression analysis, and the results are shown in Table 6.

The results exhibit a similar pattern to those shown in Table 5, indicating that migrants with more collectivistic cultural backgrounds tend to demonstrate stronger interaction tendencies when the cultural distance is small. Conversely, they exhibit stronger cultural conservatism when the cultural distance is large.

Table 3
2SLS/OLS model of acculturation strategies among migrants with varying levels of collectivism.

Variable	CulturalConservatism		InteractionTendency	
	2SLS (Robust SE)	OLS (Robust SE)	2SLS (Robust SE)	OLS (Robust SE)
RicePercent	0.0396*** (0.0065)	0.0238*** (0.0049)	-0.0481*** (0.0092)	-0.0379*** (0.0068)
Age	-0.0028*** (0.0002)	-0.0028*** (0.0002)	0.0045*** (0.0003)	0.0045*** (0.0003)
RdLength	-0.0014*** (0.0002)	-0.0014*** (0.0002)	0.0028*** (0.0003)	0.0028*** (0.0003)
Is rural	0.0145** (0.0064)	0.0148** (0.0064)	-0.0038 (0.0083)	-0.0040 (0.0083)
Is suburban	-0.0118* (0.0087)	-0.0111 (0.0087)	0.0489*** (0.0130)	0.0485*** (0.0130)
Is male	0.0097** (0.0038)	0.0100*** (0.0038)	-0.0333*** (0.0052)	-0.0334*** (0.0052)

Note: Standard errors are in parentheses.

*** p < .01.
** p < .05.
* p < .1.

Table 4
The moderating effect of SES on acculturation strategies.

Variable	CulturalConservatism		InteractionTendency	
	2SLS (Robust SE)	OLS (Robust SE)	2SLS (Robust SE)	OLS (Robust SE)
RicePercent	0.1140** (0.0484)	0.0822** (0.0322)	-0.1070** (0.0518)	-0.0998*** (0.0351)
SES	-0.0106*** (0.0017)	-0.0113*** (0.0013)	0.0203*** (0.0019)	0.0204*** (0.0015)
RicePercent*SES	-0.0065* (0.0037)	-0.0050** (0.0024)	0.0052 (0.0040)	0.0050* (0.0027)
Age	-0.0026*** (0.0002)	-0.0026*** (0.0002)	0.0043*** (0.0002)	0.0043*** (0.0002)
RdLength	-0.0011*** (0.0002)	-0.0011*** (0.0002)	0.0025*** (0.0003)	0.0025*** (0.0003)
Is rural	0.0107* (0.0062)	0.0110* (0.0062)	0.0060 (0.0080)	0.0059 (0.0080)
Is suburban	-0.0161* (0.0084)	-0.0156* (0.0084)	0.0533*** (0.0125)	0.0531*** (0.0125)
Is male	0.0078** (0.0036)	0.0079** (0.0036)	-0.0305*** (0.0051)	-0.0305*** (0.0051)

Note: Standard errors are in parentheses.

*** p < .01.
** p < .05.
* p < .1.

Table 5
The moderating effect of cultural distance on acculturation strategies.

Variable	CulturalConservatism		InteractionTendency	
	OLS (Robust SE)	2SLS(Robust SE)	OLS (Robust SE)	2SLS (Robust SE)
RicePercent * DiaDist is under 1	-0.0173** (0.0086)	-0.0059 (0.0095)	0.0297** (0.0132)	0.0264* (0.0142)
RicePercent * DiaDist is between 1 and 2	-0.0047 (0.0122)	0.0088 (0.0131)	-0.0356** (0.0169)	-0.0463** (0.0182)
RicePercent * DiaDist is between 2 and 3	0.0003 (0.0081)	0.0258* (0.0133)	-0.0259** (0.0114)	-0.0407** (0.0188)
RicePercent * DiaDist is over 3	0.0398*** (0.0056)	0.0560*** (0.0067)	-0.0535*** (0.0076)	-0.0660*** (0.0092)
Age	-0.0028*** (0.0002)	-0.0028*** (0.0002)	0.0045*** (0.0003)	0.0045*** (0.0003)
RdLength	-0.0014*** (0.0002)	-0.0014*** (0.0002)	0.0028*** (0.0003)	0.0028*** (0.0003)
Is rural	0.0152** (0.0064)	0.0148** (0.0064)	-0.0042 (0.0083)	-0.0040 (0.0083)
Is suburban	-0.0115 (0.0087)	-0.0121 (0.0087)	0.0488*** (0.0130)	0.0492*** (0.0130)
Is male	0.0091** (0.0038)	0.0089** (0.0038)	-0.0328*** (0.0052)	-0.0326** (0.0052)

Note: Standard errors are in parentheses.

*** p < .01.
** p < .05.
* p < .1.

6.2. Full sample including all migrants

Instead of excluding migrants with migration duration of less than six months, we relaxed this constraint and performed a regression analysis including all migrants to test the robustness of our findings. The full sample comprises 13,088 migrants. Despite the increase in sample size, the results from our earlier analysis remained consistent within the full sample.

6.3. Measuring acculturation strategies using call volume

Instead of using the number of contacts in migrants' hometown and the host society to measure acculturation strategies, we also use call volume. This approach allows us to more accurately assess the time and effort migrants spend communicating with contacts in both their

hometowns and the host society. In other words, these measures account for the strength of relationships within migrants' social networks. Our findings remain consistent when we use these alternative measures in the regression analyses.

6.4. Measuring I-C cultural background using provincial-level rice-farming data

Following Talhelm et al. (2014), we also used provincial-level rice-farming data and the results remained consistent.

Table 6
The moderating effect of cultural distance on acculturation strategies.

Variable	CulturalConservatism		InteractionTendency	
	OLS (Robust SE)	2SLS (Robust SE)	OLS (Robust SE)	2SLS (Robust SE)
RicePercent * DiaDist is 25 %	-0.0171** (0.0086)	-0.0074 (0.0093)	0.0299** (0.0134)	0.0278** (0.0141)
RicePercent * DiaDist is between 25 % and 50 %	-0.0039 (0.0145)	0.0067 (0.0153)	-0.0249 (0.0204)	-0.0315* (0.0210)
RicePercent * DiaDist is between 50 % and 75 %	0.0024 (0.0088)	0.0206 (0.0127)	-0.0355*** (0.0120)	-0.0470*** (0.0177)
RicePercent * DiaDist is over 75 %	0.0364*** (0.0054)	0.0537*** (0.0069)	-0.0508*** (0.0074)	-0.0642*** (0.0095)
Age	-0.0028*** (0.0002)	-0.0028*** (0.0002)	0.0045*** (0.0003)	0.0045*** (0.0003)
RdLength	-0.0013*** (0.0002)	-0.0013*** (0.0002)	0.0028*** (0.0003)	0.0028*** (0.0003)
Is rural	0.0145** (0.0064)	0.0142** (0.0063)	-0.0038 (0.0083)	-0.0036 (0.0083)
Is suburban	-0.0119 (0.0087)	-0.0126 (0.0087)	0.0489*** (0.0129)	0.0494*** (0.0129)
Is male	0.0093** (0.0038)	0.0090** (0.0038)	-0.0330*** (0.0052)	-0.0328*** (0.0052)

Note: Standard errors are in parentheses.

*** p < .01.

** p < .05.

* p < .1.

7. Discussion

7.1. Acculturation strategies and I-C cultural background

In this study, we integrate data science methods with novel cultural theories to extract insights and knowledge from a mobile phone dataset encompassing 11,216 migrants in an eastern Chinese city. Our objective is to investigate how migrants' I-C cultural backgrounds influence their acculturation strategies. We found that migrants with more collectivistic cultural backgrounds exhibit stronger cultural conservatism tendencies, while those with more individualistic backgrounds show stronger interaction tendencies. We also employed the rice suitability score as an instrumental variable to establish a causal relationship for these findings. Both analyses indicate strong and statistically significant relationships.

Our findings contribute to existing acculturation studies in several ways. Firstly, we introduce the rice theory to the acculturation theory to examine the impact of migrants' cultural backgrounds on their acculturation strategies. Previous studies have not focused on the factors driving the systematic differences in acculturation strategies among different migrant groups, although prior studies confirmed that different acculturation strategies may prevail among different migrant groups (Cao et al., 2017; Lalonde & Cameron, 1993; Migliorini et al., 2015; Neto, 2002; Yijälä & Jasinskaja-Lahti, 2010; Zhang et al., 2011). Instead, previous research has primarily concentrated on understanding the consequences of different acculturation strategies (Ma & Xia, 2021; Stogianni et al., 2021; Tatarko et al., 2020; Yoo, 2021). Understanding the systematic factors driving the group-level differences in acculturation strategies may have significant policy implications, as it will enable policymakers to develop policies that better support and accommodate migrants with diverse cultural backgrounds.

Derived from previous studies, Individualism-collectivism (I-C) cultural orientation is often considered an important source of behavioral differences (Kim, 2024), including appraising and coping strategies for stressful life events (Acikdeniz et al., 2024; Phillips, 2023). After migration, acculturative stress may also arise due to cultural conflicts between migrants' hometowns and the host society. Consequently, migrants with different I-C cultural backgrounds may employ different acculturation strategies to cope with acculturative stress (Berry, 2006; Schmitz & Schmitz, 2022), thus exhibiting different acculturation strategies. However, previous studies have not addressed this issue comprehensively. A few studies have examined individual I-C tendencies and their choice of acculturation strategies, but they failed to establish a clear relationship. This may be because previous acculturation research primarily used questionnaires and surveys to measure individual-level I-C cultural orientation, and their samples may have been concentrated on specific migrant groups that have migrated over the years. Using this method, it may be challenging to find a

relationship, as there is self-selection bias for migrants who choose to migrate, and individual I-C tendencies may shift after migration (Knudsen, 2019). Therefore, we developed new measures based on the rice theory to reflect migrants' I-C cultural backgrounds. This theory suggests that southern Chinese with a rice-farming history are more collectivistic than northern Chinese with a wheat-farming history, given the different levels of collaboration required by farming these two crops (Talhelm et al., 2014). Our empirical findings thus validate and extend the theoretical framework developed by Berry (1997) and complement previous acculturation research.

Secondly, our unique mobile phone record data offers several advantages in complementing previous studies by enabling us to construct new behavioral measures for acculturation strategies and to encompass samples with greater variety. To be more specific, while previous studies have adopted various measures to indicate different acculturation strategies, only a few literature focus on migrants' behavioral aspects (Kreienkamp et al., 2024). Behavioral operationalizations of acculturation strategies in previous studies include civic participation (Ay Kesgin, 2024), interethnic marriage (Song, 2009), and media consumption (Shoemaker et al., 1985). Although these studies provide unique insights into migrants' behavior in the host society, they often fail to capture migrants' interaction tendencies toward both the host society and their hometowns simultaneously. The strength of using a mobile phone dataset lies in its ability to provide an objective and direct measure of migrants' actual contact tendencies. As Kreienkamp et al. (2024) indicated, understanding contacts during the acculturation process is crucial. Specifically, when migrants selectively choose their contacts with people from their hometowns or with those from the host society, the different strategies employed may lead to different acculturation outcomes. Our mobile phone dataset allows us to assess migrants' actual calling behaviors and how the calling tendencies vary among migrants with different cultural backgrounds. Furthermore, our mobile phone dataset includes migrants with more heterogeneity, facilitating a systematic understanding of the diverse tendencies in acculturation strategies. In contrast, previous studies often narrow their samples to specific groups such as children (Guerra et al., 2019), adolescents (Kumi-Yeboah et al., 2020; Neto, 2002), or international students (Krsmanovic, 2020; King et al., 2020).

Lastly, the causal relationship we examined between migrants' I-C cultural backgrounds and their acculturation strategies has rarely been established in previous acculturation studies (Kunst, 2021). As shown in Kunst's (2021) systematic review, although more than 13,000 scientific articles have been published on topics related to acculturation, only a small fraction uses data that allow for causal inferences. We complement previous studies by establishing the causal relationship between migrants' cultural backgrounds and their acculturation strategies by adopting an instrumental variable method.

7.2. The interaction between contextual factors and I-C cultural background

7.2.1. Socioeconomic status

We also found that higher socioeconomic status (SES) can positively influence migrants' cultural conservatism while negatively influencing their interaction tendencies. These findings align with previous studies, which suggest attributes like higher education (Pham & Harris, 2001), language proficiency (Cao et al., 2017), and occupational prestige (Berry et al., 2006a) provide migrants with more coping resources, making it easier for them to navigate the acculturation process. Additionally, when examining the moderating effect, we found that higher SES weakens the positive relationship between a migrant's collectivistic background and cultural conservatism. However, it does not moderate the negative impact of a migrant's collectivistic background on interaction tendency. This result, which has not been studied before, may be due to the fact that higher SES provides migrants with ample resources to cope with acculturative stress in the host society and, thus, reducing their need to rely on contacts from their birthplace. On the other hand, abundant local resources do not ameliorate the low interaction tendencies of migrants with collectivistic backgrounds, suggesting the persistence of acculturation attitudes. Thus, simply offering more resources or opportunities for migrants may not easily increase these migrants' interaction tendencies with locals.

Our study also contributes methodologically to previous research. Compared to studies that mainly focus on a single dimension of SES, we developed a more comprehensive SES measure to better represent the aggregate coping resources a migrant can access in the host society. A unique feature of our dataset is the temporal-spatial information, which allows us to assess the residential location of migrants. Previous migration studies have confirmed that migrants from different residential locations or migrant enclaves exhibit differences in wage levels (Shen, 2017), economic integration (Zou & Deng, 2020), social integration (Yang, Zhou, & Jin, 2020), or degrees of segregation (Zhang et al., 2024). These differences may stem from varying opportunities to build intergroup connections and social ties (Shen, 2017), emphasizing the importance of considering migrants' surrounding communities in the acculturation process. Our network-based measure effectively captures distinctions among different calling cells, enabling a deeper understanding of the heterogeneity of migrants' resources in the local society. This comprehensive approach offers a more nuanced perspective on the role of SES in the acculturation process.

7.2.2. Cultural distance

We used dialect distance as a proxy for cultural distance and found that when the cultural distance is small, contrary to the main effects mentioned earlier, migrants with a collectivistic background exhibit stronger interaction tendency. However, when the cultural distance is large, migrants with a more collectivistic cultural background tend not to fit in due to excessive acculturative stress. Although previous literature has emphasized the importance of cultural distance between migrants' hometowns and the host society in understanding their acculturation process, most studies focus on its direct relationship with acculturation outcomes such as adjustment and adaptation (Demes & Geeraert, 2014; Galchenko & Van De Vijver, 2007; Mai & Wang, 2022). Regarding the moderating effect of cultural distance, to our knowledge, only English et al. (2021) found that the relationship between host and international support with anxiety can be moderated by cultural distance. However, their study did not address acculturation strategies.

We distinguish ourselves from previous studies by considering cultural distance as a situational factor determining acculturative stress during acculturation. Migrants with different I-C cultural backgrounds may cope with varying levels of acculturative stress in different ways, leading to diverse acculturation strategies. A surprising finding is that collectivistic migrants with low cultural distance are willing to contact locals. This may be because of their inherent nature of maintaining

harmony in their environment. This finding has not been previously reported. Additionally, migrants with collectivistic cultural backgrounds reduce their contact with locals to a greater extent as cultural distance increases. This suggests that cultural distance creates barriers for migrants to interact with locals, and migrants with collectivistic backgrounds are more sensitive to such cultural differences. This aligns with previous literature indicating that individuals with a collectivistic cultural background have stronger social sensitivity (Bhawuk & Brislin, 1992; Markus & Kitayama, 1991; Way & Lieberman, 2010). In addition, when there is a large cultural distance, migrants with collectivistic cultural backgrounds tend to cope by exhibiting stronger tendencies of cultural conservatism. This indicates that migrants with collectivistic backgrounds are rather flexible in their acculturation strategies. Depending on the acculturative difficulties and stress induced by cultural distance, they either choose to maintain their original culture (with greater cultural distance) or establish relationships with locals (with smaller cultural distance).

Our study highlights how cultural distance and I-C cultural background interact to shape acculturation strategies. Our findings provide a more holistic view of how migrants adapt to their new environments and their strategies to manage acculturative stress. This comprehensive approach contributes to a deeper understanding of the complexities involved in the acculturation process and offers valuable insights for developing targeted support for migrants.

8. Conclusion

8.1. Contributions

In summary, our research's contributions are threefold. First, previous acculturation research fails to capture an important cultural characteristic of migrants—the I-C cultural background of their hometowns. A major empirical challenge is identifying the heterogeneous cultural backgrounds of a large migrant population using traditional qualitative methods like questionnaires or surveys. Our study is among the first to introduce the rice theory and integrate it with advanced data science methods, the instrumental variable method, and the acculturation research framework to develop novel constructs for measuring migrant's I-C cultural backgrounds, allowing us to identify the important but previously overlooked causal relationship between migrants' I-C cultural backgrounds and acculturation strategies. Our empirical findings validate and extend the theoretical framework developed by Berry (1997) and complement previous acculturation research.

Second, previous research has mainly taken a univariate perspective to study various factors influencing migrants' acculturation strategies, often neglecting the interplay between these factors. This can result in policies that fail to fully comprehend the diversity and complexity of acculturation processes, leading to social and economic problems such as cultural conflicts, social segregation, and inequality. Our study utilizes novel SES and cultural distance measures constructed through advanced data science methods and network models to study the interplay between these factors and migrants' I-C cultural backgrounds, as well as their impacts on acculturation strategies. In current debates on migration policies, there is often a focus on whether to encourage assimilation to host cultures (e.g., France's assimilationism policy) or to maintain cultural diversity (e.g., Canada's multiculturalism policy) (Maisonneuve & Testé, 2007). Our empirical analysis indicates that a one-size-fits-all policy may not accommodate the acculturation needs of migrants with diverse backgrounds. Instead, authorities should combine different policy instruments, including civic integration programs, labor market training, settlement services, and mentoring programs, to facilitate the acculturation of different migrant groups.

Third, our empirical analysis employed data science methods and leveraged unique information from four distinct datasets: 1) the birthplace information of migrants in a large-scale mobile phone dataset, 2) migrants' call records, 3) rice statistics, and 4) cultural (dialect) distance

across counties in China. Along with those novel measures we developed, this research provides a data science approach for measuring individuals' SES, I-C cultural background, and cultural distance using mobile phone data, which is becoming increasingly common in empirical data analytics.

8.2. Limitations and future research

One major limitation of our study is that the migrants are all Chinese in the host city. Our future research aims to extend our study to international migration and acculturation. Second, extending the findings of this study to refugee requires further analysis, as they differ significantly from voluntary migrants. Previous research has found that the voluntariness of migration is also an important factor in acculturation (Berry, 1997).

Another limitation is the relative age of our dataset. Currently, mobile phones are used beyond just making calls and sending text messages, unlike in 2012. Although we can still gain valuable insights from this dataset—such as the different acculturation strategies employed by migrants with different cultural backgrounds—we should now consider more diverse channels of cultural contact as the Internet evolves in future studies. Contact between migrants and locals may have significantly increased through other channels in recent years, such as social media (Hofhuis et al., 2023), and contact with the host society may even occur before migration, facilitated by the Internet. Thus, future research should consider combining multiple data sources to address this issue.

CRedit authorship contribution statement

Sichen Dong: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Daning Hu:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Xuan Yang:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Michael Chau:** Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Acknowledgement

The authors gratefully acknowledge funding from Guangdong Province Research Fund (Grant Number: 2019N01X277), National Natural Science Foundation of China (Grant Numbers: 71971106, 72001099), Shenzhen Humanities & Social Sciences Key Research Bases, and Shenzhen Municipal Science, and Technology Innovation Commission - Stable Support (General) (Grant Number: 20231121163003001).

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