Circular visualization of China's internal migration flows 2010–2015

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Abstract
We adapted the chord diagram plot to visualize China's recent inter-provincial migration during 2010–2015. The arrowheads were added to present the direction of the flows. This method allows us to show the complete migration flows between 31 provinces in China including the direction and volume of the flows. The spatial component was also clearly depicted in the plot using four color palates representing four regions in China (i.e. East, Center, West, Northeast) and arranging the 31 provinces in an approximate geographic order. Besides that, we extend the chord diagram plot to describe China's bilateral net migration during 2010–2015.

Since the initiation of the economic reforms and opening up policies in the late 1970s, China has witnessed a process of rapid urbanization. Persistent regional inequalities in wages, job opportunities and social services drew an estimated 200–250 million migrant workers from the rural areas to the more economically prosperous coastal regions and megacities (Chan, 2012). Although the future ageing of the population is expected to produce a slowdown in population movements, another 100 million rural migrants moving towards

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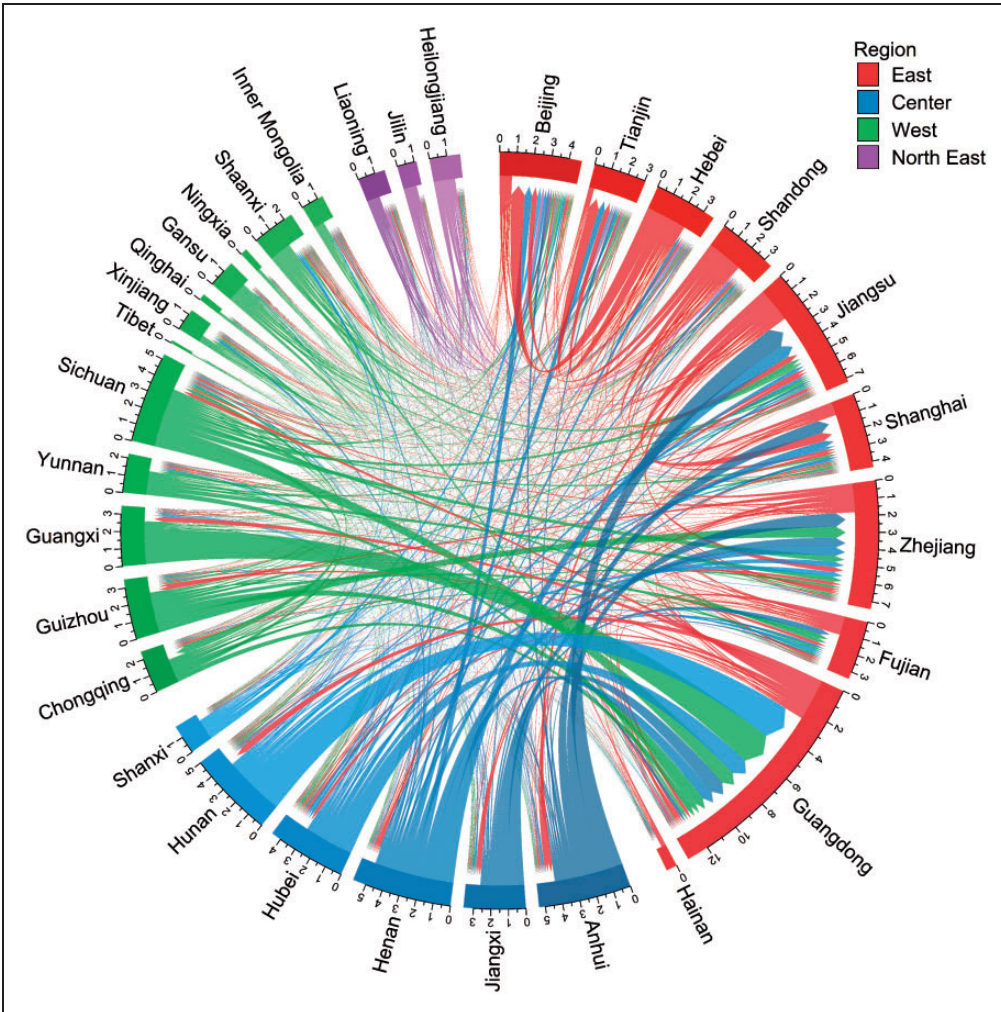Email: guy.abel@oeaw.ac.at

Figure 1. Bilateral migration flows during 2010–2015 in China (unit: million).

China's cities is foreseen in the coming years (The State Council of The People's Republic of China, 2014).

Data to monitor these flows are enumerated using a number of migration measures. Bilateral migration flows provide an effective representation of contemporary migration patterns and facilitate the prediction of future trends (Abel, 2013). There are 31 provinces in mainland China making 930 inter-provincial flows in the internal bilateral origin–destination migration system.

Here, we introduce an adapted chord diagram plot to visualize the complex internal migration system in China using the circlize package in R (Gu et al., 2014). We take the inter-provincial population migration data from 2010 to 2015 as an example, aiming to illustrate the latest pattern of population movement in China. Each flow displays information on origin, destination, direction and volume of flows between all provinces. The data are based on tabulations from the 2015 National Population Sampling Survey (Department of Population
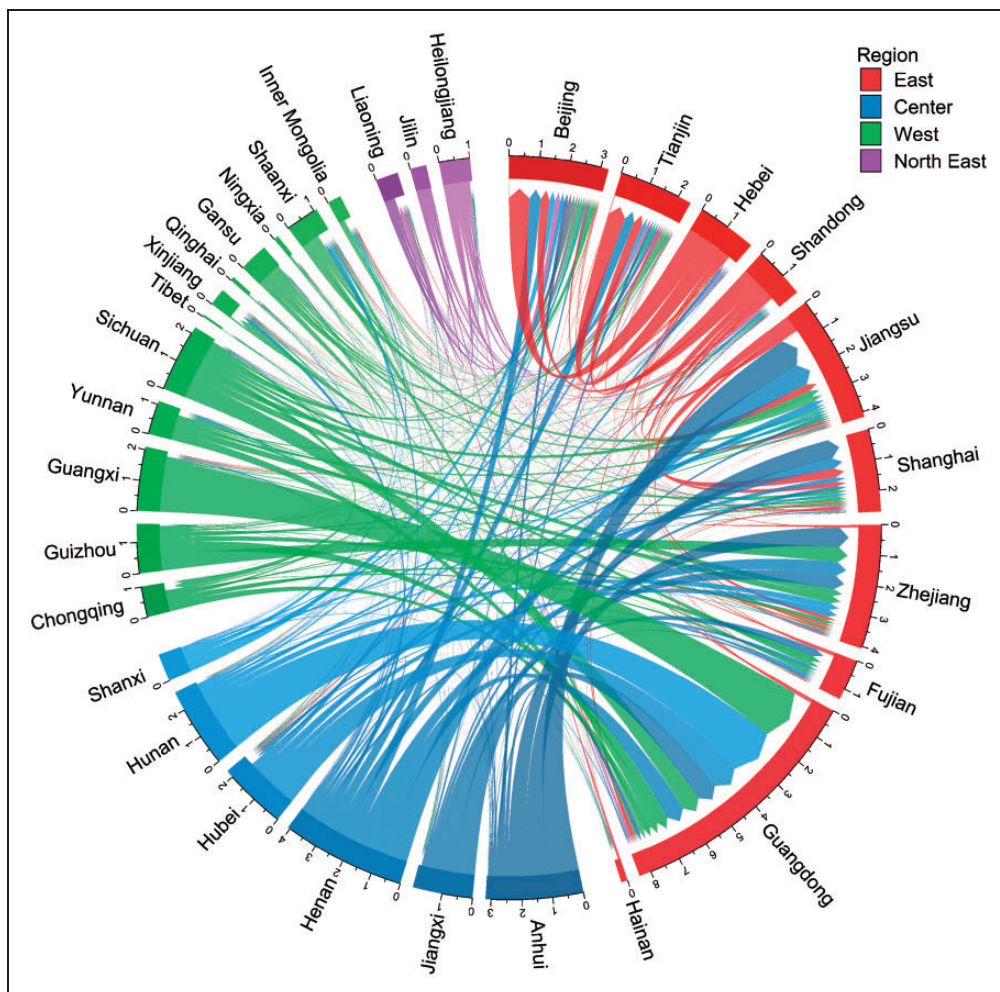
Figure 2. Bilateral net migration during 2010–2015 in China (unit: million).

and Employment Statistics of National Bureau of Statistics of China, 2016). Actual population numbers are derived from dividing the sampling ratio by 1.55%.

As shown in Figure 1, the chord diagram plot presents a complete inter-provincial migration system in China. Each chord starts from the province of origin and ends in the province of destination. The direction of the flows is illustrated using arrowheads on each chord. This addition provides a more effective representation of direction of bilateral relations than those in previous chord diagram visualizations of migration data (e.g. Abel and Sander, 2014). The width of the chord at the origin represents the number of migrants who moved over the five-year period. Larger flows are plotted last, on top of the smaller flows, to highlight the biggest bilateral migration corridors. The length of the province axis refers to gross migration size (total immigration and total outmigration) in each province. The 31 provinces are distinguished by different colors taken from four palates, each representing a different geographical region in China. They are shown in an approximate geographic order so that neighboring provinces are relatively close to each other. The plot highlights the largest migration flows in China originated from Central or Western provinces

towards the provinces in the East. The largest flow during 2010–2015 was from Hunan to Guangdong, the province receiving the most migrants. Zhejiang, Jiangsu, Shanghai, Beijing, Tianjin were also popular destination provinces, while Henan, Anhui, Hunan, Sichuan, and Hubei are predominant sending provinces.

As shown in Figure 2, we extend the chord diagram plot to describe China's bilateral net migration. The net migration value between two provinces is calculated by the difference of two bilateral flow sizes, where only the positive net flow values are shown. For example, there are 2.1 million migrants from Guangxi to Guangdong, while there are only 0.3 million migrants from Guangdong to Guangxi. The net migrants between these two provinces is 1.8 (2.1−0.3 = 1.8) million. The length of the axes in Figure 2 represents the sum of the total net in-migrants and total net out-migrants. The bilateral net migration circular plot allows us to clearly identify the unbalanced interprovincial migration corridors. The largest bilateral net migration is the flow from Guangxi to Guangdong (and not from Hunan to Guangdong as shown in Figure 1). For popular migrant destinations, such as Guangdong, Zhejiang, and Jiangsu, the net migration values capture the intensity of net in-migrant flows. Similarly, for those migrant-sending provinces such as Henan, Anhui, and Sichuan, we observe higher net out-migrant flows.

The adapted chord diagram plot allows for an effective visualization of the complex migration system. Both the flow and stock patterns can be described in the plot. The visualization method works well when there are not too many geographic units. For instance, we visualized the 930 bilateral flows, and 465 bilateral net flows, among China's 31 provinces. Plots at the next level of administrative geography would involve over 8.1 million flows among China's 2850 county-level units making the plot illegible. In short, the adapted chord diagram plot presents an alternative visualization method to depict inter-provincial bilateral and net migration flows in China where all flows including their direction and size can be represented.

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