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Featured graphic. Visualizing the minimum solution of the transportation problem of linear programming (TPLP) for Beijing's bus commuters

A number of scholars (see Horner, 2002; White, 1988) have established a framework for analyzing the efficiency of regional commuting patterns. Typically, this framework has a minimum and maximum commute (T_{min} and T_{max}). Commuting is considered excessive if actual commuting (T_{act}) deviates from T_{min} in a given city region. T_{min} assumes that individuals commute, on average, to the closest possible workplace in terms of some measure of zonal separation (eg, distance, time) while T_{max} assumes the opposite.

However, while many scholars have calculated T_{min} and T_{max} for various cities, none has attempted to map their solutions. Thus, we still do not have any cartographic knowledge of how the geography of flows associated with T_{min} compares with T_{act}. Using one week of bus users' origin and destination (OD) flow data attained from Smartcards in Beijing for 2008, we not only calculated T_{act} and T_{min} for bus commuters in the city but also mapped the corresponding commuting flows. The figures below are our mapping results. For technical details regarding how we derive and validate OD flow data for bus commuters in Beijing, please refer to Long et al (2012), while Horner (2002) can be consulted for details on how to calculate T_{act}, T_{min}, and T_{max}.

Figure 1 shows the commuting flows associated with T_{act}. Tian'anmen square (indicated by the star) represents Beijing city centre. It can be seen that most bus commuters reside in job-poor areas to the north of the city centre but work in job-rich areas. Their average commuting distance is often longer than 5 km. A notable percentage of bus commuters have a journey to work length longer than 12 km. While not extensive, cross-commuting can also be observed while the general pattern of commuting shows some level of dispersion. Figure 2 shows the commuting flows associated with T_{min}. As depicted in the graphic, if most bus commuters were to live closer to where they work then commuting would be more efficient, at least in terms of journey distance. The graphic also shows that the general pattern of bus flows when users are behaving optimally is remarkably radial in nature and is oriented towards flows along radial routes converging in the centre. This results in actual average commuting distances of 8.2 km for bus users as opposed to 11.2 km for car users due to the greater complexity of travel patterns for car users.

What is surprising, however, is that there seem to be enough housing units in close proximity to job-rich areas to accommodate bus commuters but not all users take up these units. Since we consider only housing units that bus commuters currently live in and employment that bus commuters currently hold when calculating T_{min} and T_{max}, the above also implies that bus commuters have relatively good quantitative jobs–housing balance. This may be associated with the legacy of *Danwei* (that is, a work unit that offers both housing and employment opportunities for employees in a compound) (Wang and Chai, 2009). Liu and Lu (2012) reported that there may be many empty homes in Beijing. But the TPLP data we derived from the swipecard data deal only with individuals associated with real origins and destinations. Thus we are not sure how empty homes, if any, might affect local bus users' commuting efficiency. However, if there were empty homes, they would affect the jobs–housing balance in individual districts or zones, which could potentially affect commuting efficiency: that is, everything all else being equal, empty homes in one zone may mean that workers are forced to search for an alternative home further away from their employment destination in a greater geography and reside further away from their workplaces than otherwise.

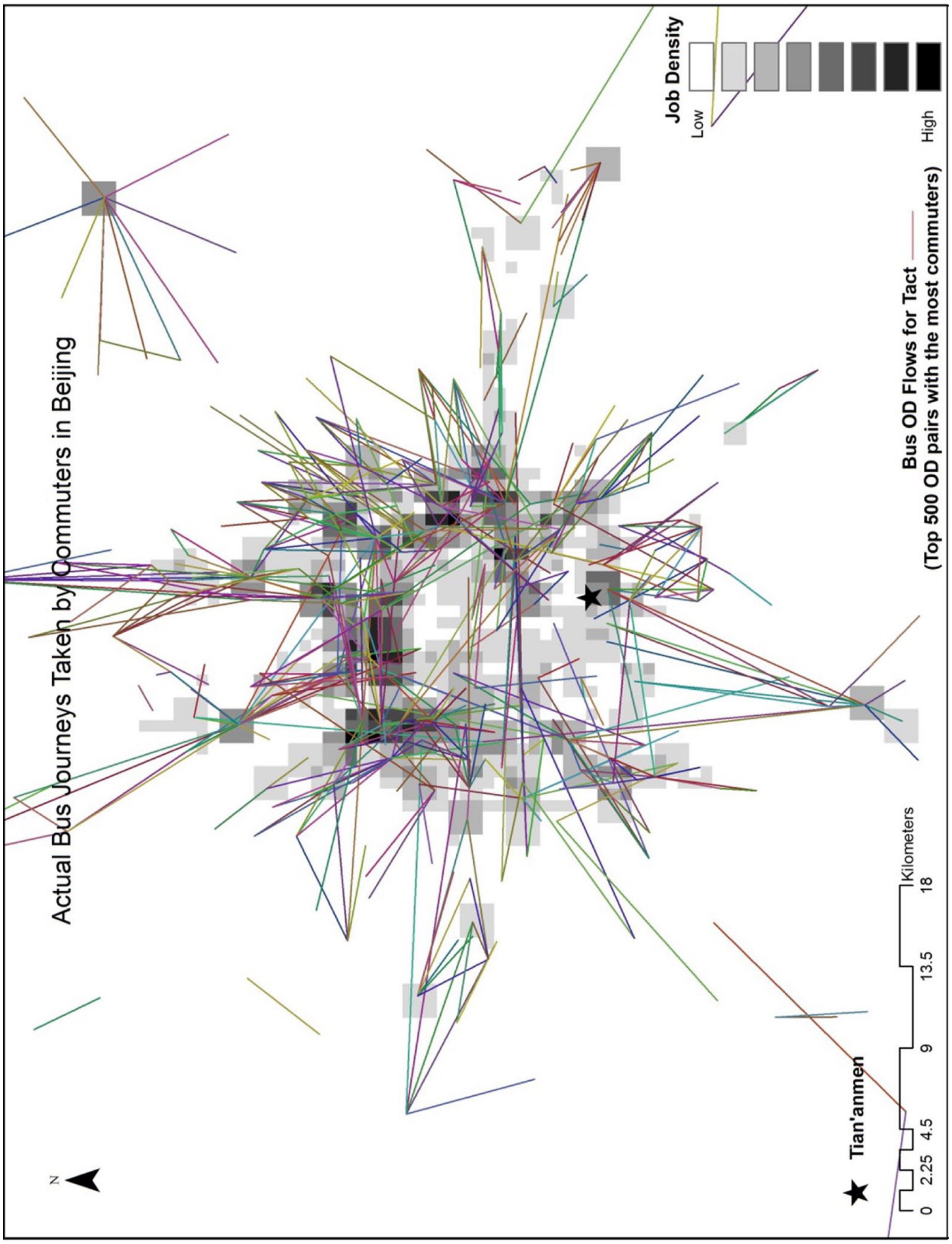

Figure 1. [In colour online.]

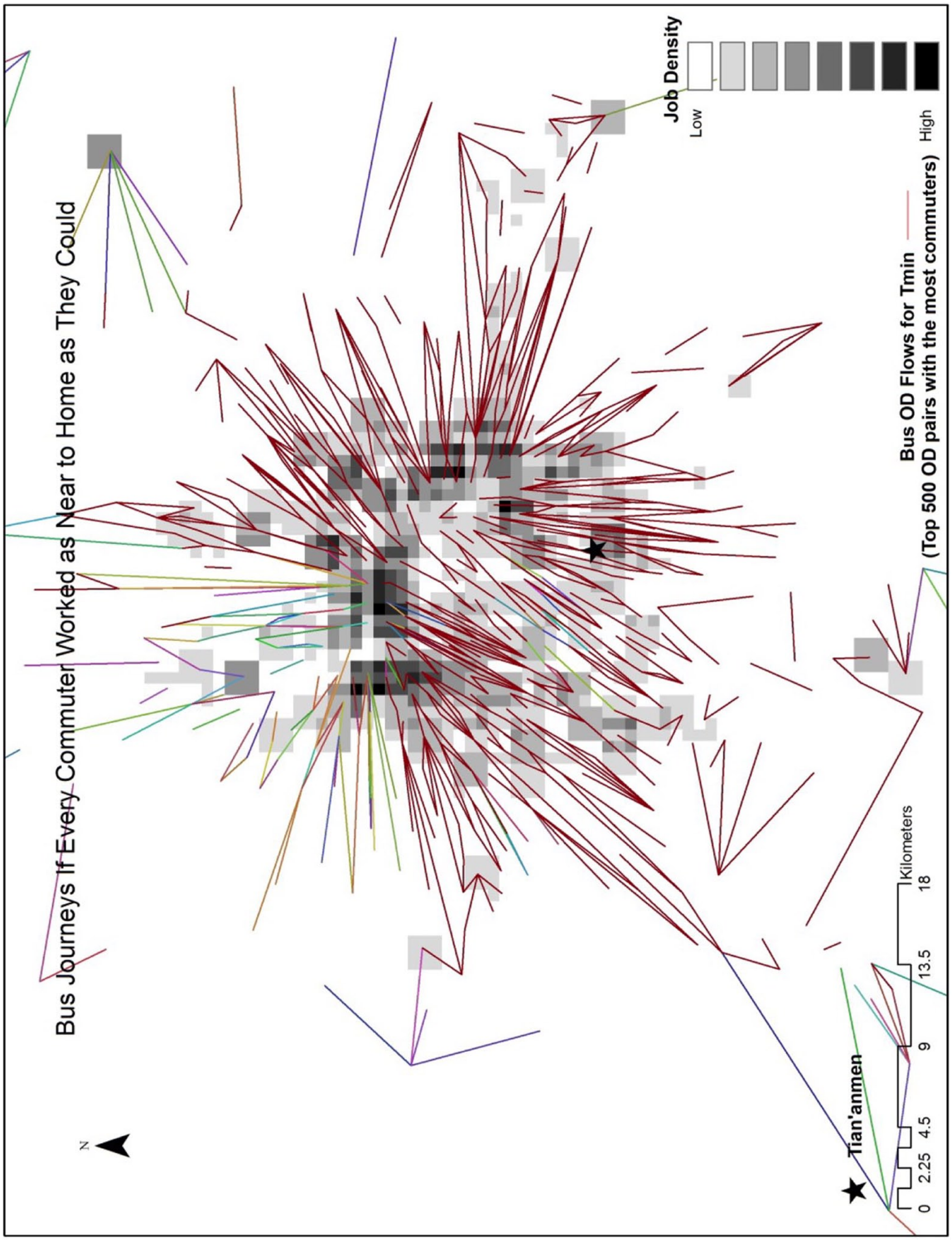

Figure 2. [In colour online.]

Overall, our graphical maps of key OD movements are an innovative approach to demonstrating flows of actual travel patterns as well as those associated with the minimum solution of the TPLP. In this sense they are a useful addition to aid with the interpretation of results emerging via the excess commuting framework. They demonstrate spatial variations in flow patterns associated with T_{min} and T_{act} and provide useful insights into the geography of transport flows associated with these solutions which are otherwise lost in previous studies of the same nature.

Jiangping Zhou, Department of Community and Regional Planning, College of Design, Iowa State University; e-mail: zjp@iastate.edu

Enda Murphy, School of Geography, Planning and Environmental Policy, University College Dublin; e-mail: enda.murphy@ucd.ie

Ying Long, Beijing City Planning Institute; e-mail: longying1980@gmail.com

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Software: TransCAD 5.0; ArcGIS 10.2 (http://www.caliper.com/TransCAD/GeographicAnalysis.htm#.UtBR55L2Z8E; http://www.esri.com/software/arcgis/arcgis-for-desktop/whats-coming/features)