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Jobs–housing imbalance, spatial correlation, and excess commuting

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ABSTRACT

In this paper, we use continuous urban structure instead of zonal model, try to calculate unbiased excess commuting with joint distribution of homes and workplaces developed by Vaughan (1974), and describe the relationship between urban structure and commuting distance explicitly and theoretically for generalized home–workplace assignment pattern. We simplify the quadrivariate distribution model to a model with three important parameters: the spread of homes, the spread of workplaces, and the spatial correlation of homes and workplaces. Then we show that excess commuting and capacity utilization are expressed by the imbalance and the spatial correlation of jobs–housing structure in a theoretical context, moreover it explicitly evaluates targeting US and Japanese/Korean cities.

1. Introduction

Many researchers have challenged the measurement of excess commuting, which is calculated as the difference between the actual and minimum average commuting distances (or times). The latter is obtained by solving the transportation problem using linear programming, with the distribution of homes and workplaces being fixed. Excess commuting may be interpreted as the commuting that can be eliminated by adjusting the locations of homes or workplaces. If the excess is large, the commuting distance (or time) can be drastically reduced by controlled matching of homes and workplaces.

Since White (1988) re-examined the fundamental assumption of cost minimization by applying linear programming, many empirical studies have been carried out in this regard. These studies aim to estimate the excess commuting in sample cities and assess the usefulness of urban policies intended to balance jobs and housing (e.g., Frost et al., 1998; Kim, 1995; Merriman et al., 1995; O'Kelly and Lee, 2005; Small and Song, 1992).

Other studies on excess commuting have provided methodological extensions, especially on the conceptual side. In particular, researchers have introduced the concept of maximum commute, which is calculated using linear programming, to maximize the commuting cost for trips between homes and workplaces (e.g., Boussauw et al., 2011; Charron, 2007; Horner, 2002; Layman and Horner, 2010; Ma and Banister, 2006b; Murphy, 2009; Murphy and Killen, 2011). The theoretical range of the commute, i.e., the difference between the maximum and minimum commutes, is the available commuting potential of a city. The ratio of the actual excess commute and the theoretical commute range is an indicator of commuting efficiency.

However, in the aforementioned studies, the researchers could not decide how the urban structure, i.e., the distribution of homes and workplaces, influences excess commuting. Merriman et al. (1995) carried out a simulation study to show that any structural change toward the decentralization of employment centers would result in an increase in excess commuting.

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Ma and Banister (2007) discussed the relationship between changes in the trip length and urban form, as well as that between changes in the urban form and urban commuting capacity, in relation to the measurement of urban spatial change and excess commuting. However, as pointed out by Horner and Murray (2002), in the abovementioned researches, the modifiable areal unit problem was overlooked. This was because the exact extent of the excess was not determined, which in turn was because of the imperfect measurement methodology used: a zonal approach that yields aggregation biases.

The estimated value of excess commuting is very sensitive to errors in the measurement method, geographical boundaries, and data resolution, as well as to differences in the individual commuting behavior across various cities. For this reason, it is difficult to draw general conclusions from empirical studies when this approach is used.

Very few theoretical studies have been carried out to evaluate the best employee distribution for a desirable urban structure. One reason for this is that it is difficult to express clearly the spatial distribution of homes and workplaces and its relation to commuting. Therefore, in this study, we adopt an analysis method based on Vaughan's (1974) joint distribution of homes and workplaces. Although this model can be used to express such complicated relations at a macrolevel, it has not been used frequently thus far.

This study aims to describe the relationship between urban structure and commuting distance explicitly and theoretically for generalized home and workplace assignment patterns. Accordingly, we try to calculate the unbiased excess commuting by using a joint distribution model of homes and workplaces and a continuous urban structure instead of a zonal model.

Section 2 presents a review of the debate on excess commuting. In Section 3, we describe a model to verify the relation between urban structure and commuting distance. First, we simplify the quadrivariate distribution model (Vaughan, 1974) to a model with three important parameters: (1) spread of homes, (2) spread of workplaces, and (3) the spatial correlation between homes and workplaces. Second, we show that the average commuting distance can be evaluated explicitly by the abovementioned three parameters and that excess commuting and capacity utilization can be theoretically expressed by the imbalance and spatial correlation between the jobs and housing structure. In Section 4, we present our findings along with a comparison of the results obtained for some US and Japanese/Korean cities. Section 5 presents our conclusions.

2. Debate on excess commuting and its extensions

Excess commuting is defined as the difference between the actual and the minimum average commute for a given distribution of homes and workplaces. By measuring excess commuting, we can determine the extent to which commuting distance or time is an inevitable result of the functioning of a vast interconnected economic system and the extent to which it is the result of inefficient matching of homes and workplaces.

Hamilton (1982) carried out a test on excess commuting using a monocentric model in which the workers were assumed to be distributed according to a Clark-type model. He concluded that for several US cities, the excess was 80% or more of the actual commuting distance. He focused on the fact that commuters do not necessarily minimize their commuting costs, as is often assumed in models of urban economics.

White (1988) adopted a zonal approach. She divided the targeted area into several zones and calculated the flow using an origin–destination matrix. She derived the minimum average commuting time by solving a transportation problem. After carrying out tests on some US cities, she evaluated the excess to be about 10% criticizing the inability of Hamilton's monocentric model to account for the actual distribution of residences and workplaces, but her method included an aggregation bias. Hamilton (1989) and Small and Song (1992) corrected the bias and found the excess to be more than 60%.

Following Hamilton (1982, 1989) and White's (1988) study on the concept and estimation of excess commuting, many empirical studies have been carried out for different cities. For example, excess commuting in the Tokyo metropolitan area was studied by Merriman et al. (1995). In the zonal approach, the urbanized area within 60 km of the center of Tokyo was divided into 211 jurisdictional zones and the minimum average commuting time was 42 min, whereas the average observed commuting time was 49 min. Thus, the excess was 15%, which was significantly less than the actual figure for US cities. The excess increased to 36% when commuting distance was used instead of commuting time. In US cities, however, the excess was found to be above 60% even when commuting distance was used.

Frost et al. (1998) studied excess commuting in a selection of UK cities. Kim (1995) developed models that predict the commuting distances for two-worker households and estimated the excess commuting in Los Angeles. O'Kelly and Lee (2005) developed a trip distribution model that disaggregates journey-to-work data according to occupation type, in order to estimate actual commutes and to measure the theoretical minimum and maximum commutes via a linear program. They reported variations in the excess commuting and the jobs–housing balance for different occupation types.

Recently, Horner (2010b) also focused various worker groups and looked at the matter that in general the theoretical minimum commute might be overestimated using aggregated data within the measurement of excess commuting. To clarify the error potential in the minimum commute calculation by using disaggregating worker data, several computational calculations were estimated based all possible combinations on the proportional allocation method and random allocation method. Much larger theoretical minimum commutes gained by disaggregating worker data into finer groupings.

Several trials extending or reinterpreting the excess commuting method have been carried out using the transportation optimization problem. The first trial was performed by Black and Katakos (1987). They considered the urban spatial structure for which the commute is maximized by using an optimization method; this method is equivalent to that proposed in previous studies on excess commuting. To classify different urban structures, they calculated an *urban consolidation index*, which is defined as the ratio of the minimum and maximum commuting distances for a given city.