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Mobility potential as a window to explore social capital in urban systems

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Extended Abstract

One of the definitions of social capital is the strength of an individual's social network and community [1]. Thus social capital involves various types of human interaction, including human mobility. Numerous aspects of society encounter mobility, such as commuting, shopping, dining, and recreation, and they all come down to socioeconomic properties [2–4]. However, many human mobility models, such as the gravity model [5, 6], describe human mobility with numerical models at a pairwise level, which does not incorporate the landscape of social ties in a local community. In this context, mobility potential [7] provided a new systematic window to investigate the local mobility flow.

The potential is a field theoretically defined in space to explain an object's ability to move. The potential differences in physics mathematically determine the motions of numerous physical forces in time. Likewise, the mobility potential difference describes how local mobility flow between two areas is aligned in a straight line inside the city (see Fig. 1(a)). In this paper, we calculate the mobility potential in fifty US cities using the SafeGraph dataset [8] from 2018 to 2020. After dividing cities into grids of 2 km by 2 km, we define a mobility vector as $\vec{W}_i = \vec{T}_{ij}/T_i$ for grid i, where T_{ij} is several trips to points of interest (POIs) in the grid j and T_i is the traffic volume of the grid i. Then, we numerically calculate the mobility potential difference between adjacent grids i and j as

$$V_j - V_i = -\vec{W}_i \cdot \vec{r_{ij}}, \tag{1}$$

where V_i is the mobility potential and r_{ij} is the distance between grids i and j. We set the potential of the urban boundary to zero and cumulatively add the potential toward the center multiple times to ensemble them to obtain the final mobility potential [7]. The mobility potential landscapes have minimum values in the urban center (i.e. sink of the human mobility, see Fig. 1(b))

Social capital is an important factor to make society, and members of the society, to function effectively, often measured as the value of public goods, infrastructures, human capital, norms and culture. In the rise of online social interaction platform, we now can measure individuals' social capital with human interaction beyond the aggregated quantities. In this paper, we adopt economic connectedness (EC) as a bridging social capital that describes how people with different socioeconomic statuses (SES) befriend [1, 9]. In that study, EC was well explained with exposure and friending bias which quantify how people befriend individuals in different income levels, and how people prefer high-SES friends beyond exposure, respectively. To go beyond measuring social capital, here we demonstrate that the mobility potential explains the social capital in the level of local mobility flows accounting for local community structure.

The regression model in Table 1 shows that the mobility potential explains neighbor exposure and friending bias with significance. While the mobility potential does not bring significant explanatory power to describe the bridging social capital (EC) in our model, we find

that the mobility potential is associated with both exposure and friending bias, which have a substantial correlation with the EC. In the model, we can find contradictory relations among variables, which may cause the loss of explanatory power in the model. While mobility potential is negatively related to both exposure and friending bias, exposure and friending bias have positive and negative correlations with the EC, respectively. We compare the result including population, which is a fundamental variable to describe mobility attraction, and we find that the significance of the mobility potential is robust. Overall, the regression model indicates that low mobility potential (mobility sink) makes people more exposed to and biased toward befriending high-SES individuals.

Furthermore, the relationship between mobility potential and social capital varies according to the business category of destination places. To show this, we obtained the landscape of the mobility potential for each business category by extracting the visits to POIs in the category. While mobility potential explains exposure and friending bias well, this connection becomes more explanatory in some business categories. For example, the mobility potential explains the public administration sector better, describing the more localized center of mobility. On the contrary, the mobility potential for the retail trade sector does not explain exposure and friending bias well.

In conclusion, we obtained the landscape of the urban mobility potential and related it to social capital including exposure, friending bias, and economic connectedness. From the regression model, we show that mobility potential is correlated indirectly with economic connectedness via exposure and friending bias. Furthermore, we find that the result varies according to the business sector, especially depending on characteristics of the business sector, such as public or private and local or global. We expect our findings will help understand social capital with local mobility flow and solve urban problems such as segregation or inequality.

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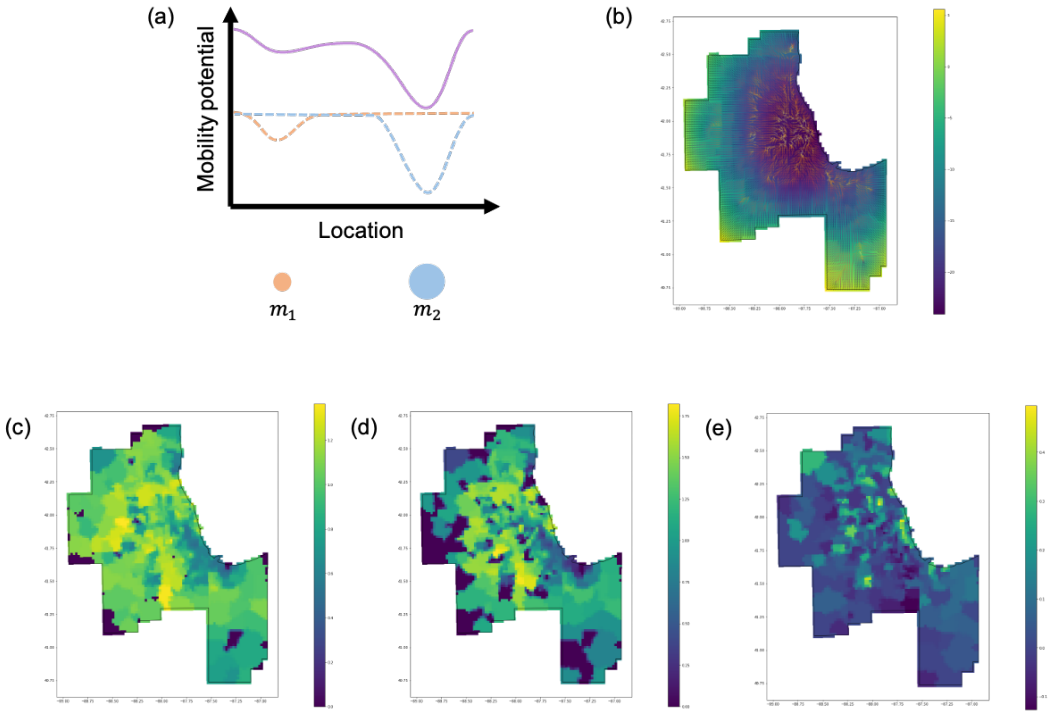

Figure 1: **Mobility potential and social capital in Chicago.** **(a)** The schematic diagram to describe mobility potential. **(b)** Potential field landscape. **(c-e)** Landscapes of (c) exposure, (d) friending bias and (e) economic connectivity.

	Exposure			Friending bias		
	(1)	(2)	(3)	(4)	(5)	(6)
Mobility potential	-0.0055***		-0.0069***	-0.0067***		-0.0065***
	(0.0005)		(0.0005)	(0.0001)		(0.0001)
Population (log)		0.1443***	0.1480***		-0.0276***	-0.0250***
		(0.0040)	(0.0040)		(0.0008)	(0.0007)
Adj. R-squared	0.1058	0.1390	0.1435	0.1103	0.0783	0.1206

Table 1: Regression table for exposure and friending bias