DISENTANGLING SOCIAL CAPITAL – UNDERSTANDING THE EFFECT OF BONDING AND BRIDGING ON URBAN ACTIVITY PARTICIPATION

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ABSTRACT

Social capital is a critical glue for economic and social development in urban areas. Yet, to effectively guide research and practice, there is a need for careful measurement of social capital and how it links to important aspects of urban system functions. This study is aimed at examining the multi-dimensional nature of social capital and the relationship between these dimensions and travel behavior. Prior research has shown connections between stand-alone social capital concepts, such as resources gathered via social networks, with specific aspects of travel behavior. In this work we expand the definition and modeling of social capital to cover separate dimensions, modeled via multiple indicators. Specifically, we make use of data from the Pew Internet Networks and Community Survey to build a Structural Equation Model dividing social capital into two latent dimensions: *bonding* and *bridging* to examine the relationship of both these dimensions with discretionary urban activity participation diversity and frequency. Moreover, broader measures of neighborhood and community engagement are included in the model to explain how such engagement can help with accumulation of social capital. Our results indicate a positive relationship between both social capital dimensions and activity participation. Further, the results also suggest absence of correlation between bonding and bridging capital, strengthening the hypothesis that social capital is multi-dimensional. In terms of explaining the social capital accrual, we find that while community engagement is positively correlated to bridging capital, no evidence was found for a relationship between community engagement and bonding capital. Further, neighborhood engagement was not found to be associated with any of the social capital dimensions. This suggests that individuals predominantly rely on close-knit and stronger relationships for social/emotional support, while instead, community engagement significantly helps in accumulation of bridging capital. The result from the study can be used by policy makers to improve transportation planning, management, and community well-being.

Keywords: Network Capital; Structural Equation Modeling; Bonding Capital; Bridging Capital; Urban Activity Participation

1. INTRODUCTION

The importance of *social capital* in shaping the development and character of urban systems is well known. Social capital can be described as the glue that holds together institutions, maintains a sense of community identity, and governs interactions among people, thereby contributing to economic and social development (Dasgupta and Serageldin, 1999). Social capital is a resource embedded in social relations and it can be "*…accessed and/or mobilized in purposive actions"* Lin (2002). Thereby, social relations encapsulate a *"capital effect"* that facilities flow of information, and affects decisions such as empowering communities and building support for pro-environmental policies in cities (Alvarez et al., 2017; Dean et al., 2016).

Since its conception, social capital has received growing attention and has been studied in a variety of contexts. For example, there is strong evidence that social capital has a positive impact on general health, subjective well-being and quality of life (Hamdan et al., 2014; Nilsson et al., 2006; Yip et al., 2007). Further, it has also been studied in relation to its impact on success/failure of organizations (Nahapiet and Ghoshal, 1998); individual success and income attainment (Boxman et al., 1991); and resilience and accessibility in urban systems (Aldrich, 2017; Aldrich and Meyer, 2015; Östh et al., 2018). There is also growing evidence that social capital is deeply connected with travel, mobility and activity participation, where its association has primarily been studied in two ways: 1) to understand its role in enabling travel and activities (Maness, 2017a, b; Nguyen et al., 2017); and 2) to understand how travel and activities help in the creation of social capital and thus reduce the chances of social exclusion (Coutts et al., 2018; Schwanen et al., 2015).

Despite the central role of social capital in urban development analysis, a gulf between its theoretical understanding and the ways it has been measured in empirical work has persisted (Paxton, 1999). Though the initial use of social capital was qualitative in nature, a more quantitative approach has gained momentum in the last few decades (Borgatti et al., 1998; Lin, 1999). An important insight that has emerged is the existence of multiple dimensions of social capital. There is mounting evidence that this multi-dimensionality must be recognized to have a complete understanding of its impact on various phenomena (Nahapiet and Ghoshal, 1998; Neira et al., 2019; Putnam, 2000; Van Der Gaag and Snijders, 2005).

In light of the above discussion, the goal of this study is to advance our understanding of the role of social capital in underpinning urban travel and activity participation to support sustainable urban systems via three main research objectives.

First, we examine and identify separate social capital dimensions that are, in turn, tied to mobility and activity participation. Though there are numerous existing efforts to quantify facets of social capital on some aspect of travel, most work has taken single indicators as evidence for social capital effects and to investigate its relationships with travel decisions. In this paper we seek to take a broader view and provide a more robust modeling approach by examining how social capital is defined, measured, and explained in relation to travel behavior.

Second, building on the evidence from other fields that social capital is multi-dimensional, we use measurement models to identify and analyze two social capital dimensions, namely '*bonding social capital*' and *'bridging social capital'*. As noted above, previous travel related studies have relied on single question/indicator constructs such as receiving help for tasks like childcare or housekeeping etc. (Calastri et al., 2018; Di Ciommo et al., 2014), or the number of ties in alters' personal social network (Maness, 2017a) to measure social capital[1]. While the use of single indicators does provide valuable information, this potentially leads to measurement errors and loss of explanatory power. Here, we take the view that the measurement of multiple social capital dimensions requires the use of multiple indicators to reliably understand the relationship both among dimensions and its connections to travel behavior.

[1] The terms *ego* and *alter* comes from the egocentric view of the social network analysis domain where social network around a particular social actor is of interest. The central social actor is called *ego* and the actors connected to the ego are called *alters*. The alternative view is where the analysis is done on entire network of ties between the actors. For more information on egocentric network analysis, readers are referred to Crossley et al. (2015).

Third, we use a structural equation model to gain insights on how different social capital dimensions impact activity behavior, both separately and exploring synergies.

Drawing on data from 1,434 respondents in the Pew Internet Networks and Community Survey (Hampton et al., 2009), we build a structural equation model (SEM) dividing social capital into two dimensions: bonding and bridging social capital and then study the relationship of these dimensions with discretionary urban activity participation *diversity* and *frequency*. Moreover, we also include neighborhood and community engagement as two separate latent variables in the model to explain how these are associated with the accumulation of different social capital dimensions.

The proposed framework reveals the differential impact of bridging and bonding social capital on activity participation frequency and diversity. The model also highlights the role of neighborhood/community participation in supporting social capital accrual, which will potentially have wide-ranging implications for transportation planning, management, and community well-being.

The remainder of the paper is structured as follows. Section 2 presents a brief review of the literature on social capital definition, multi-dimensionality, measurement, and linkage to mobility. Section 3 describes the available data and mathematical details of the SEM framework, followed by our view of social capital in this paper and the research hypotheses linking different dimensions of social capital with urban activity frequency and diversity, along with a conceptual path diagram for the structural equation model in Section 4. Section 5 presents the SEM estimation results, followed by conclusions and policy implications from this study and avenues for future research in Section 6.

2. LITERATURE REVIEW

In this section, we summarize the literature on three relevant aspects of social capital: 1) social capital definition and multi-dimensionality; 2) linkage between social capital and mobility or activity participation; and 3) social capital measurement.

2.1. SOCIAL CAPITAL DEFINITION

There is lingering interpretive fuzziness in defining social capital in the literature. Social capital is often termed as a polysemic and is a contested concept with a variety of different forms and definitions (Daly and Silver, 2008; Schwanen et al., 2015; Woolcock, 2010). Field (2008) summarizes the theory of social capital in two words – '*relationships matter*' and Crossley (2008) points out that most definitions of social capital revolve around how social networks act as a resource for its members.

Two main ideas related to social capital exist in the literature (Crossley et al., 2015; Field, 2008) namely: 1) social capital as access to resources (Bourdieu, 1986; Lin, 2002), 2) social capital as social cohesion and *brokerage* across *structural holes* (Coleman, 1988; Putnam, 2000).

Social capital as access to resources originates from the work of Bourdieu (1986), for whom social capital is one of four forms of unevenly distributed capitals in the society (the other three being financial, cultural and symbolic capitals). In this view of social capital, connections provide direct or indirect access to other forms of capital and hence are of value. For Bourdieu, only ties that provide access to other forms of capital count in the analysis of social capital (Crossley et al., 2015). Lin (2002) takes a similar view, adds that ties between low and high-status individuals (i.e. ties between individuals with difference in status) tend to be weak, compared to in-group ties, which tend to be stronger. This is also in line with the theory of homophily which postulates that similar individuals are more likely to be connected to each other (McPherson et al., 2001; Monge et al., 2003; Yuan and Gay, 2006).

Putnam (2000)'s view of social capital differs from that of Bourdieu's. While Bourdieu focuses on ties with higher status individuals as access to resources, Putnam *also* emphasizes the value of strongly bonded, closely knit networks. Putnam makes two important distinctions in terms of social capital. Firstly, he refers to *bonding* capital, which corresponds to a network of closely knit individuals and favors both the individual and their group. Bonding capital cultivates trust, cooperation and mutual support thereby shifting the focus from an individualistic view to a more collective analysis perspective. Coleman (1988) argues

that actors in such close-knit networks have an incentive to cooperate to avoid reputation damage or exclusion.

A second distinction is of *bridging* social capital, which refers to the ties across groups, which tend to result in the flow of novel information and resources. Bridging helps prevent social segregation of close-knit communities (Putnam, 2000). The concept of bridging social capital echoes the popular work on '*strength of week ties*' by Granovetter (1973) and the work on structural holes and brokerage by Burt (1992).

From the discussion presented above it emerges that there are two main social capital dimensions, first related to the stronger ties between individuals (i.e. bonding) who tend to be similar to each other following the principle of homophily, *versus* weaker ties between individuals who are different from each other and hence bring novel resources (i.e. bridging).

While there are several other studies that point to the likely existence of distinct social capital dimensions (Nahapiet and Ghoshal, 1998; Neira et al., 2019; Van Der Gaag and Snijders, 2005; Vilhelmsdóttir, 2012), much of this work is based largely on the social capital conception by Bourdieu/Putnam/Lin/Coleman/Burt and the identified dimensions are closely related to bonding and bridging capital. Further, several studies already identify bonding and bridging as two dimensions of social capital as (Gittell and Vidal, 1998; Nicholas et al., 2018; Putnam, 2000; Stanley et al., 2019; Stone et al., 2003). Hence, in this study, we focus our attention on the broadly defined *bonding* and *bridging* dimensions of social capital. Further discussion on this is presented in Section 4.

2.2. LINKS TO TRAVEL, MOBILITY AND ACTIVITY ENGAGEMENT

There is growing evidence of the association between social capital and mobility or activity participation. **Table 1** provides a summary of existing literature in this context. The majority of the existing literature is focused at understanding the role of individual social network in generally travel or travel related choices. For example, Sadri et al. (2015) argue that joint travel or activity participation intrinsically occurs within a social context, and thereby social networks data is likely to contribute to understanding joint travel. Di Ciommo et al. (2014) examined the role of social capital in the context of modal shift after opening of a new metro train station and found that including social capital variables improved the prediction performance in a mode choice model. They argue that social capital variables used in their study capture network resources (and trip generating capacity), which influence time availability constraints of travelers. Maness (2017a) focuses on weak social networks in his study and argue the weak social network ties increase the diversity of information available to an individual about activities, thereby impacting travel. Further, Maness (2017b) presents a theory of strong and weak ties and their relationship with leisure activity participation, arguing that strong ties are related to leisure activity participation due to individual tendency to seek social safety.

Other work has studied the opposite effect, where social capital is *generated* as a result of travel. For example, Schwanen et al. (2015) proposed that social exclusion and disadvantage can be rethought from a social capital lens and argued that it could reduce or enhance social exclusion and transport disadvantage. Coutts et al. (2018) studied the commuting behavior of school children in Toronto, Canada and found that longer commute time and more use of public transit led to discouragement from attending school, and participation in extra-curricular activities and hence impacted long-term social capital growth.

In this study, we take the view that different dimensions of social capital are related to travel; however, the impact of these dimensions may not be homogenous. Further, while understanding social capital generation as a function of travel is of interest, we take the view that it is a rather longer-term phenomenon. Hence our modeling explores separate social capital dimensions and assumes the correlation to run in a single direction.

2.3. SOCIAL CAPITAL MEASUREMENT

In transportation research (and social network literature, in general), a variety of approaches have been proposed and used to measure social capital including social network measures like size/degree (calculated as the number of alters that an ego is connected to in a personal social network), density (proportion of pairs

of alters that are connected), heterogeneity (variety of alters with respect to relevant dimensions like gender, age, race etc.), closeness (total graph theoretic distance from ego to all others in the network), and betweenness (number of times an ego falls along the shortest path between two other actors) (Borgatti et al., 1998; Burt, 2009; Freeman, 1978). Researchers have also devised other advanced methods to measure social capital like position generator (Lin and Dumin, 1986) and resource generator (Van Der Gaag and Snijders, 2005). **Table 1** also summarizes the measures of social capital and its dimensions typically used in the transportation literature. The measures used in these studies are diverse, including receiving help for tasks like childcare, housekeeping etc., number of ties in ego's personal social network, occupational diversity etc. In general, these indicators can be broadly divided into the following four categories:

- Personal social network-based measures like network size, density, alter attributes, spatial proximity to alters, and homophily
- Social network resources related measures like network diversity, and occupational prestige
- Civic/Community engagement related measures like whether a respondent engages in community participation or service
- Neighborhood engagement related measures like connection with neighbors, whether the respondent received help from neighbors on issues like household chores, lending money.

Importantly, most studies use these indicators as stand-alone measures, or do not recognize the multi-dimensionality of social capital. Only few prior studies recognize the multi-dimensionality of social capital (Liu et al., 2020; Nicholas et al., 2018; Stanley et al., 2019; Wang et al., 2021), but do not use multiple indicators to measure these dimensions. We anchor the measurement of different dimensions of social capital in the existing literature and a detailed discussion on this is provided in section 4.2.

TABLE 1: Review of the literature on use of social capital concepts in transportation related studies

Study	Travel and Social Capital Context	Social Capital Indicators Used	Main Findings
Carrasco and Cid-Aguayo (2012)	To assess role of transport in social support	• Communication pattern between alters and ego via various modes • Whether individual have received/given advice/money etc. from others.	• Argues that having a car at home does not necessarily imply difference in social capital
Chang (2020)	To understand the effect of building environment and social features like social capital and cohesion on outdoor activity participation of older adults.	Neighborhood social capital: • People in this neighborhood share similar values • I would seek personal advice from my neighborhood • I would attend a neighborhood organization Neighborhood social cohesion • People around here are willing to help their neighbor • People in this neighborhood feel connected to one another • People in this neighborhood can be trusted • People in this neighborhood generally get along with one another	• Found that participants with higher levels of neighborhood social capital participated in more outdoor activities but no support was found for social cohesion impacting outdoor activity participation
Coutts et al. (2018)	To study influence of commute on post-secondary student's social capital	• Whether commute discourage students from coming to campus, • If student pick courses based on commute • If commute discourage student from participating in extra-curricular events	• Student with higher commute time and those who used public transit have higher level of discouragement
Di Ciommo et al. (2014)	Modal shift after opening of new transit stations. Social capital as proxy for trip generating capacity and network resources	• Receiving some help for child-care or for housekeeping • Voluntary participation in some non-compulsory meetings or activities	• Social capital variables improved the fit for mode choice models • Shift was higher for people receiving help than for people participating in voluntary activities
Isbel and Berry (2016)	To investigate the role of transportation in accessing activities that contribute to connectedness and well-being of older people.	• Community participation • Personal social cohesion	• Conceptualize driving a vehicle is important in engagement in social activities and is linked to well-being.

Kamruzzaman et al. (2014)	To analyze the patterns of social capital associated with transit-oriented development	• Trust and reciprocity • Connections with neighbors	• Found that individuals living in transit oriented developed regions had higher social capital than others.
Liu et al. (2020)	To understand outdoor activity patterns of older adults to help in development of tailored physical activity programs.	Social Capital • How many people in your neighborhood do you know well enough to talk with? Social Cohesion • How do you rate the social relations with your neighbors?	• Older adults reporting low social capital more likely to belong to clusters representing low frequency/short duration and high frequency leisure-time physical activity patterns. • Older adults reporting high social cohesion less likely to belong to clustering representing long duration leisure-time physical activity patterns.
Liu et al. (2021)	To examine the association between neighborhood characteristics and frequency of type-specific outdoor activities	Social capital (5-point likert scale): • How many people in their neighborhood the respondents know well enough to talk? Social cohesion (5-point likert scale): How do you rate the social relations with your neighbors in five categories from very poor to very good	• Social capital positively correlated with frequency in leisure walking and skill-based leisure activities
Love et al. (2020)	To understand the effectiveness of three intervention programs to change travel behavior of children to/from schools. Special focus on how social capital effects children's independent mobility.	• Child plays in street often • School is close by • Child has friends in area • Home location is a good place for children to grow up • Local organizations involved on school site • Number of businesses involved in school • Parents attend meetings regularly • Intervention programs assist community to change	• Study found the degree of connectedness of the school and the individuals to have most impact on effectiveness of intervention program
Maness (2017a)	To use position generator to measure network resources and its impact on predicting activity selection	• Core network size • Homophily • Spatial proximity • Tie dispersion • Alter attributes • Network diversity	• Network diversity measures calculated using position generation were better predictor of activity participation than measures from name generator

		• Upper reachability	
Maness (2017b)	Present a theory to understand how strong social ties and diversity of weak social ties are associated with difference in leisure activity frequency and variety	• Network size • Upper reachability of weak network calculated based on status levels associated with each alter in the weak ties network	• Positive association between measures of network capital and leisure activity frequency and variety.
Nguyen et al. (2017)	To study the role of social capital on trip generation and destination choice for discretionary activities	• Number of close social contacts in the region where the respondent lives • Number of acquaintances inside and outside the region where respondent lives • Participation in community service	• Social capital associated with both trip generation and trip destination choice for discretionary activities
Nicholas et al. (2018)	To understand the relation between social capital and impact of long-distance commuting on a regional community	• Studied two dimensions of social capital: bonding and bridging • Strength of social networks, neighborhood social cohesions • Bridging social cohesion	• Results indicate negative relationship between long-distance commuting and subjective well-being but no mediating role of social capital
Parady et al. (2019)	To understand connection between social networks, social interactions, and out-of-home leisure activity	• Network density • Network size • Club membership	• Positive association between network size/club membership and leisure activity • Negative association between network density and leisure activity
Sadri et al. (2015)	Role of social networks in joint trip frequency between alters and egos.	• Network density • Homophily • Heterogeneity	• Found that personal network measures and heterogeneity among alter-ego ties had significant impact on joint-trip making process.
Schwanen et al. (2015)	To understand link between social exclusion and transport disadvantage via social capital	---	• Suggest that social capital is Janus-faced and is a medium of both effectuation of progressive social change and the creation of social inequalities.
Stanley et al. (2019)	• To understand role of mobility in promoting social inclusion • Role of bridging social capital in reducing the risk of social exclusion	• Frequency of contact with alters	• Bridging social capital negatively associated with risk of social exclusion
Stroope (2021)	To understand the relationship between active transportation behavior and three indices of social capital	Community participation	• Found active transportation participation to be associated with

		• Written a letter or made a telephone call to influence policy issue • Attended an event that provided information about community services • Attended a meeting to pressure for city or county policy change Sense of community • I can get what I need in this neighborhood • This neighborhood helps me fulfill my needs • I feel I belong in this neighborhood	community participation but not with sense of community
Utsunomiya (2016)	To understand role of local public transportation in social capital	• Participation in regional festivals, NGOs etc. • Trust index • Network index	• Found that the network and participation indices standing for social capital to be positively correlated with level of local bus services
Wang et al. (2021)	Identification of determinants of low carbon travel by incorporating social relations information	Structural social capital (strong ties) • Intimacy level with head of household Cognitive social capital • Head of household's low-carbon preference • Family reciprocity • Community of low carbon atmosphere	• Structural social capital effects travel behavior by influencing resources available via the head of household • In terms of cognitive social capital, head of household's preferences also impact low carbon travel preferences of household members.
-- No indicators of social capital used or mentioned in the study			

3. DATA AND METHODOLOGY

3.1. DATA

We make use of data from the Pew Internet Networks and Community Survey (Hampton et al., 2009), which was conducted in 2008 in the United States. The survey was interviewer administered to a US national sample via telephone with a response rate of ~22%. Potential respondents were contacted as many as 10 times, were offered post-paid cash incentives for participation. The survey was targeted at adults over 18 years of age and consisted of the following 7 modules:

- *Internet usage:* this module asked respondents about their internet usage behavior including frequency of internet use at home and at work, type of internet connection, engagement in instant messaging, online blogging, use of social network websites, etc.
- *Name generator and interpreter:* consisted of two questions designed to gather information on names of alters: a) with whom the ego (respondent) discussed important matters in the last 6 months and b) who were especially significant in the ego's life. The number of names were restricted to a maximum of 5 in each case (10 total). In addition, respondents were asked various information about their alters including gender, length of ego's relationship with the alters, frequency of contact with alters via face-to-face conversation, phone, email, geographic distance between the home locations of the ego and alters, alters' race, and political inclination. Note that the name generator is a popular technique to delineate characteristics and structure of ego-centric networks and has been used by many studies in the past several decades (Burt, 1984; Kowald and Axhausen, 2014).
- *Position generator:* this module collected information on resources embedded in the respondent's social network (Lin, 2001). Specifically, respondents were asked whether he/she knew anyone active in each of the following 22 occupations: a nurse, a farmer, a lawyer, a middle school teacher, a full-time babysitter, a janitor, a personnel manager, a hair dresser, a bookkeeper, a production manager, an operator in a factory, a computer programmer, a taxi driver, a professor, a policeman, a chief executive officer in a large company, a writer, an administrative assistant in a large company, a security guard, a receptionist, a congressman, or a hotel bell boy.
- *Neighborhood involvement:* This module inquired about the type of housing, dwelling duration, to what extent the respondent knows the names of his/her neighbors, frequency of conversation between the respondent and the neighbors via various modes of conversation, and whether the respondent has received or given help to his/her neighbors in form of listening to problems, help with household chores, caring for the family members, or financial assistance.
- *Community involvement:* a module focused on assessing respondent community involvement and the role of the internet in helping the respondents become more involved in community groups. Specifically, the survey inquired about involvement in any community group, local sports league, youth group, religious group like a church or any other social club.
- *Public spaces:* this module gathered information on the respondents' frequency and diversity of activity participation in public places. Specifically, the respondents were asked the number of times they visited a café or a coffee shop, a religious center, a public library, a restaurant (fast food or any other type), a community center, a public park or plaza, or a bar in the last month.
- *Personal and household characteristics* module asked the respondents information on various personal and household characteristics such as age, gender, race, household income, number of adults and children in the household, education, employment, and marital status.

The dataset from the survey consisted of 2,512 observations in total with several observations having missing variables, which is typical in large social networks related surveys. After cleaning the data to remove observations with missing relevant variables, we were left with a total of 1,434 complete observations for the analysis. **Table 2** presents the descriptive statistics of the personal and household characteristic and social activity participation behavior of the respondents.

TABLE 2: Descriptive statistics of the personal, household, and social activity participation characteristics of the respondents

Variable		Statistic
Gender	Male	47.8 %
	Female	52.2 %
Income	Less than $10,000	6.1 %
	$10,000 - $20,000	9.2 %
	$20,000 - $30,000	12.8 %
	$30,000 - $40,000	11.4 %
	$40,000 - $50,000	11.2 %
	$50,000 - $75,000	16.3 %
	$75,000 - $100,000	14.2 %
	$100,000 or more	18.8 %
Race/Ethnicity	White	80.4 %
	Black or African American	11.6 %
	Asian or Pacific Islander	2.2 %
	Mixed race	1.9 %
	Native American/American India	1.1 %
	Other	1.5 %
	Don't know / Refused	1.3 %
Employment Status	Employed full-time	51.8 %
	Employment part-time	11.4 %
	Retired	18.9 %
	Not employed	13.7 %
	Disabled	2.7 %
	Student	0.7 %
	Other	0.7 %
Education Status	None, or Grade 1-8	1.7 %
	High school incomplete	5.0 %
	High school graduate	29.9 %
	Technical, trade or vocational school	2.4 %
	Some college, no 4-year degree	24.5 %
	College graduate	21.3 %
	Post-graduate	15.1 %
Age	Less than 25 years	10.7 %
	25-39 years	23.8 %
	40-59 years	40.8 %
	60-75 years	19.9 %
	More than 75 years	4.9 %
Marital Status	Married	51.9 %
	Living with a partner	6.8 %
	Divorced	11.2 %
	Separated	2.2 %
	Widowed	7.7 %
	Never been married	18.6 %
	Single	1.3 %
	Don't know/Refused	0.4 %
No. of children in the household	None	62.1 %
	One	14.8 %
	Two	14.3 %
	Three or more	8.9 %
No. of adults in the household	One	25.0 %
	Two	54.7 %
	Three or more	20.3 %

Social Activity diversity	Mean	4.0
	Median	4
	S.D.	1.7
Social Activity frequency	Mean	13.9
	Median	13
	S.D.	8.03

S.D.: Standard Deviation

Note that the social activity diversity variable was defined as the total number of public places (out of a total of 6), as mentioned in the public space module, visited at least once in the last month. Further, the social activity frequency variable takes the number of times each of the six places were visited in the last month and counts the total number of social / leisure trips made in the last month.

3.2. STRUCTURAL EQUATION MODELING

We make use of a generalized structural equation modeling (SEM) framework (Muthén, 1984) in this study to understand the multi-dimensional nature of social capital and its relationship with social activity participation behavior. Structural equation models are multivariate regression structures which allow reciprocal, direct and indirect relationships among variables. SEMs also allow estimation of latent variables, which are measured through various observable indicators (Asgari et al., 2016). A generalized SEM consists of two components: 1) a *structural* model that captures the inter-relationship between various latent variables; 2) a *measurement* model that captures the relationship between continuous latent variables and their observed indicators. The structural component of an SEM can be written as:

$$\eta = \alpha + \mathrm{B}\eta + \epsilon \quad (1)$$

where

η = vector of latent variables
α = vector of intercepts
B = matrix of parameters governing the relationship between latent variables
ϵ = vector of error terms associated with the latent variables

The measurement component can take two different forms depending upon whether the observed indicators are considered categorical or continuous. For categorical indicators, the measurement model is specified using the following equation:

$$y^* = \nu + \Lambda\eta + \mu \quad (2)$$

where

y^* = a vector of continuous latent variables or propensity function
ν = a vector of intercepts
Λ = a factor loading matrix
μ = vector of measurement errors

The relationship between observed indicator value y and y^* is expressed using the following mapping function:

$$\tilde{y} = \begin{cases} 0 & \text{if} \quad y^* \le \psi_1 \\ j & \text{if} \quad \psi_{j-1} < y^* \le \psi_j \; \forall \, j \in (2, \dots, J-1) \\ J & \text{if} \quad \psi_{J-1} \le y^* \end{cases} \quad (3)$$

where

J = number of ordered categories in a categorical indicator
ψ_j = threshold parameter dividing y^* in various categories

For continuous indicators, the relationship between the indicators and the latent variables is written as:

$$y = \nu + \Lambda\eta + \mu \quad (4)$$

We make use of the "*lavaan*" package in R programming language to estimate the SEM model (Rosseel, 2012), which uses the popular mean and variance adjusted weighted least square (WLSMV)

procedure in cases where categorical indicators are involved (Olsson et al., 2000; Suh, 2015). For more information on structural equation modeling, readers are referred to Kline (2015).

4. SOCIAL CAPITAL DIMENSIONS AND RESEARCH HYPOTHESES

In this study, we measure social capital as a property of an individual rather than group based. In Putnam's definition, while social capital associated with a person is also associated with the group they belong to, we measure social capital associated with an individual since the scope of this study is related to understanding individual travel behavior. While several different dimensions of social capital exist in the literature, we adopt two broadly defined dimensions of bonding (network of closely tied individuals) and bridging (ties between heterogeneous individuals). These two dimensions offer the advantage of encompassing most niche dimensions identified in other studies. To formally define, *bonding capital* is described as the capital gathered from close contacts, people who are similar in characteristics and ideologies (Nicholas et al., 2018), and helps people 'get by' in life (Stone et al., 2003). *Bridging social capital* involves overlapping networks and helps gain access to resources and opportunities that do not exist in one's own network (Stone et al., 2003). Bridging capital is described to cover networks between heterogeneous individuals (Nicholas et al., 2018).

Regarding the ties between social capital and travel, here we take the view that urban travel activity participation is a function of social capital, i.e., social capital helps generate travel. The opposite causation, where social capital may be facilitated by travel activity, may also be in play, but here we take the view that this is rather a long-term phenomenon and is beyond the scope of this study. Further, we also emphasize that the travel discussed in this study is not limited to joint trip-making (i.e. travel that takes place with other individuals), since solo travel can still be rooted in social networks.

Regarding the impact of different dimensions of social capital on travel, we take the view that both of the identified dimensions (i.e. bonding and bridging) impact leisure/discretionary travel and activity participation but the impact these dimensions have on travel are differential. In the context of bonding capital, we propose that individuals that score high on bonding (i.e. those embedded in a more a tightly knit network) have a higher number of social constraints to abide by and thus are compelled to make more discretionary travel to avoid network contraction and loss of social safety or support (Rubin & Bertolini 2016). In the context of bridging capital, we argue that individuals with higher bridging social capital make more discretionary travel since they have access to novel resources and information through their social connections. This includes access to a mobility tool, information regarding a newly opened restaurant, or access to membership of a club etc., which otherwise would not have available.

Further, we assume that the social capital dimensions are latent in nature and cannot be measured correctly using a single indicator. Hence, a conceptual SEM framework is presented, where we use multiple indicators to measure the social capital dimensions and their association with urban activity participation. An important note here is that while several studies have used community and neighborhood participation as an indicator of social capital, two major issues arise with this approach. First, neighborhood or community participation propensities of an individual are latent in nature and need multiple indicators to provide a reliable measurement. Second, even when multiple indicators are used, neighborhood or community engagement should not be taken as a proxy for social capital, rather it is a way to accumulate social capital. This distinction is important to fully characterize social capital and its relationship with travel. In section 4.1 and 4.2, we present the specific research hypotheses that we test in this study using a SEM framework and the indicators used to measure different latent variables involved.

4.1. RESEARCH HYPOTHESES

Figure 1 presents the conceptual framework used in the structural equation model relating social capital dimensions and urban activity participation. In the framework, we test four different hypotheses as presented below:

H1. *Social capital is latent and multi-dimensional in nature and is separable into two main dimensions: bonding and bridging.* To test this hypothesis, we have incorporated two dimensions of social capital

as different latent variables measured via three indicators each. Further, we also allow the estimation of error covariance between these two dimensions, to examine whether these dimensions are truly separable.

H2. *Neighborhood and community engagement are latent variables and require multiple indicators for measurement. Further, these engagement dimensions help to accumulate (strengthen) different social capital dimensions.* To test this hypothesis, we consider neighborhood and community engagement as two separate latent variables measured via multiple indicators. Further, we specify path coefficients linking each engagement dimension to the social capital dimensions. Thereby we capture the accumulation of social capital via neighborhood and community engagement. Note here that we again allow error covariance between the two constructs to examine their connection.

H3. *Different dimensions of social capital have significant and differential impact on urban activity participation frequency and diversity.* To test this hypothesis, we allow paths from the two social capital dimensions to different urban activity diversity and frequency measures. Further, given that urban activity frequency and diversity are potentially correlated, we allow error covariance between these two variables as well.

H4. *Part of the variation in urban activity frequency and diversity can be explained by individuals' socio-demographic information.* We formally test this hypothesis by allowing paths from individuals' socio-demographic characteristics to urban activity frequency and diversity variables. The joint control for social capital and socio-demographic variables allows us to gain a more cohesive image of the relative importance of each category of factors. The socio-demographic variables included in the model are respondents' gender, household income, household size, age, employment status, education level status.

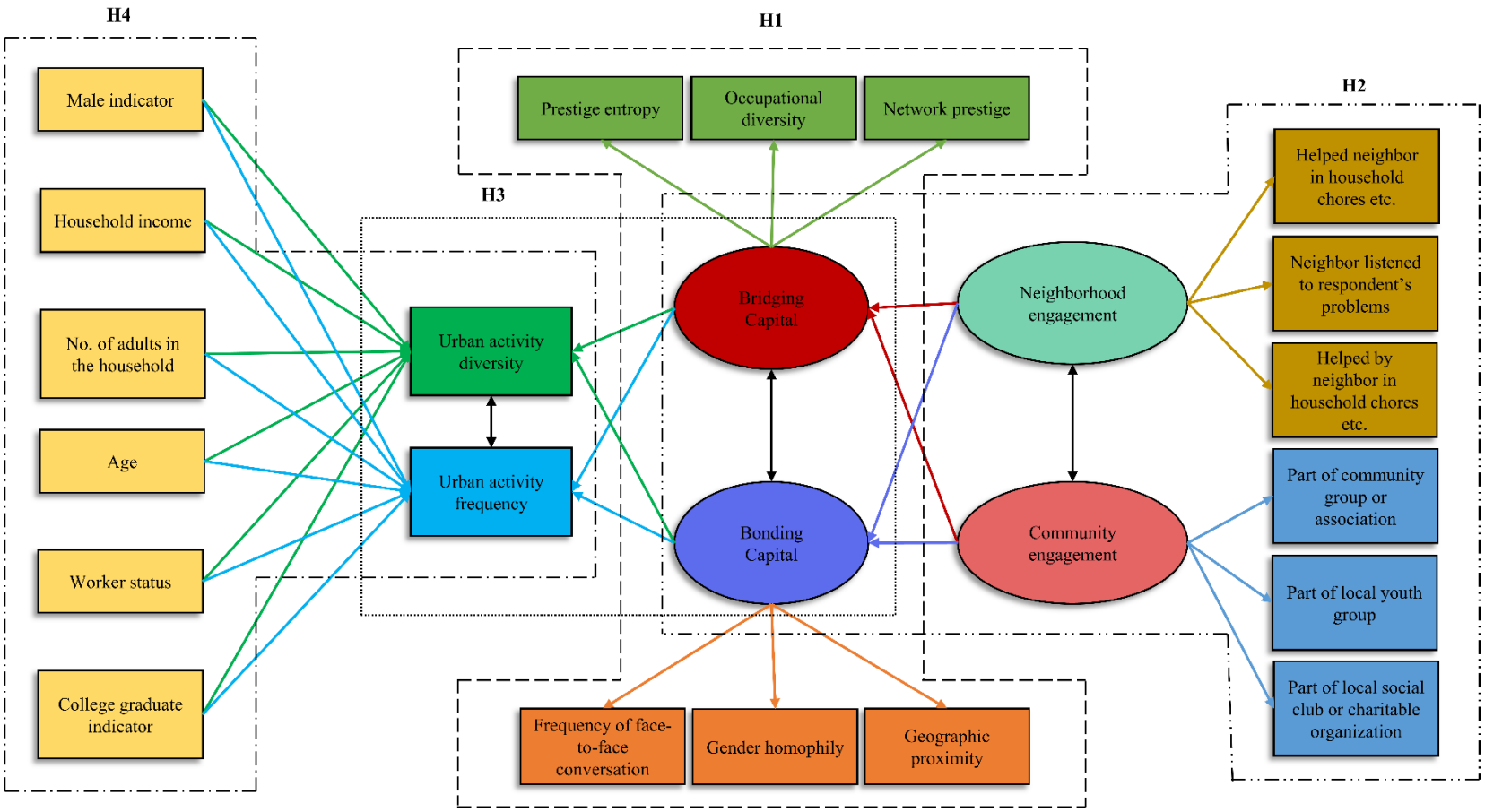


Figure 1: Conceptual SEM Framework

4.2. MEASUREMENT OF THE LATENT VARIABLES

We capture the four latent variables in our conceptual framework (which are bonding capital, bridging capital, neighborhood engagement, and community engagement) using three indicators each. The information regarding the indicators used in this study for each of the four latent variables is given below:

4.2.1.BONDING CAPITAL

The measurement of bonding capital is anchored in the existing literature. Since bonding capital is derived from a network of closely tied individuals who are similar to each other, potentially geographically closer and interact more frequently, we use the following three indicators derived from the name generator to measure bonding capital:

- Average **frequency of face-to-face conversations** with alters.
- **Geographic proximity**, calculated as the average distance between home location of the ego and the alters.
- **Gender homophily**, calculated to measure similarity between the respective gender of ego and alters. We used the negative of the E – I index (Krackhardt and Stern, 1988) given below as a measure of homophily:

$$\boldsymbol{E - I\ index} = \frac{\boldsymbol{ties_{a-b} - ties_{a-a}}}{\boldsymbol{ties_{a-b} + ties_{a-a}}} \quad (2)$$

  where $ties_{a-b}$ is the number of alters different from the ego (w.r.t gender) and $ties_{a-a}$ is the number of alters similar to the ego (w.r.t gender). Gender homophily varies between 1 and -1, where 1 corresponds to higher homophily (meaning higher similarity between ego and his/her alters).

4.2.2.BRIDGING CAPITAL

Since bridging capital is derived from ties with individuals who are potentially different from an individual and have access to novel resources that are otherwise not available to the ego, we use the position generator to measure the resources embedded in ones' social connections. Based on the position generator, we use the following three indicators of bridging capital in this paper:

- **Occupational diversity:** Following Maness (2017a), we calculated occupational diversity as the number of occupational ties (out of 22 occupations listed in the position generator) connected to the respondents. Occupational diversity is designed to capture the variety of resources potentially available to the respondent.
- **Network prestige:** Using the Standard International Occupational Prestige Scale (Ganzeboom and Treiman, 2003; Treiman, 2013) and following Maness (2017b), we associated each occupation in the position generator with a prestige score. The prestige score and the information of whether a respondent knows someone with a given occupation was used to calculate the implied amount of prestige present in an individual's social network. Along with the absolute value of the network prestige, we calculated a normalized value using the maximum possible prestige value of 1036, which occurs if a respondent would know someone from each of 22 listed occupations. The tenet here is that higher prestige leads to better access to resources and hence contributes to higher bridging capital.
- **Prestige entropy:** In addition to the above network prestige, the diversity is also considered. Given that, a more even distribution of prestige is likely to be more effective in leading to higher bridging capital, we used normalized entropy (Shannon, 2001) as a measure of evenness in the distribution of occupational connections in the network. The normalized prestige entropy is calculated as:

$$\boldsymbol{Normalized\ Prestige\ Entropy} = \sum_{1}^{K} \frac{\boldsymbol{p_k \ln(p_k)}}{\boldsymbol{\ln\left(\frac{1}{K}\right)}} \quad (3)$$

  where p_k is the proportion of total prestige associated with the k_{th} occupation and K is the total number of occupations known to the respondent (same as the occupational diversity). The

maximum possible value of the normalized entropy is 1, which means that the total prestige embedded in the network is equally distributed among the occupations.

4.2.3.NEIGHBORHOOD ENGAGEMENT

To measure neighborhood engagement, respondents were asked:

- Whether the respondent has helped his/her neighbors with household chores, shopping, repairs, house-sitting, or lending tools or supplies.
- Whether the respondent's neighbor has ever listened to respondent's problems
- Whether the respondent has received help by his/her neighbors with household chores, shopping, repairs, house-sitting, or lending tools or supplies.

We use the responses to these questions as indicators of neighborhood engagement. These responses were captured as binary indicators, where 1 represents if someone engages in a particular activity (like helping neighbors with household chores) and 0 otherwise.

Table 3 presents the descriptive statistics of the various indicators used in this study.

TABLE 3: Descriptive statistics of the indicators

Variable	Measure	Value
Occupational diversity	Mean	10.0
	Median	10
	S.D.	4.9
Normalized Network prestige	Mean	0.5
	Median	0.5
	S.D.	0.2
Normalized Prestige entropy	Mean	0.9
	Median	1.0
	S.D.	0.2
Mean frequency of face-to-face conversation (on 7-point Likert scale)	Mean	2.9
	Median	3
	S.D.	1.4
Mean geographic proximity (on 9-point Likert scale)	Mean	4.2
	Median	4.3
	S.D.	1.8
Gender homophily	Mean	0.0
	Median	0
	S.D.	0.6
Helped neighbor in household chores	Yes	44.5%
	No	55.5%
Neighbor listened to respondent's problems	Yes	38.8%
	No	61.2%
Helped by neighbor in household chores	Yes	34.2%
	No	65.8%
Part of community group or association	Yes	17.1%
	No	82.9%
Part of local youth group	Yes	17.6%
	No	82.4%
Part of local social club or charitable organization	Yes	28.1%
	No	71.9%

S.D.: Standard Deviation

4.2.4. COMMUNITY ENGAGEMENT

To measure community engagement, respondents were asked:

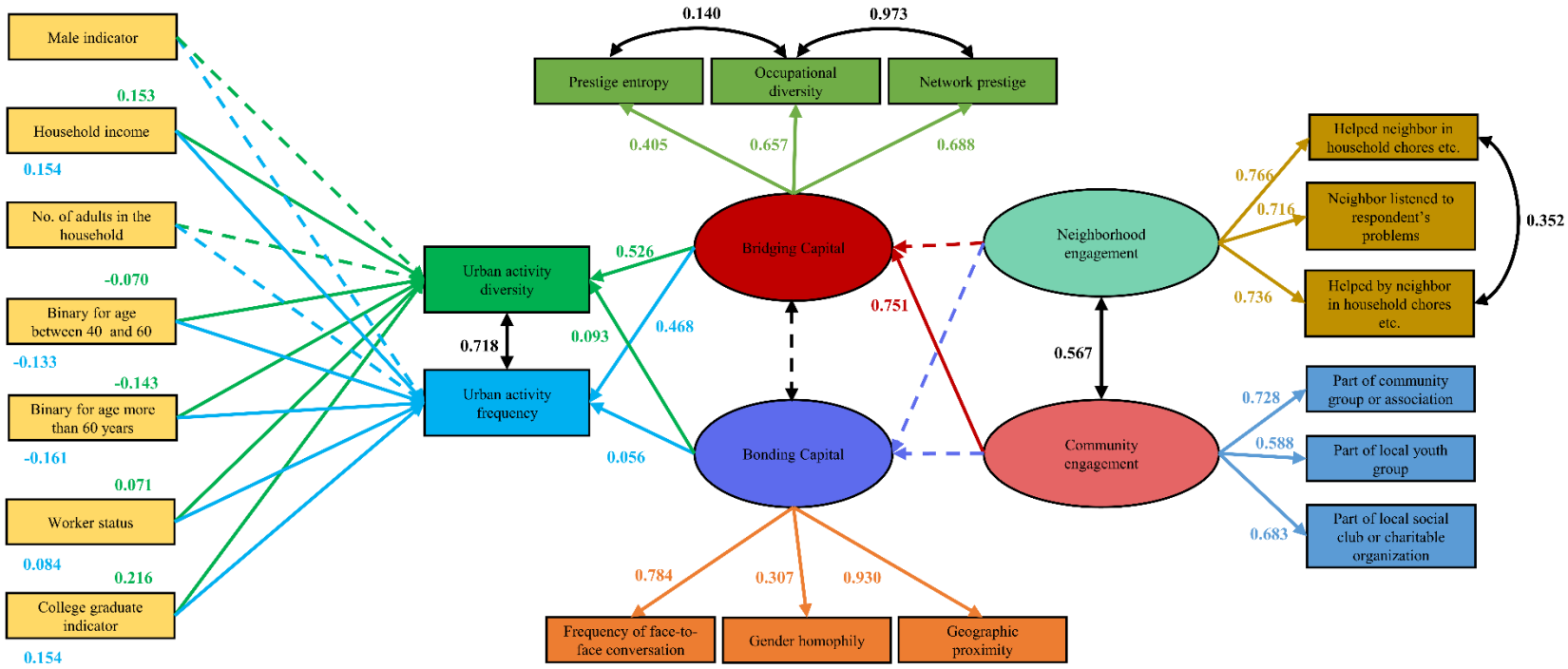
- Whether the respondent is part of a community group or neighborhood association that focuses on issues or problems in your community
- Whether the respondent is part of youth group, such as scouts or the YMCA
- Whether the respondent is part of a local social club or charity

We used the binary responses to these questions to measure community engagement.

5. RESULTS AND DISCUSSION

Table 4 presents the estimation results from the structural equation model and **Figure 2** shows these results on the path diagram. In this figure, paths where the corresponding parameter was statistically significant at the 95% confidence level are shown using a solid arrow, while the paths which were hypothesized but resulted in an insignificant parameter are shown using a dashed arrow. For brevity, error variances are not presented in the path diagram but are reported in **Table 4**. Note that the results presented in **Table 4** are from the final estimated model where all the insignificant variables have been removed. **Table 5** presents various model fit measures for structural equation model. Given the nature of the estimator used, we present both the standardized and robust versions of the fit measures, where applicable. Given the relatively large sample size, the most reliable measures of fit for our model are comparative fit index (CFI), root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR) (Hooper et al., 2008; Kenny, 2015). We also present the expected cross validation index (ECVI) (Browne and Cudeck, 1992) which measures the discrepancy between the covariance matrices of the fitted model and an external sample of the same size. Typically, a CFI/TLI value greater than 0.90 (0.95 as suggested by some studies) is considered a good fit. For the presented model, the robust CFI value was 0.839 and the robust TLI value was 0.886. While these values are slightly lower than the generally prescribed cut-offs, the CFI/TLI values in our model were greatly affected by the inclusion of socio-demographic information (H4) and the CFI/TLI values in the model without the socio-demographic variables were well above 0.95. Nevertheless, prior research suggest these metrics to be lower in magnitude as model complexity increases (Allen et al., 2018; Biehl and Stathopoulos, 2020). The RMSEA value (upper bound of 90 % confidence interval) for our model was 0.059, which is well below 0.08 value of acceptable cut-off. Further, our model shows a SRMR value of 0.036, which is lower than the maximum acceptable value of 0.08 and the ECVI value was 0.639. Note than there are no prescribed cut off values for ECVI since this is a comparative fit measure though the ECVI value of the presented model was better compared to other variations of the path diagram we tested. Overall, from various measures of model fit, our model seems to fit reasonably well to the data, highlighting the confidence in our results and findings.

Several interesting observations can be made from the estimation results and are presented in following subsections on social capital multi-dimensionality, foundations of social capital, resulting travel behavior, and demographic determinants.



FIT INDICES (robust values)

comparative fit index (CFI) = 0.839

Tucker-Lewis index (TLI) = 0.886

root mean square error of approximation (RMSEA) 90 % confidence interval upper bound = 0.059

standardized root mean square residual (SRMR) = 0.036

Expected Cross Validation Index (ECVI) = 0.639

Statistically insignificant path

Statistically significant path

Figure 2: Result from the SEM shown on a path diagram (Note: Dashed lines represent statistically insignificant paths)

TABLE 4: Structural Equation Model Estimation Results

Variables	Parameter Estimates	t-stats
Latent Variables		
Occupational diversity ← Bridging Capital	0.657	10.6
Prestige Entropy ← Bridging Capital	0.405	8.5
Network Prestige ← Bridging Capital	0.688	11.0
Helped neighbors with household chores ← Neighborhood Engagement	0.766	15.6
Neighbors listened to respondent's problems ← Neighborhood Engagement	0.716	16.7
Received help from neighbors with household chores ← Neighborhood Engagement	0.736	14.7
Part of local social club or charity ← Community Engagement	0.683	18.4
Part of community group or association ← Community Engagement	0.728	18.0
Part of local youth group ← Community Engagement	0.588	13.2
Geographic proximity ← Bonding Capital	0.930	23.7
Gender homophily ← Bonding Capital	0.307	11.9
Frequency of face-to-face contact with alters ← Bonding Capital	0.784	21.8
Regression Parameters		
Bridging Capital ← Community Engagement	0.747	8.3
Activity diversity ← Bonding Capital	0.093	3.5
Activity diversity ← Bridging Capital	0.526	11.0
Activity diversity ← Dummy for age between 40 and 60 years	-0.070	-2.5
Activity diversity ← Dummy for age more than 60 years	-0.143	-5.1
Activity diversity ← College graduate indicator	0.216	8.1
Activity diversity ← Household Income	0.153	5.5
Activity diversity ← Worker indicator	0.071	2.8
Activity frequency ← Bridging Capital	0.486	10.5
Activity frequency ← Bonding Capital	0.056	2.0
Activity frequency ← Dummy for age between 40 and 60 years	-0.133	-4.7
Activity frequency ← Dummy for age more than 60 years	-0.161	-5.6
Activity frequency ← College graduate indicator	0.154	5.6
Activity frequency ← Worker indicator	0.084	3.2
Activity frequency ← Household Income	0.154	5.6
Error Covariance		
Activity diversity ↔ Activity frequency	0.718	14.974
Neighborhood Engagement ↔ Community Engagement	0.567	13.2
Occupational diversity ↔ Network Prestige	0.973	12.7
Occupational diversity ↔ Prestige Entropy	0.140	3.6
Helped neighbors with household chores ↔ Received help from neighbors with household chores	0.352	2.3
Error Variances		
Occupational diversity	0.568	13.2
Prestige Entropy	0.836	21.9
Network Prestige	0.527	12.6
Helped neighbors with household chores	0.413	--
Neighbors listened to respondent's problems	0.487	--
Received help from neighbors with household chores	0.458	--
Part of local social club or charity	0.534	--
Part of community group or association	0.470	--
Part of local youth group	0.654	--
Geographic proximity	0.135	2.2
Gender homophily	0.906	21.4
Frequency of face-to-face contact with alters	0.386	9.0

Activity diversity	0.589	18.4
Activity frequency	0.677	20.2
Bridging Capital	0.443	--
Neighborhood Engagement	1.000	--
Community Engagement	1.000	--
Bonding Capital	1.000	--
Thresholds for binary endogenous variables		
Helped neighbors with household chores	0.510	4.6
Neighbors listened to respondent's problems	0.400	3.6
Received help from neighbors with household chores	0.690	6.0
Part of local social club or charity	1.195	9.2
Part of community group or association	1.744	11.5
Part of local youth group	1.407	10.1
Intercepts		
Occupational diversity	1.151	13.4
Prestige Entropy	4.669	39.8
Network Prestige	0.961	10.9
Geographic proximity	2.232	25.8
Gender homophily	0.294	3.3
Frequency of face-to-face contact with alters	2.065	23.5
Activity diversity	1.682	20.2
Activity frequency	1.196	13.8

--- t-statistics not available as the corresponding variables were fixed to allow for identification of parameters
A ← B: Represents a path from variable B to A in the path diagram
A ↔ B: Represents the error covariance between variables A and B

TABLE 5: Fit measures for the present structural equation model

Fit Measures	**Standard**	**Robust**
Number of observations	1434	--
Degree of freedom	91	--
Comparative Fit Index (CFI)	0.882	0.839
Tucker-Lewis Index (TLI)	0.917	0.886
Root Mean Square Error of Approximation (RMSEA)	0.061	0.055
90 percent confidence interval – lower bound	0.057	0.051
90 percent confidence interval – upper bound	0.065	0.059
Standardized Root Mean Square Residual (SRMR)	0.036	0.036
Excepted Cross Validation Index	0.639	--

5.1 SOCIAL CAPITAL MULTI-DIMENSIONALITY

Firstly, there is clear evidence of two separate social capital constructs with different impacts on travel behavior, and different anchoring in broader social engagement. From exploratory and confirmatory model testing we confirm the first research hypothesis that these dimensions are latent and can be measured using multiple indicators, showcased by the statistically significant parameters describing the relationship between the social capital constructs and the respective indicators. Moreover, as can be seen from Figure 2, the error covariance between bonding and bridging capital was statistically insignificant. Taken together, this supports our hypothesis H1 that social capital is latent and multi-dimensional, with a clear distinction between bonding and bridging. It is worth mentioning that we examined several alternative specifications of the core social capital constructs, including a simplified version assuming that social capital was a unidimensional latent variable, measured by all six indicators. However, the presented model with separate dimensions of social capital had better fit to the data.

Several important observations arise from the measurement model results. First, *bridging capital*, i.e., resources that can be activated via weak social ties surrounding a person, are positively correlated with both the diversity of occupations and the prestige entropy. This finding confirms that a higher prevalence of (high-status) occupations among acquaintances need to be coupled with diversity to effectively bolster bridging capital. On the other hand, *bonding capital* representing close ties, not surprisingly, is positively correlated with spatial proximity, gender homophily and frequency of face-to-face conversations. Here we note a caveat about the apparent importance of spatial proximity for bonding capital accumulation. We expect that a more recent dataset would reflect a greater role of virtual/remote social support indicators to support close ties.

5.2 FOUNDATIONS OF SOCIAL CAPITAL

The second research question seeks to determine the grounding of the social capital measures in the broader social engagement of respondents. In support of the hypothesis H2, we identify that neighborhood and community engagement are latent in nature and can be measured using multiple indicators. This is evident from the fact that the parameters associated with the two latent variables and their indicators are statistically significant. Of more practical relevance, we find neighborhood and community engagement latent variable to be two separate entities though with moderate overlap. Furthermore, while we find a statistically significant relationship between community engagement and bridging capital, no relationship was found between the two engagement variables and bonding capital. This suggests that while individuals are expected to expand their bridging capital via community engagement (and indirectly via neighborhood engagement given the partial overlap), they still predominantly rely on much closer contacts for bonding capital. These findings are in line with prior research that suggests neighborhood engagement to be geographically local and restricted compared to community engagement and hence potentially does not contribute to attainment of novel resources (Wellman, 1979; Wellman and Leighton, 1979).

Overall, this suggests that community engagement is the main booster of the bridging aspect of social capital. This makes sense as we generally expect engagement outside our immediate neighborhood, with community members, to contribute to the accumulation of social network related resources.

5.3 RESULTING TRAVEL BEHAVIOR

The third goal is to investigate the association between social capital dimensions and travel. As mentioned earlier, there is an intuitive linkage: travel is needed to maintain social connections, and vice versa, social resources can enable or promote travel by providing information on events, transportation options or offering support for travel to take place (Di Ciommo et al. 2014; Liu et al. 2020). The results reveal that different dimensions of social capital affect travel behavior differently, resonating well with our third research hypothesis. Specifically, while the results suggest that both social capital dimensions have a positive and statistically significant effect on social activity diversity and frequency, the magnitude of the impacts is drastically different. This can be seen from the path diagram in figure 2, where the path parameters from bridging capital to urban activity diversity and frequency are equal to 0.526 and 0.468, respectively. On the contrary, the parameters associated with paths from bonding capital to social activity diversity and frequency are much lower (0.093 and 0.056, respectively). This difference is significant and is only evident since we allow social capital to be captured multi-dimensionally. From a behavior standpoint, these differences can be explained from a combination of following three main perspectives:

- *network maintenance:* urban activity participation is needed to maintain ties with individuals in one's network.
- *information flow:* activity participation is likely the result of gaining novel information like recommendation for a new café or restaurant.
- *accessibility:* activity participation results from improved accessibility to activity locations due to access to either a new mobility tool, or membership in groups/clubs etc., via social ties.

Since bridging capital related to access to novel resources and information and bonding capital is associated with a stagnation effect as mentioned earlier, there is a large different between the effect of these two social capital dimensions. Drawing together all these findings we note that bridging capital appear to be the key dimension to shape urban discretionary travel behavior. Moreover, weak ties underpin the bridging capital formation precisely because they require more maintenance, give access to more novel information, and are more likely to supply access to resources like mobility tools or club membership that are otherwise not available to the ego.

5.4 DEMOGRAPHIC DETERMINANTS.

Lastly, in line with the hypothesis H4, the model also captures the impact of personal and household characteristics on urban activity participation. The results suggest that households with higher income, that are larger, with respondents who are full time workers and those who have a college degree, engage in much higher urban activity frequency and diversity. Interestingly, while male respondents were more likely to have higher frequency of social participation than female respondents, no difference was found in the activity diversity between male and female respondents. Further, the impact of age on social activity diversity and frequency is non-linear, with respondents under the age of 24 having the highest activity diversity and frequency, while both frequency and diversity decrease more than proportionally with age.

6. POLICY IMPLICATIONS

There are several potential implications emerging from our analysis. We discuss practical implications of this work starting from the enhanced understanding of travel activity decisions to the social capital interactions, onto the broader foundations related to neighborhood and community engagement.

6.1 TRAVEL ACTIVITY DRIVERS

The results in this study suggest a strong relationship between social capital (and networks, in general) and travel. Going forward, this points to a need to account for dimensions related to bridging and bonding social capital in transportation planning and management. Specifically, we suggest a need to focus on three areas, namely expanding data-collection, travel modeling and planning/forecasting analysis.

First, our findings point to an opportunity for **travel surveys** to broaden data-collection plans to capture the social embeddedness of travelers, expanding on the current practice of collecting (more narrow individual and household) socio-demographic information. For example, the National Household Travel Survey (NHTS) in the Unites States typically does not collect information beyond household/individual socio-demographics and intra-household interactions and thereby may overlook valuable information on the broader social network surrounding an individual or household. In this study we highlight two main constructs and several relevant indicator-questions, that show a path to account for multi-dimensional social capital. In proposing social capital data-collection, it is important to carefully balance the added insight against the respondent burden. We note that collecting ego-centric network data is a relatively straight-forward addition to existing survey efforts. Also, position generator data – which is typically a shorter instrument than name generator approaches – shows relevance in explaining activity diversity and frequency. Our analysis suggests transportation planning agencies will benefit from data on the social context in which travel decisions are made, to better model the frequency and diversity of urban travel behavior.

Second, richer data can inform new **modeling** practices. Specifically, incorporating social-capital data sources into travel demand forecasting involves the dual challenge of creating socially embedded synthetic populations and modeling interdependent decision making. Illenberger (2012) presents a framework to incorporate social network data into travel demand modeling where: (1) social network data is analyzed to discover social network properties, (2) these properties are combined with land use data to spatially model social networks in order to generate synthetic social networks, (3) and these synthetic populations are used in travel demand models to forecast travel demand. The next important step involves creating socially embedded synthetic populations at the population synthesis level. Findings from the

current study strongly suggests that the population synthesis component needs to build not only on structurally sound social networks, but also incorporate social network resources into such networks. Current social network models (e.g., exponential random graph models (ERGMs), discrete choice generative network models, game theoretic network models) can be calibrated using name generator and name interpreter data. However, further research is needed to incorporate weak ties. These weaker tie networks likely do not need to be modeled explicitly (or it would be computationally prohibitive), but there is no agreed upon method for generating this type of social capital in a population synthesis model.

Third, taken together this will help create a network theory approach to travel demand forecasting where the social networks affect travel **behavior outcomes**. As a result, the socially informed analysis will lead to new insights involving the planning and coordination of activity schedules and travel plans beyond immediate households. For example, this study shows that the generation of (urban) activities involves social capital – specifically, activity diversity, and thereby diversity in travel destinations, likely involves bonding and bridging capital. Given these results, it becomes important to account for social capital (and its sub-dimensions) to understand activity coordination and travel.

6.2 COMMUNITY ENGAGEMENT TO INCREASE WELL-BEING AND LIVABILITY IN CITIES

The results in this study highlight the role of community/neighborhood engagement in social capital (bridging capital, in particular) accrual. Further, the study also shows a relationship between social capital and urban activity participation. An important implication of these relationships lies in the design and targeting of information campaigns by policy makers to promote travel behavior changes, such as increasing local travel engagement with urban third places to promote *urban revitalization*. That is, rather than focusing directly on activity participation promotion campaigns aimed at individuals, agencies might take the larger view and focus on supporting and boosting social networks that connect residents. This could potentially be done by facilitating community engagement, which can boost bridging capital and thereby leads to more urban activity participation. Ultimately, this indirect causation path promotes the value of supporting place-making, facilitating local community engagement, and promoting community-building efforts like collective bike-rides, and pop-up pedestrian infrastructure.

Further, the results from this study also highlights a well-being perspective. Mokhtarian (2019) points out that the efforts to reduce discretionary travel present a policy dilemma where: "*attempts to curtail (personal vehicle) travel to achieve sustainability goals may simultaneously diminish our collective well-being…*" (p. 504). Other studies have also pointed out that the ability to engage in leisure/social activities with others have a significant impact on life satisfaction and well-being (Reardon and Abdallah, 2013; Spinney et al., 2009). The current study shows a linkage between activity engagement and social capital. Several prior studies have pointed out a positive association between social capital and well-being (Chatman et al., 2019; Dharmowijoyo et al., 2020; Hamdan et al., 2014; Nilsson et al., 2006; Van Den Berg et al., 2016; Yip et al., 2007). The current study thereby adds to this existing body of works by analyzing the positive association between neighborhood/community engagement and social capital, which in turn promotes socially oriented travel. Overall, the observed paths in our model suggest positive indirect effects between community/neighborhood engagement and well-being via social capital accrual and increased urban activity participation. Given these results, planners and policy makers should pay attention to creating better opportunities for neighborhood and community engagement to, ultimately, improve community well-being.

7. SUMMARY AND EXTENSIONS

7.1. SUMMARY OF FINDINGS

In this study, we examined the multi-dimensional nature of social capital and their respective relationship with travel behavior. Specifically, we made use of data from the Pew Internet Networks and Community Survey to build a structural equation model dividing social capital into two latent dimensions: *bonding* and *bridging* and then studied the relationship of these dimensions with urban activity participation diversity

and frequency. Furthermore, we analyze the sources of accumulation of social capital via neighborhood and community engagement, modeled as two separate latent variables. The main ***conclusions*** from the study are as follows:

- The results show strong evidence of two separate social capital dimensions, namely bonding (linked to network of closely tied individuals who are similar to each other) and bridging (linked to ties with individual who are different and provide access to novel resources). The multi-dimensional nature of social capital is further validated by confirming an absence of correlation between the constructs.

- Our results indicate a positive relationship between both social capital dimensions and urban travel activity, shown by the positive linkage to both activity participation diversity and frequency. This suggests that travel activities that are essential for urban functions are tied to social capital. Moreover, the results suggest that the strength of this relationship is higher between bonding capital and urban activity participation, highlighting that weak ties are the primary boosters of urban travel.

- Lastly, we found that while community engagement contributes to bridging capital accrual, it does not contribute to accrual of bonding capital. Furthermore, no support was found for a postulated relationship between neighborhood engagement and social capital dimensions. These results suggest that individuals predominantly rely on much closer and stronger relationships for social and emotional support. Ultimately, the most important channel of causation to model urban travel activity appears to be related to the following path: community engagement → accumulation of bridging capital → more urban travel activities.

7.2. LIMITATIONS AND FUTURE RESEARCH

There are several limitations to the presented study, and these naturally lead to avenues for future research. These are presented below:

- Our measurement of bonding capital dimension focusses on face-to-face contacts rather than virtual / online connections. While the role of in-person contacts to maintain social networks and capital is important, the increasing penetration of ICT and personal device ownership is not reflected in this work. In current times, virtual and remote communities, and networks, will compliment and/or replace in-person contacts, triggered further by the ongoing COVID-19 pandemic and social distancing measures. Hence, while we hold our model approach to be valid, there is a need for continued research with more recent data to understand the role of virtual/online contact technologies, virtual communities, and social capital accumulation.
- The definition and measurement of urban activity/travel participation frequency and diversity in this study was relatively limited and can potentially be expanded. Specifically, the survey data used in this study asked respondents about the number of times they visited each of eight different social activity locations in the last month (see section 3.1). Urban activity participation is neither limited to only these locational activities, nor is there a guarantee that these are socially motivated, as participation in activities at these locations can also be done in solitude without being socially motivated. We encourage future research to identify a more robust measurement of urban activity participation, along with joint/solo activity participation, to develop a complete understanding of the relationship between travel, social networks, and vibrancy of life in cities.
- Another important avenue of future research is to measure bridging capital using alternative instruments. Specifically, we derived our indicators for bridging capital from a position generator. However, other recently popular methods like a resource generator (Van Der Gaag and Snijders, 2005) are also of interest to better characterize social network resource capital.
- Lastly, further work is needed to validate and potentially expand the understanding of social capital multi-dimensionality. Specifically, we call for a deeper understanding of how specific dimensions

relate to mobility (e.g. timing, mode, frequency, destinations, trip-chains). For example, our study identifies bridging capital which is linked to diverse resources. However, this dimension could be further divided into components like mobility, financial and information resources. A deeper characterization of social capital can increase our understanding of relationship between these dimensions and urban travel patterns.

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