# Chapter 5
# The Influence of Built Environment on Walking Behavior: Measurement Issues, Theoretical Considerations, Modeling Methodologies and Chinese Empirical Studies

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## 5.1 Introduction

The built environment provides spatial, temporal and social contexts for human behavior. They usually comprise the following elements: (1) land use patterns, including the spatial distributions of buildings and human activities; (2) transportation systems, including hard transport infrastructure and soft transit service and (3) design, including the arrangement and appearance of physical elements (Handy 2005; Saelens and Handy 2008). Certain studies of the built environment on walking behavior in Western cities are driven by planning reform movements, such as new urbanism, smart growth and transit-oriented development (TOD). By shaping the built environment, planners aim to encourage walking behavior while reducing motorized movement. A built environment is labeled as "pedestrian-oriented" if it has relatively high density, a mixture of land uses, a street network with high connectivity, human-scale streets and desirable aesthetic qualities (Cervero and Kockelman 1997). Because walking is emerging as an important form of moderate-intensity physical activity and a practical health improvement method for the general public, public health is putting great effort into researching walking behavior (Owen et al. 2004).

However, several issues require further work. (1) Measurement of the key variables: the lack of an agreed-upon definition of a "built environment" has led to various measurement approaches in empirical studies. Most studies view the relation between the built environment and human walking choices from objective or physical perspectives. The effect would obviously go unrealized without

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human awareness (Kremers et al. 2006). However, perception and cognition are not physically measurable, and the objective measurements do not effectively complement their subjective counterparts. Validated and consistent measurements of the built environment, both objective and subjective, are required and will lead to more meaningful empirical studies. (2) The nature of the influence, to “forecast” or to “understand”: a rarely mentioned question is “why, after all, a relationship should exist between travel behavior and built environment” (Van Acker et al. 2010). To understand the nature of the influence, we need to explore how the built environment factors into the human decision-making process (Handy 2005; Boarnet and Crane 2001). Forecast models such as the discrete choice model are useful and widely adopted in transportation research. However, the specific attributes that should be attached to choice alternatives are calibrated only from proposed built environment attributes and collected travel behavior data, and are hence not enough to truly understand walking behavior. Social psychology focuses on how people think, feel and behave, and how these thoughts, feelings and behaviors are influenced by others. The theory of planned behavior (TPB), a more structural theory, should indicate whether we should use these variables and introduce hints for understanding human behavior. The combination of a discrete choice model and the TPB holds promise. (3) The application of Western experiences to Chinese cities: a great majority of studies on this subject are based on Western cities. Conclusions drawn from developed countries’ experiences may not be applicable in other contexts, especially to countries like China that are undergoing rapid economic growth and urban development (Shen 1997; Pan et al. 2009). The transferability of primary study findings and recommendations to Chinese cities remains to be tested.

This paper attempts to provide an overview of measurement issues, behavior theory underpinnings, modeling strategies concerning the influence of built environment on walking behavior, and empirical studies in a Chinese context. Following this introduction, Sect. 5.2 discusses measurement of the built environment and walking behavior. Section 5.3 introduces the theoretical basis. Section 5.4 describes our conceptual model and study design. Section 5.5 examines the specific characteristics of Chinese cities and elaborates on the study progress in China. Concluding remarks and comments on future work are given in Sect. 5.6.

## 5.2 Measurement Issues

Heath et al. (2006) call for a better conceptualization of the built environment to guide measurement of their components (Heath et al. 2006). Without a generic conceptualization, empirical studies could lack the appropriate guidance. Validated and consistent measurements of the built environment and walking behavior are still required (Cunningham and Michael 2004).

### *5.2.1 Measuring the Built Environment: Objectively or Subjectively?*

In general, objective measures come from data collected in the field (Hoehner et al. 2005) or from existing land use databases available in geographic information systems (GISs) (Lin and Moudon 2010). The majority of studies show that both objective and subjective attributes are related to walking behavior (Handy et al. 2002; Lee and Moudon 2004). Subjective measures are self-reported perceptions of the environment obtained from survey questionnaires (Humpel et al. 2004). In urban planning and transportation, most empirical studies do not incorporate subjective factors. Some researchers argue that perceptions, attitudes and preferences are difficult to measure and thus cannot be taken into account (Golledge and Stimson 1997; Gärling et al. 1998). Most physical activity studies use subjective environmental measures, ostensibly because the data are obtained more economically than those of field-collected objective measures, or because detailed objective GIS land use data are not yet commonly accessible.

#### 5.2.1.1 Objective Measures

Distance and aesthetics have the most direct influence on walking choice. In higher-density neighborhoods, land use is compact and destinations are closer, making walking more advantageous. Diversity indicates a mix of land use (Cervero and Kockelman 1997). Being equipped with more land use types that are within walking distance is favorable to increase walking rates (Handy and Clifton 2001). Density and diversity are land use indicators in conjunction with transport systems. Design refers to the aesthetic or quality of the land use and the streetscape, including the presence and attractiveness of natural sights (e.g. trees, hills), recreational facilities (e.g. public open spaces, private gardens), architectural design and pollution levels. Transit use is classified as active travel because it almost always requires walking at one or both ends of the trip (Besser and Dannenberg 2005); hence, distance to transit is an indicator. Areas well served by public transit have bus or rail stops within convenient walking distance, which could decrease automobile dependence.

Though their division is ambiguous and unsettled, these *D* variables are useful in organizing the empirical literature. However, the effects of distance and aesthetic factors may vary depending on the behavior types being studied, the competitiveness of other modal choices, the destination to be accessed and the quality of the destination to the user (Giles-Corti et al. 2005). One variable may have both positive and negative effects. For example, density can increase the capability of direct access, but lower travel speeds. Land use mixing reduces trip costs by placing destinations closer to origins. This could induce more trips and people probably travel further at the same cost, but to get more opportunities and benefits (Boarnet and Crane 2001;

van Wee 2011). An integrated indicator combining these *D* variables may increase the comparability of the studies. Accessibility has long been a central concept in urban planning. It is a measure of the spatial distribution of facilities adjusted for the desire and ability of people to overcome "spatial separation" (e.g. distance or travel time) to access a facility or activity (Handy and Niemeier 1997; McGinn et al. 2007; Hansen 1959). Accordingly, desire and ability are influenced by the importance of the trip to the user (the arrangement of that activity), attractiveness of the facility (design), location of the facility (land use) and the user's access to transport (Giles-Corti et al. 2005). Some studies adopt accessibility as an integrated indicator. For example, Kockelman (1997) uses accessibility measures by purpose and mode in both origin and destination zones; for non-work trips, the measures count sales and service jobs within 30 min walking distance (Kockelman 1997). Krizek (2003) adopts neighborhood accessibility measures that combine density, land use mix, block size and regional accessibility based on gravity (Krizek 2003).

#### 5.2.1.2 Subjective Measures

Most studies have found little agreement between objective and perceived measures of environmental attributes (McCormack et al. 2008; Gebel et al. 2009; McGinn et al. 2007). The studies conducted to date have provided limited guidance on the relative effectiveness of subjectively measured attributes of the built environment in estimating their influence on walking behavior. It has been found that definitions of subjective measures such as accessibility to or convenience of destinations are inconsistent across studies due to different contexts and the distinct survey questionnaires applied to different types of walking. Further, the mechanism that forms individual perceptions is not explicitly instructed. Unstructured questions such as those involving the presence of destinations (e.g. shops) contribute little to the understanding of the true nature of human perception (Moudon et al. 2006). The measures employed are often the results of questions in which respondents impose their own views on the attributes. General perceptions of a residential-based hypothesis may not be enough; we need to know exactly what the respondents are referring to. These differences not only hinder comparisons across studies, but also lack instructive information for policy implications. Social psychology theories provide hints for structured subjective measures and will be illustrated later.

### *5.2.2 Measuring Walking Behavior: Objective or Self-Report?*

There are two types of walking behavior: walking for transport and walking for leisure. While the best way to measure these behaviors is still unclear and separate measurements for the different types are still required, the importance of walking is widely recognized (Heath et al. 2006).

In transportation research, walking behavior is usually recorded by travel diary. Travel diaries ask respondents to keep a log of all trips made during a particular time period, usually 1 or 2 days. A detailed travel diary includes origins and destinations, modes of travel, durations of trips and primary activities at trip destinations. However, walking data in the diaries are usually incomplete (Handy et al. 2002) and less valid (Lee and Moudon 2004). Travel diaries typically focus on driving and public transit rather than walking, which could inevitably lead to a lack of walking data. In addition, the separation of walking for leisure from walking for transport is not necessarily straightforward (Handy 2005). Duncan and his colleagues suggests that a global positioning system (GPS), especially when used in combination with GIS, offers great promise in objectively measuring individual behavior in terms of physical and transport-related activity (Duncan et al. 2009).

In physical activity studies, self-report measures play a central role in measuring physical activity in general and walking in particular (Johnson-Kozlow and Matt 2004; Pereira et al. 1997). They are economical and allow large populations to be assessed quickly and easily (Tudor-Locke et al. 2004). Assessments are variously quantified as sessions and duration per week, number of miles per week, number of blocks walked and as walking more or less with reference to others of the same age. Many studies investigate biases and response errors in self-reported data on physical activity (Sallis and Saelens 2000). A growing number of studies are utilizing objective measures of walking behavior in conjunction with self-reporting. A common method is to utilize a device such as a pedometer or accelerometer, which detect steps and distances travelled throughout the day (Tudor-Locke et al. 2004). However, the high cost of the devices limits their usage in studies with large sample sizes. In addition, the devices alone cannot identify different built environments.

### *5.2.3 Specificity and Matching*

Barriers are formed by spatially matching sufficiently detailed data between the built environment and walking behavior (Cervero and Kockelman 1997). Survey data are usually collected at the census collector district level (Duncan et al. 2010), leading inevitably to a lack of built environment attributes related to walking. Taking pedestrian networks as examples, street networks are too coarse to trace the paths chosen by pedestrians. A true pedestrian network should incorporate formal and informal paths, including sidewalks, laneways, pedestrian bridges and park paths that are informal but used frequently for transit. The missing pedestrian paths in the street network database are likely those that can greatly increase the connectivity of separate locations in the real world. Most accessibility studies use only street networks in their analyses, which may result in inadequacies in the description and prediction of walking travel and induce arguments about the reliability of the analysis result (Chin et al. 2008).

Introducing greater specificity to models that seek to explain the impact of the environment on behavior would greatly improve the predictability of the developed model (Giles-Corti et al. 2005). Further, correspondence between the boundaries within which environmental data are collected and the environments to which the perceptions refer is of great importance (Smith et al. 2010). For example, a researcher's definition of a neighborhood offering area-level data may be substantially different from that of a questionnaire respondent's. The lack of specificity also weakens the correlation between respondent perceptions and objective environment measures.

## 5.3 Theoretical Basis for Examining the Influence

The built environment's influence on walking behavior varies with walking types. Travel demand provides a theoretical foundation for the influence mechanism on walking for transport. Travel demand depends on the balance between the "utility" of the activity and the "travel cost" of reaching the destination. Because walking for leisure has health, exercise and relaxation utilities, it is included in the utility framework. It also fits in the broader daily activity context, as it offers the choice to decide where, when and how long (in the built environment) this leisure activity will be conducted. Activity patterns are thus expected to give a more complete picture of an individual's walking behavior. Discrete choice models and the TPB are useful in forecasting and understanding the travel choice that forms the skeleton of activity patterns.

### *5.3.1 Travel Demand Derived from Activity Patterns*

The original contributions of activity pattern studies can be traced to the works of Hägerstrand (1970) and Chapin (1974). Hägerstrand (1970) focuses on three kinds of constraints restricting human movement in a spatial-temporal framework, including (1) capability constraints, (2) coupling constraints and (3) authority constraints. Capability constraints refer to limitations imposed by physiological necessities such as sleeping, eating and personal care. Coupling constraints define where, when and how long an individual can interact with other individuals. Authority constraints limit access to either space locations or time locations (e.g. a bank's business hours) (Hägerstrand 1970). The effects of the built environment can be expressed in these three constraint forms. Chapin (1974) describes a motivational framework in which activity patterns result from the interaction between individual propensities and perceived opportunities to engage in activity. He argues that individuals perform activities to meet their basic needs, which in turn determines their propensity to engage in activities (Chapin 1974). By taking opportunities into account, Chapin could assess the effect of the built environment on activity patterns (Ettema and Timmermans 1997). Hägerstrand (1970) and Chapin (1974) provide a theoretical basis for the study of human daily activity patterns, from which travel demand (including trip generation and modal choice) can be derived.

Crane (1996, 2001) explicitly incorporates the built environment into the aforementioned travel demand theory based on the utility maximization principle of microeconomics (Boarnet and Crane 2001; Crane 1996). It has been reasoned that when land use variables exert an influence on travel behavior, such an influence is seen in the effect on the relative trip cost (e.g. speed and distance) of the available modes. To include the built environment in an explicitly activity-based framework, Matt and his colleagues illustrates how the built environment can influence trade-offs between utility and cost (Maat et al. 2005). While compact built environments may reduce an individual's travel time and ability to obtain the same amount of activity benefits, the timesaving benefits of compact designs may also increase trip generations. Whether saving travel time results in less travel, longer trips to obtain extra utility or allocation of time to other activities remains in question. Maat points out that an individual's aim is not primarily to minimize travel costs, but to maximize utility within space and time constraints.

Walking for leisure can also gain theoretical support from activity-pattern studies. A better understanding of how individuals incorporate leisure walking into their daily activities allows for the development of effective policy interventions to facilitate more walking. Furthermore, because recreational activities comprise a substantial share of individuals' non-work activities, studies of participation and time use in recreational activity episodes contribute to activity-based travel demand modeling. There has been relatively little attention paid to the spatial and temporal contexts of physical activity participation, that is, on the when, where and how long of physical activity participation (Sener and Bhat 2012). Leisure-walking participation studies can provide important insight into the design of customized physically active lifestyle promotion strategies in different built-environment and time-of-day contexts.

### *5.3.2 Forecast-Oriented Behavior Theory*

Travel modal choices form the skeleton of activity patterns. Choices in walking, transit or driving are discrete by nature. Discrete choice models are thus very helpful for this kind of analysis, which is based on the assumption that choice alternatives can be represented as bundles of attributes. Individuals are assumed to derive some utility from these attribute values and combine them into an overall measure of utility (Ben-Akiva and Lerman 1985). Because of measurement errors and taste variations, these utilities are assumed to comprise a systemic measurable component and a random term. Depending on the assumptions made in these error terms, choice probabilities can be derived.

However, the forecast-oriented travel behavior theory tends to limit the variables included in models. Rather than the larger set of variables, only factors that can be forecasted and that researchers believe might affect travel behavior are employed. McFadden recognizes the importance of the perceptions and attitudes of individuals, but argues that such factors cannot be forecasted and hence should be excluded from forecasting models (McFadden 1974). As a result, even today, forecasting models incorporate relatively few attributes (Handy 2005). In addition, we can only detect the revealed effect of a built environment on walking due to the calibration nature of discrete choice models. Calibration is difficult because revealed behavior – what residents actually do – is not necessarily the same as preferred behavior – what residents would choose to do given a desired set of alternatives (Handy and Niemeier 1997). Revealed behavior is shaped by the specific alternatives available. For example, if a community does not have good pedestrian access, residents will make few pedestrian trips; however, this does not imply they would not make such trips if pedestrian access were better. Hence, an understanding-oriented theory that defines specific factors influencing travel behavior could provide a constructive process that explores the real concerns of individuals.

### *5.3.3 Understanding-Oriented Behavior Theory*

Social psychology theories have been used widely in physical activity studies, including empirical studies that apply the TPB to walking behavior. The theory of reasoned action (TRA) and its extension, the TPB, together provide a framework to decipher individuals' actions by identifying, measuring and combining their beliefs, allowing us to understand their own reasons that motivate the behavior of interest (Montano and Kasprzyk 2008). The TRA and TPB assume that the best predictor of a behavior is behavioral intention (Ajzen 1991). In the TPB, the first determinant of intention, attitude, is an individual's positive or negative evaluation of the behavior. The second determinant, subjective norm, is the person's perception of the social pressure to perform or not perform the behavior under consideration. The third determinant, perceived behavioral control, is the sense of self-efficacy accompanying the ability to perform the behavior of interest. It has been argued that spatial cognition of the environment is equal to the salient beliefs of the TPB and the preference is the same as intention (Van Acker et al. 2010). If more theoretical foundations and empirical evidence on this point could be proven, the TPB may be used to normalize subjective measurements of that environment.

Relevant behavioral outcomes, referents and control beliefs are likely to be different for different populations and behaviors (Ajzen and Driver 1992). Belief elicitation study is a critical step when using the TPB to establish the cognitive foundation of a population's salient behavioral, normative and control beliefs (Ajzen and Fishbein 1980). Only after the belief elicitation procedure can the general TPB theory be applied to understand a specific behavior for a specific population. Although the elicitation phase of TPB studies is important, it is often neglected by researchers (Hagger et al. 2002; Downs and Hausenblas 2005). In the TPB, these background factors are insignificant when constructing the determinants of behavior (Ajzen 2005). In contrast, in transportation studies, it is doubtful that an individual's socio-demographic and socio-economic background factors have real effects on travel behavior, and land use indicators may be surrogates of those factors. Ajzen argues that although a given background factor may influence behavioral, normative or control beliefs, there is no necessary connection between background factors and beliefs. Background factors, including demographic and economic characteristics, are assumed to operate through model constructs but do not independently contribute to explaining the likelihood of a behavior being performed. Whether or not a given belief is affected by a particular background factor is an empirical question. Hence, the TPB leaves us spaces to complement the determinants of walking behavior if the necessity arises.

### *5.3.4 Utility Maximization and "Rationality"*

Clarifying basic assumptions will help us understand the theories. Activity-based approaches and discrete choice models assume that human decision making is based on the utility maximization principle (Koenig 1980). Discrete choice models and the TPB hypothesize that human behavior is rational. It should be noted that the common use of the term "rational behavior" is based on the beliefs of an observer, not the individual, about what the outcome of a decision should be. The beliefs and objective functions of different observers may vary.

It has been recognized that individuals do not always act rationally when maximizing their utility. This is not to say that individuals are irrational; rather, it means that rationality is not always simple (Golledge and Stimson 1997; Montano and Kasprzyk 2008). A fundamental assumption of the TPB is that individuals are "rational actors" who process information and have underlying reasons that determine motivations to perform a behavior. These reasons constitute one's behavioral, normative, and control beliefs, and determine his or her attitudes, subjective norms and perceived control, regardless of whether those beliefs are rational, logical or correct by some objective standard (Fishbein 2007; Montano and Kasprzyk 2008). Some researchers argue that behavior is "irrational" when the behavior changes to a habit (Verplanken et al. 1998). However, measurements of habit strength are neither reliable nor provable. Studies have found that a prior behavior (habit) doesn't predict a later behavior effectively when the built environment has changed (Bamberg et al. 2003).

## 5.4 Conceptual Model and Study Design

Many studies signify the need for better conceptual models to guide future studies (Handy 2005; Handy et al. 2002; Ewing et al. 2003; Owen et al. 2004). Other than the cross-sectional study design, researchers must undertake longitudinal design to achieve a "deeper examination of direct and indirect relationships, interactions, and hypothesized paths of causality" (Saelens and Handy 2008). To fully explore the built environment's influence on walking behavior, both forecast-oriented and understanding-oriented theories should be applied.

### 5.4.1 Cross-Sectional Designs Examining the "Association" Relationship

Cross-sectional designs provide continuous empirical studies to quantify the relation between the built environment and walking behavior by comparing different neighborhood types. The examination of the relationship usually runs in the following kinds of regression analysis. (1) Objective measures regress on walking behavior: most studies in transportation are based on this method, especially with the aid of GIS. (2) Subjective measures regress on walking behavior: most studies in public health adopt this method. (3) "Objective and subjective" measures regress on walking behavior: First, both objective and subjective variables are employed to run the regression, respectively. The two measures are then combined to check if the predictability can be improved. This method identifies whether the objective measure, subjective measure or their combination explains the walking behavior more effectively. (4) "Spatial distortions" and walking behavior: Analyses explore the "mismatch" between the objective measures and their subjective counterparts and the effect of this mismatch on walking behavior outcomes (Gebel et al. 2009). The regression results usually show that the built environment has a significant effect on individuals' walking behavior. However, in reality, it is only statistically significant rather than remarkable and the correlation coefficient is relatively small. In addition, although the cross-sectional design is effective in controlling potentially confounding effects (e.g. socio-economic or socio-demographic), it poses challenges in identifying the causal mechanisms involved.

### 5.4.2 Longitudinal Designs Examining the "Causality" Relationship

Several longitudinal design studies have also been conducted. Krizek (2003) uses longitudinal household travel data in Seattle to examine the relationship between changes in neighborhood forms and household travel behavior. The results show that in controlling for changes in lifestyle, relocating households to neighborhoods with more accessibility could effectively reduce vehicle miles traveled, but it has no significant effect on trip generation or mode splitting (Krizek 2003). Cao et al. (2007) examine the relationship between the residential environment and non-work travel frequencies by automobile, transit and walk/bicycle modes in Northern California. Their study uses quasi-longitudinal data from 547 movers and assumes the movers' residential preferences and travel attitudes remain constant (Cao et al. 2007). Through a structural equation model, they detect more promising neighborhood characteristic effects than those found in previous studies after controlling for "self-selection." However, the reliability of the movers' memories leaves room for argument.

Longitudinal designs exploring causal relationships include two kinds of perspectives or efforts. (1) Examination of the changes in behavior before and after an effort to change human behavior beliefs: "Intervention" studies of physical activity typically take this line of methodology, but it is difficult to say how long this behavior change could last (Sallis et al. 2006). (2) Examination of the changes in behavior before and after a change in the built environment: Urban planning and transport policy studies focus on this method. It is feasible only if there is variation in the environmental conditions detailed by respondents. A key step involves conducting a longitudinal before-and-after survey using the same samples that experienced the changes while working on the assumption that individual attitudes towards travel remain stable. However, physical changes in the built environment are difficult, especially in Western developed cities. In contrast, Chinese cities are experiencing rapid urban growth with built environment changes holding large potential. This will be illustrated in Sect. 5.5.

### *5.4.3 A Combination of the Discrete Choice Model and the Theory of Planned Behavior*

This study proposes a conceptual model (Fig. 5.1). A discrete choice model is calibrated from travel survey data with objective and subjective environmental measures employed jointly. The TPB is used to guide and normalize the process of constructing the subjective measures. A TPB questionnaire is designed to identify key behavioral, normative and control beliefs affecting behaviors equal to perception, cognition and preference. The discrete choice model forecasts the built environment's influence on walking behavior, with more attention paid to the reasons behind the behavior and the underlying preferences of residents. While the TPB is used to construct the perception or cognition process, it can also predict the behavior via the inherent structural equation models between its constructs.

A longitudinal survey of the same respondents that experienced a change in built environment is encouraged. Through the "before" measurements, the relationship

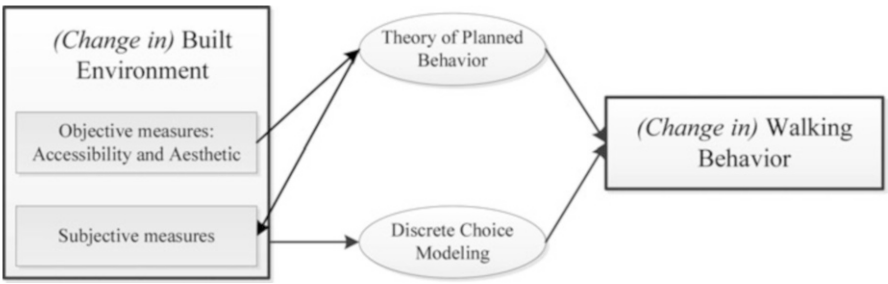


**Fig. 5.1** A conceptual model combining discrete choice model and TPB

between the built environment and travel behavior is analyzed. Based on that, the situation after the change in built environment will be predictable. The “after” measurement can act as a comparison with the predictions. It is instructive to examine the degree to which the measures obtained in the first wave predict those obtained in the second wave and, more importantly, to compare the temporal stability of the measures in terms of different modes of transportation. To assess the overall impact of the change, studies can also compare attitudes, subjective norms, perceived behavioral control, intentions, past behavioral tendencies and reported behaviors before and after the change in built environment.

## 5.5 Study Progress for Walking Behavior in Chinese Cities

It is noteworthy that most of the current studies in this field have been carried out in developed Western countries and regions (e.g. Australia, the United States and Western Europe). The experiences of developed countries may not be applicable to other contexts, especially those undergoing fast-paced urbanization and motorization like China. There is a great potential for China to provide fresh evidence and significant insight.

### *5.5.1 Chinese Cities Versus Western Cities*

#### 5.5.1.1 Developed and Developing

Since the Second World War, Western city urban growth patterns have been dominated by low-density development and employment decentralization. Cities in developed countries are largely built up with an automobile-oriented structure, within which the society is dominated by an automobile culture. After the 1980s, North American and European countries experienced “new suburbanization.” United States studies focus on whether and how the addition of a compact city development strategy in a low-density context can reduce automobile-based travel and improve air quality (Cervero and Duncan 2006). Empirical studies in Western cities tend to confirm the transport and health benefits of land use strategies such as densification, infill development, mixed land use and the job-housing balance.

China, however, is still experiencing rapid urbanization and motorization. Its urbanization rate will increase from 46 % in 2010 to 60 % by 2025. Compared with employment decentralization in Western countries, China’s current suburbanization is characterized by residential decentralization due to old city transformation and the suburban housing market (Zhao et al. 2011). Job opportunities are not comparable with housing decentralizations. The finance, insurance and real-estate sectors are concentrated and growing rapidly in the central areas of cities. The featureless expansion of the central built-up area will most likely form a mono-centric rather than a multi-nuclei city (Jiawen Yang et al. 2011). Fortunately, most Chinese cities are still in the early stages of motorization, with an average of just 47 vehicles per 1,000 people in 2009 compared with 802 in the United States (World Bank 2011). However, China's automobile industry boom and highway construction will further encourage private motor vehicle ownership. It is critical to avoid the formation of car-dependent travel attitudes and lifestyles in this stage of city "restructuring" (Zacharias and Tang 2010).

#### 5.5.1.2 Public Ownership and Institutional Intervention

Different from Western cities, urban land in China is under public ownership. Although the transformation of land use from a planning economy to a market economy has replaced numerous urban administrative procedures, the municipal government is still fundamentally in charge of making and implementing detailed land use plans and infrastructure investment strategies, taxing users of urban land and licensing various kinds of urban activities (Shen 1997). Yang et al. (2011) point out that the continuous expansion of Beijing's central built-up area and the absorption of the suburbs are not purely market-based processes but processes conditioned by government-formulated spatial planning and infrastructure investment strategies. The highest quality infrastructure and social services are supplied in the central part, while suburban communities are relatively neglected in terms of receiving municipal investment (Jiawen Yang et al. 2011). If polices are centralized, it is hard to form decentralized self-sustainable centers with working, living, education, shopping and entertainment units, all of which are believed beneficial to encouraging short trips and non-motorized movement.

In the transformation process of Chinese cities, old institutions and new institutional factors coexist and have a mixed effect on individual travel patterns. *Danwei,* with its successors *xiaoqu* and *shequ*, atomizes the structure of trip sets and urban life at the neighborhood scale (Yang and Gakenheimer 2007; Wang and Chai 2009; Bray 2005). Zhao and Lu (2010) argue that in the case of China, the housing provision system and labor mobility management have played important roles in influencing job accessibility and hence commuter behavior (Zhao and Lu 2010). They conclude that in addition to controlled household income, individuals' occupations and the transport mode, the interaction of the housing provision system (welfare-oriented housing versus market-oriented housing (Li 2000)), the market system (labor market institution), the *Hukou* system (urban *Hukou* versus rural *Hukou*) and the urban life unit (*xiaoqu* or *shequ*) have had a significant effect on individual commuting behavior. More attention should be paid to these institutional factors when researching the built environment's influence on walking behavior in China.

#### 5.5.1.3 High Density and Overconcentration

Contemporary urban China is conducting the same strategies as Western cities, such as new urbanism, smart growth and TOD, but in high-density urban areas.

Many Chinese metropolitan areas average 200–250 persons per hectare, with local urban densities reaching much higher figures. Megacities like Shanghai and Beijing are among the densest urban areas in the world (Yang and Gakenheimer 2007). In Hong Kong's urbanized areas, dwelling density reaches over 1,250 units per hectare; this is in stark contrast to European cities, where inner-city areas rarely exceed 125 residential units per hectare (Cerin et al. 2011). In such a high density, however, less than 10 % of the urban land is used for road infrastructure in most pre-reform Chinese cities. Hence, overconcentration is a potential problem affecting individual travel and urban transport. The distance-saving benefits of high densities will probably be offset by the congestion stemming from overconcentration (Jiawen Yang et al. 2011). Yang et al. (2011) have confirmed that neighborhoods with relatively high densities do not necessarily have lower drive commute percentages. It seems difficult to strike a balance between high density and overconcentration in China.

## *5.5.2 Pilot Studies in Chinese Cities*

### 5.5.2.1 Pilot Studies and Stage Results

Typical empirical studies in China are summarized in Table 5.1, and several findings can be observed. First, pilot studies are mainly conducted in megacities such as Beijing and Shanghai. Fewer cases are found in medium-sized cities. Second, the built environment is usually measured objectively. Regression models are adopted to reveal and forecast the behavior. Internal human psychology factors are rarely considered. Third, job-housing balance and commuting behaviors are the major focuses rather than non-work behavior. The mismatch of jobs and housing spaces in these studies is believed to be a main reason for traffic congestion during rush hour (Zhou and Liu 2010; Zhao et al. 2011). Finally, most of these studies are carried out by Western-trained and foreign scholars.

### 5.5.2.2 Learning from China's History

China has a longer urban development history than most developed countries. Rather than borrowing ideas from the West, China may be better off learning from its own history. Recent urban development has departed significantly from the traditional compact, mixed-use settings with most activities within walking distance that used to characterize Chinese cities. Neighborhoods in China have continuously evolved and undergone several major societal and institutional transformations, including the declined work-unit compounds (*danwei*), the courtyard in Beijing, the *Linong* in Shanghai, and the newly raised *xiaoqu* and *shequ*. In China, walking and bicycling have a long tradition. Jiang found that old neighborhood forms

**Table 5.1** Typical empirical studies of walking behavior in China

| Reference | Sample | Study design | Environmental attributes | Walking scenario | Scale | Method | Results |
|---|---|---|---|---|---|---|---|
| Pan et al. (2009)<br>***Shanghai*** | 1,709 individuals from four selected neighborhoods (conducted by on-street interviews) | CS, O | (1) *Distance to city center*: Distance to CBD and the nearest city sub-center;<br>(2) *Diversity of land use*: Commercial, industrial, etc.;<br>(3) *Density*: Population density, average block size, road length, road density;<br>(4) *Distance to transit*: Number of bus stops and rail transit stations within 1 km radius of the neighborhood centroid | Travel modal choice: Non-motorized modes (walking and cycling), transit and driving | N | Multiple logistic regressions | In traditional neighborhood with relatively high densities and small street blocks, trip distance is shorter and people are more likely to choose walking or cycling |
| Cervero and Day (2008)<br>***Shanghai*** | A before-and-after survey of 900 recent movers (containing 2,840 inhabitants) in three suburban neighborhoods | LD, O (relocation) | (1) *Distance to transit*: Metro rail services, levels of mixed-use activities;<br>(2) *After relocation*: In superblock, less walking-friendly, mixed-use environments than residents' previous neighborhoods | Mode change: Non-motorized to motorized transport; bus to other motorized transport | R & N | Descriptive statistics and binary logistic models | Relocating to a suburban area near a metro-rail station encourages commuters to switch from non-motorized and bus transit to rail. Proximity to regional rail networks has stronger influence on commuting behavior than neighborhood street designs and land-use patterns |

(continued)

**Table 5.1** (continued)

| Reference | Sample | Study design | Environmental attributes | Walking scenario | Scale | Method | Results |
|---|---|---|---|---|---|---|---|
| Wang and Chai (2009)<br>***Beijing*** | 736 heads of households who are employed | CS, O | (1) House provided by *danwei* (self-contained work unit compound); (2) House provided by private market | Commuting behavior; walking is included in non-motorized transport | R & N | Structural equation model | *Danwei* (work-unit) housing commuters have shorter commuting trips and higher usage of non-motorized transport modes than those in market housing |
| Yang (2010)<br>***Beijing*** | 1,499 workers from 48 neighborhoods, with 25 households surveyed in each neighborhood | CS, O | Neighborhood location: Distance to Beijing's geometric center (*Tian an men* Square), distance to the closest job centers and distance to the closest subway station | Mode choice (percentages of commutes by various transport modes) | R & N | Simple regression model | Commuting time and mode split vary according to the age of the neighborhood. The newer the neighborhood, the higher the percentage of non-motorized modes (including walking and cycling) and the shorter the commuting time |
| Zhou and Deng (2010), Zhou and Liu (2010)<br>***Guangzhou*** | 1,006 individuals from 800 household in 11 "street blocks" that are enclosed by roads with 1 $km^2$ area | CS, O | (1) *Housing types:* House provided by *danwei*, low-priced welfare housing, rental housing, commercial housing, urban village (*chengzhongcun*), affordable housing (*jingjishiyongfang*), etc.; (2). *Housing locations:* Traditional city centers, transaction zones, fringes of the city | Daily activities with mode choice, walking may be included but not specific | R & N | Distance buffer analysis | The spatio-temporal activity patterns vary with different classes (income). The activity space of the lower class is smaller, concentrated mainly in the inner city and the area around their residential communities, opposite to the higher income class, who have free choice of housing |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Zhou and Yan (2006)<br>***Guangzhou*** | 1,428 individuals from 827 households in 8 "street blocks" | CS, O & P | House types and locations (same as aforementioned), population density and service facilities | Walking is included in commuting behavior | R & N | Correlation statistics, GIS | Residents in the city center area have shorter commute times, and more walking and bicycling may be adopted. Perception is collected roughly but not employed in travel behavior analysis |
| Yang Jiang et al. (2012)<br>***Jinan*** | 1,233 user surveys at 19 bus rapid transit (BRT) stations along three BRT corridors | CS, O & P | (1) *BRT station context*: Terminal, transfer or typical; (2) *Corridor types*: Arterial edge, integrated boulevard, below expressway | Distance people will walk to access the BRT | N | Ordinary least squares regression | People would walk farther to BRT stations when the walking environment has certain features (median transit-way station location, shaded corridors, busy and interesting) |

*CS* cross-sectional design, *LD* longitudinal design, *O* objective, *P* perceived, *N* neighborhood, *R* regional are associated with 65–80 % less travel energy use than the “superblock” (Jiang 2010). The energy reduction is probably due to the mixed land uses, implicit traffic calming measures and parking restrictions. Today, mid-rise and high-rise residential towers have gradually replaced neighborhoods with unique local characteristics. To improve automobile accessibility using the transportation infrastructure investment, only the motor-vehicle ways have been widened and extended, while sidewalks and cycle tracks have been narrowed in most cases (Yang and Gakenheimer 2007). Nevertheless, historical design principles could be revisited to inspire China’s policymakers and urban planners to establish guidelines for new neighborhood forms in future urban development.

#### 5.5.2.3 Potential for Longitudinal Design Studies

Economic growth is the major driving force of development. In addition to the urban growth and plan reform movements, land use pattern changes, transportation and design occur almost every day in China. Relocation is common in Chinese cities, from inner cities to the outskirts, freely or as a result of enforcement, with goals of housing ownership, good living conditions and physical proximity to workplace (Cervero and Day 2008). Examining longitudinal design in China to track movers and conducting a before-and-after survey of their walking behavior will provide not only fresh experiences, but also rigorous evidence for the built environment’s causal influence on walking behavior.

#### 5.5.2.4 Transit-Oriented Development May Be the Future

Given China’s large population and limited land size, the ideal choices for urban China are compact and transit-friendly cities rather than American-style automobile-oriented urban landscaping (J. Yang and Gakenheimer 2007). Cervero and Day (2008) suggest that TOD holds considerable promise for placing rapidly suburbanizing Chinese cities on more sustainable pathways (Cervero and Day 2008). Opportunities for creating sustainable city forms by bundling land use investments and TOD in large Chinese cities are quite substantial and largely untapped, and to date, China has not formed this interconnection (Pan et al. 2007). Today, increasing numbers of large, rail-served Chinese cities consider TOD an alternative form of urbanism that reduces over-reliance on private automobiles. Many new communities developed along TOD corridors could become veritable bedroom communities and deserve more attention. Even if the TOD concept is favorable, the kind of TOD we should pursue remains an urgent question (Zhang 2007). This cannot be answered without empirical investigation in the local context.

## 5.6 Conclusions

This study reviews and analyzes the experiences and results of the influence of built environment on walking behavior conducted in Western countries. It argues that while accessibility as an integrated objective measure could improve comparability across studies, more subjective measures are needed. It suggests that the TPB can help us understand the built environment's influence on walking behavior and normalize the procedure to subjectively measure the built environment. In addition, introducing greater specificity to the measures would improve the explanatory ability of the developed model. A theoretical basis for the examination of the influence is offered from two perspectives: a forecast-oriented perspective by a discrete choice model and an understanding-oriented perspective by the TPB. Discrete choice models mostly adopt objective measures, while the subjective measures constructed by the TPB can be systematically employed into a discrete choice model as complements. A conceptual model combining a discrete choice model and the TPB is proposed to explore the built environment's influence on walking behavior.

Different from Western cities, Chinese cities are experiencing rapid motorization and urbanization. Driven by economic growth and transportation infrastructure investment, contemporary urban China is departing from a history marked with high-density, mixed-land-use and walking traditions. The built environment changes every day. Residence relocation is ongoing either freely or under enforcement, making longitudinal design studies very possible. Although the effect of the market economy on the urban form is becoming more significant, institutional factors still play an important role in the modern city transformation process. Governments are still pivotal in making urban planning polices in China. Opportunities for creating sustainable city forms through bundling land use investment and TOD in large Chinese cities will be quite substantial in the future. Most Chinese studies focus on the job-housing balance and less on the social differentiation and stratification caused by the job-housing separation. More empirical studies that move beyond Western experiences and policies are required.

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