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A Statistical Meta-Analysis of the Design Components of New Urbanism on Housing Prices

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Abstract

The principles of New Urbanism such as increased density, mixed land uses and street connectivity are often recommended in response to the typical conditions of suburban developments. Much current empirical research has begun to test whether these principles can increase property values. The findings of these empirical studies have, however, been quite inconsistent. This research attempts to quantitatively synthesize these conflicting findings through a statistical meta-analysis. This study found that a lower density, decreased street connectivity and a closer proximity to a transit stop contributed to increased housing premiums, while mixed land uses were not shown to always do so.

Keywords: New Urbanism, meta-analysis, density, mixed land use, street connectivity, transit proximity, housing price, hedonic modeling

Introduction

The design philosophies embraced by New Urbanism emphasize certain urban forms such as higher densities, larger proportions of mixed land uses, less disconnected streets, and higher ecological sensitivity when compared to conventional suburban sprawl (Newman and Saginor 2016). Many advocates of New Urbanism posit that this approach can create physically active, socially interactive, and environmentally friendly built environments (Talen 1999; Lee and Moudon 2004). To support this argument, previous scholarly research has holistically examined the impacts of neighborhood design on quality of life in the domains of materials (e.g., energy saving, land conservation, cost efficiency, and safety) (Anderson et al. 1996; Southworth 1997), physicality (e.g., physical activity and mental health) (Lee and Moudon 2008), sociology (e.g., place attachment, sense of community, and social interactions) (Freeman 2001; Frumkin 2002), and environmental change (e.g., air quality and habitat protection) (Ewing and Rong 2008; Kahn 2000).

The impacts of neighborhood design on market prices paid for residential properties have also been frequently studied as housing value has proven to be a practical and effective indicator to measure overall satisfaction of residents (Yang 2008). These studies are often called hedonic pricing or hedonic models. The hedonic pricing model assumes that increased or decreased value in the sales prices of residential properties can imply the level of contentment of residents about their neighborhoods, when controlling for other property value determinants (Adamowicz et al. 1994; Sirmans et al. 2005). While the effects of New Urbanism, as a design framework, have received a relatively little attention by economic researchers compared to other conditions such as scenic views, open space, and/or proximity to amenities, there have been a few attempts to isolate which particular design elements of New Urbanist neighborhoods influence housing price premiums (Song & Knaap 2003). Findings from previous studies have not fully supported the New Urbanist design philosophy for the creation of favorable conditions for residents, regardless of research scope. In some cases, research has shown an increased neighborhood satisfaction for denser, more walkable residential environments (Song and Knaap 2003; Irwin 2002; Shultz and King 2001; Diao and Ferreira 2010), while other studies found that consumers are willing to pay less for houses in New Urbanist neighborhoods (Myers and Gearin 2001).

This study attempts to help shed light on this quandary by seeking to determine if New Urbanist-based design elements increase or decrease housing prices. Unlike previous studies, however, this research does not conduct an additional hedonic pricing model. It integrates separate findings across multiple individual studies which assessed similar research questions. Instead of providing a narrative and descriptive summary, this study employs a statistical meta-analysis to quantitatively evaluate associations between housing premiums and New Urbanism based neighborhood design components using density, mixed land use, street connectivity, and proximity to transit as measures.

Previous Studies: Theories and Empirical Findings

Theoretical arguments: The benefits of New Urbanism

Beginning in the late 1990s, New Urbanism-based developments became some of the most influential and widely adopted projects. These projects ranged from both public (e.g., HUD community design guidelines for HOPE VI, or Homeownership Zones) and private sectors (e.g., master planned communities or subdivision developments). Although the focus and ultimate implementation/build out of each New Urbanism design can be slightly different —as New Urbanism often embraces various types of "sustainable" design strategies such as transit oriented development (TOD), traditional neighborhood development (TND), or the urban village model—each shares key design elements such as high density, mixed land uses (including mixed housing types), well-connected streets, proximity/accessibility to transit and facilities supporting more walkable and sustainable neighborhoods (Williams, Burton, and Jenks 2000; Katz 1994; Ford 1999; Cervero and Kockelman 1997). This study focused on these four key concepts— high density, mixed land use, street connectivity, and proximity to transit—each of which has been shown to primarily determine the basic lay-out of neighborhoods and the flow of activities of residents (Lynch and Rodwin 1958) and has consistently appeared in articles testing the impacts of New Urbanism designs.

In theory, these four design elements can be positive potential correlates to neighborhood satisfaction resulting in increased housing premiums. **Density** is a development intensity-based measure that is typically calculated by land consumption per population, households or dwelling units. A neighborhood with a higher density is likely to be more clustered (Tsai 2005) so that people can optimize the use of land and other resources while reducing energy consumption (Ewing and Rong 2008; Echenique et al. 2012). A higher density is also a preliminary requirement for promoting walking, bicyling (Brownstone and Golob 2009; Duany et al. 2001; Forsyth et al. 2007) and social interaction (Putnam 2001; Ewing 1997) because developments are located close enough to each other so that urban functions can be shared effectively and people have more of a chance of running into each other (Frumkin 2002; Anderson, Kanaroglou, and Miller 1996; Williams et al. 2005; Williams, Burton, Jenks, et al. 2000). **Mixed land use** denotes a mixture of well-suited and compatible land uses in a certain area. It is theorized that mixed land use can also increase pedestrian activity since people can easily walk to places where they can shop, eat, and play (Lee and Moudon 2008); in turn, it can also lessen travel expenditures and energy consumption for private vehicles (Jabareen 2006). Increased pedestrian travel and natural surveillance from stores open at all hours with people interacting with them also contributes to chances of social encounters (Jacobs 1961). This can, then, result in an active public life and strengthened social ties (Duany, Plater-Zyberk, and Speck 2001; Rohe and Stewart 1996). Mixed land use often incorporates diverse housing types in a single neighborhood. It is assumed that homogeneous single-family dominant neighborhoods can decrease demographic and socioeconomic diversity (Rowley 1996; Frumkin 2002). Monotonous types of houses proscribes empty nesters and couples with no children who need to move to smaller houses (Frumkin 2002; Elkin et al. 1991), but want to remain in the same neighborhood from a neighborhood they have aged in place.

Streets and blocks comprise the basic framework of a neighborhood by both dividing and connecting areas. Creating street patterns is one of the primary design elements of New Urbanism, especially at the community scale. Street patterns are also closely related to pedestrian accessibility and movement (Southworth and Owens 1993; Lee and Moudon 2004). In cooperative endeavors with a higher density and mixed land use, well-connected streets can promote pedestrian travel and an active street life which can lead to increased social interactions (Duany et al. 1991; Talen 1999) and more physical activity and better public health (Frank and Engelke 2001).

Proximity to transit is one of the most critical elements of New Urbanism based designs, suggesting that various types of transportation modes (other than private cars) such as walking, bicycling, trains, subways and buses should be incorporated into new and existing developments. Increased accessibility to transit services can reduce travel costs (money and time) to job and activity centers, ease congestion and lower energy consumption and emissions while promoting land conservation, increasing tax revenues for transit agencies and municipalities and improving social interactions and physical activity (Ryan 1999; Evans et al. 2007; Cervero 2004). People and municipalities have begun acknowledging the benefits of having rapid transit systems and there will be more demands in the future (Bartholomew and Ewing 2011).

Empirical Studies: Impacts of design on housing premiums

A large and growing body of research has quantitatively examined the impacts of urban design components on neighborhood preference, using housing premiums as a measure. It is theorized that by examining how much consumers are willing to pay for goods, the extent to which existing environmental and service factors affect the preference of residents or potential home buyers can be estimated (Li and Brown 1980; Sirmans, Macpherson, and Zietz 2005). Many cases involving previous research also adopted this method and examined the impacts of New Urbanists' principles. They found mutually incompatible results. Several researchers discovered that **high density** is likely to decrease individual housing prices (Geoghegan et al.

1997; Song and Knaap 2003; Irwin 2002; Shultz and King 2001), while Lcggett and Bockstael (2000), Sohn et al. (2012), and Bowes and Ihlanfeldt (2001) reported opposite findings. Further, Tu and Eppli (1999) concluded that high density was a favorable condition in increasing housing premiums, but only where other design components of New Urbanism principles were also implemented. Preferences for higher densities have also shown varying results when examining multiple study areas (Matthews and Turnbull 2007), scales or units of analysis (Geoghegan, Wainger, and Bockstael 1997) and/or different control variables (Li and Brown 1980). Therefore, the overall estimated impacts of high density on housing premiums are not entirely understood.

As noted, **mixed land use** has been reported as both a positive and negative condition for increasing housing prices. Van Cao and Cory (1982) and Geoghegan, Wainger, and Bockstael (1997) found that a greater mix of land uses typically increased housing prices. Inversely, Song and Knaap (2003), Irwin (2002), and Sohn et al. (2012) stated that people were less willing to pay premiums for houses where various kinds of land uses were located. Song and Knaap (2004), then specified the measures of mixed land use and strengthened the conclusions of their previous research, determining that the proximity to and a level of mix of specific types of land uses resulted in differing effects. Findings concluded that 1) being closer to a commercial area was likely to increase housing prices, whereas being farther from multi-family housing, institutional areas and industrial land uses raised housing prices and 2) having a large proportion of commercial and multi-family housing tended to increase property values, but larger ratios of industrial and institutional land uses in neighborhoods tended to decrease them. Relatedly, Shultz and King (2001) suggested that more commercial land uses had positive influences on housing values, while industrial land uses presented negative associations when using different sample sizes even within the same neighborhood definition (census block). Results tended to be more disparate when using different neighborhood definitions with similar sample sizes.

Well-connected streets have shown similar trends with higher density and mixed land use. Some research reported that well-connected streets was an unfavorable condition for neighborhood inhabitants (Diao and Ferreira 2010; Song and Quercia 2008; Asabere 1990; Shultz and King 2001; Boatwright et al. 2013), others claimed the opposite (Konecny 2011; Shin 2013; Li et al. 2014; Song and Sohn 2007). Interestingly enough, Song and Knaap (2003) found conflicting results for well-connected streets, depending on the measures of “well-connected.” A high links-nodes ratio (the ratio of street segments to number of nodes of activity) and street density (the total street segments per unit area)—a high level of connectedness— were shown to likely increase housing values. The presence of cul-de-sacs—or less connectivity—was, however, also shown to increase housing values. In research which only observed the presence of cul-de-sacs, many concluded that less street connectivity advocated increased housing premiums. Only when also utilizing a links-nodes ratio and street density was the reverse situation shown to occur.

Like other design compoennts of New Urbanist principles, impacts of the proximity to transit also show inconsistent results. Lewis-Workman and Brod (1997) and Hess and Almeida (2007) found that a close proximity to a transit station were likely to increase housing prices, while Voith (1991), Yan et al. (2012), and Kim and Lahr (2014) observed increased housing prices in areas that did not have a transit station in any census tract. Armstrong and Rodriguez (2006) reported both insignificant and positive influences of transit stations depending on analysis model construction while Landis et al. (1995) found positive impacts of being close to transit stations on housing premium, but only in two counties out of four study areas. Even in the same municipality, the impacts can vary by rail lines, times and modeling approaches (Cervero 2006; Mathur and Ferrell 2009; Kuethe 2012).

Literature Gaps

Observing an individual piece of empirical research is interesting because the research settings of each of them (such as construct, measurements, samples, sample size, unit of analysis, or location) varies. However, a generaltionalized understanding of the extent to which New Urbansim can impact housing values is needed. As discussed above, a narrative synthesis can be one way to integrate separate pieces of research and understand trends in previous studies, but it rarely brings a generalized conclusion from a mixed bag of results. A statistical meta-analysis could be one way to provide an estimate of the positive or negative associations, the level of significance and the consistency of the effects of New Urbanism-based design principles on housing prices in a quantative way.

Research Design

Identification of previous research

To initiate the meta-analysis, this study sets up three criteria for the process of collecting articles. First, we identified empricial articles written in English which were available after 1980 through Google, Google Scholar, ScienceDirect, Web of Science, JSTOR, and ProQuest with key words including value, housing price, housing premium, property price, hedonic (pricing) paired with density, land use, mixed use, urban form, street pattern, street connectivity, gird, cul-de-sac, transit, TOD, TND and New Urbanism. Articles listed in the reference list from each of identified papers were also detected. To avoid a potential bias of published results—most of the published peer-reviewed journals are likely to report highly significant findings, which is called a "file-drawer problem" (Ewing and Cervero 2010; Field and Gillett 2010)—unpublished, preprints, and reports were included, if available. Conference proceeding papers, disserations or theses were also included, but if disserations, theses or conference procedings were published with the same form in peer-reviewed journals, we only included the peer-reviewed published versions. Second, studies that employed density, land use mix, street connectivity, and proximity to transit as control variables were taken into account due to the limited numbers of works that independently or simultaneously observed our interests. Through this process, we firstly identified more than 200 papers, but 139 different analyses from 52 articles with a total sample size of 654,762 were compiled for the final analyses becase of following criteria; 1) we exclude papers that are not successful to reported valid statistics—including descriptive literature review papers—such as t-value and p-valuefor the computation of the effect sizes; and 2) As Sánchez-Meca and Marín-Martínez (1997) suggested, explanatory variables examined in less than six studies were not included to avoid tentative conclusions and contribute to a more meaningful interpretation for a meta-analysis. For example, papers that examined job ratio as a measure of land use mix were excluded since both it was collected less than six cases. Details of articles used for statistical meta analysis in this paper are presented in the Appendix.

Clarification of measurements

Since some independent variables of interest were quantified differently in previous studies. As shown in Table 1, slightly different measurements were grouped into the same categories, if the variation of measurement was not large enough. For example, studies that measured the presence of cul-de-sacs by observing cul-de-sacs (e.g., 50 % or more) within a neighborhood or a house within 50 or 100 feet from cul-de-sacs; this is because of different unit of analysis (neighborhoods vs. parcels). This study identifies those two measures as the same because if a neighborhood was dichotomously identified as a cul-de-sac, this implies that the neighborhood had a cul-de-sac dominated street pattern so that a property is likely to have a cul-de-sac nearby. Both sales and appraised values were considered as housing prices because the usage of appraised value has previously been justified in the previous research by presuming that the reviewers from each journal accepted each researcher's explanations for using appraised value. Combining different regressions consisting of variables with different metric units (e.g., feet, mile, or meter for the length measurement) and transformations were not treated as large concerns since dissimilar metrics only affect the deviation, not the effect size (or correlation coefficients) that we are principally examining in this study.

[Table 1. about here]

Meta-analysis procedure

The statistical meta-analysis in this study follows the guidelines suggested by Field and Gillett (2010) and Hunter and Schmidt(2004). First, the results from each study were converted to a common index of effect size before calculating the weighted average effect size across studies. That is, either a t-statistic value or odds ratio provided by each regression were converted into correlation coefficients.[1] Second, the population effect size ($\bar{r}$) was estimated with an individual effect size (r) weighted by the sample size [2, 3] using the random-effect model proposed by Hunter and Schmidt (2004), as opposed to the Hedges and Vevea (1998) model. The Hunter and Schmidt (2004) method has been shown to provide more accurate results than the Hedges and Vevea (1998) (Schulze 2004) and fits better with social science data whose true effect varies across studies (Borenstein et al. 2011). Third, the variance of the sample effect size and the sampling error variance in the sample correlations were computed to retrieve the effect size with a 95% confidence interval and an 80% credibility interval.[4] As Cohen (1992) proposed, this study interprets the effect size of $\bar{r} \approx 0.1$ as small, $\bar{r} \approx 0.3$ as medium, and $\bar{r} \approx 0.5$ as large. Last, the consistency of each variable was calculated. A recent meta-analysis by Huang et al. (in press) indicated that not only is reporting effect sizes in a meta-analysis is important, but so is consistency. In this research, consistency is described by the statistical significance and percentage of the estimated overall effect being significantly positive, significantly negative or insignificant at the 0.05 level, a level of significance assessed with Z-value as suggested by Higgins et al. (2003).[5] Further, a chi-square statistic (χ^2) is used to measure homogeneity of effect sizes (Field and Gillett, 2010). The consistency was interpreted as minimal if the value fell between 0 and 33%, moderate if between 34 and 66%, and high if between 67 and 100%. Table

2 and Figure 1 show the overall outputs and impacts of density, mixed land use, street connectivity and proximity to transit on housing prices from the study. Findings from these outputs are discussed in the following sections.

Findings

Density

Population density was studied in 31 of the utilized cases. Among them, 10% of the studies reported positive, 52% negative and 39% non-significant effects of population density on housing premiums. The calculated mean coefficient was statistically significant by the effect size ($\bar{r}$) of -0.04. This implies that if a neighborhood has a higher population density, the housing prices will be more likely to decrease, which was moderately consistent across previous studies. Fifteen percent of previous studies among 27 cases showed positive, 59% negative, and 26% non-significant effects of **dwelling density**. The weighted mean coefficient was also statistically significant by $\bar{r}$ = -0.03. Like population density, a higher dwelling density generally contributes to the reduction of housing prices, which was moderately consistent across the studies.

Mixed land use

Initially, the **proximity** to non-residential land uses such as commercial, industrial and institutional uses was observed by measuring the distance to each land use. Among 16 studies that researched the effects of the distance from the house to the nearest commercial land use, 38% reported positive, 19% negative, and 44% non-significant impacts on housing premiums. The effective size was not statistically significant ($\bar{r}$ = 0.01). The distance to the nearest industrial land use was tested in ten studies. Sixty percent of them reported positive, 10% negative, and 30% non-significant effects of being located farther from industrial land uses. The effect size was not statistically significant ($\bar{r}$ = 0.02). Despite half of the studies declared that being closer to industrial land uses had negative impacts, it was not a statistically significant. Six studies reported 17% positive, 50% negative, and 33% non-significant of being situated farther from the nearest institutional land use. Overall, the weighted effect size was 0.05 ($\bar{r}$ = -0.05), which was statistically significant and negatively related to housing prices. That is, when an institutional land use is closely located to a residence, housing prices are more likely to increase. Overall, being closer to institutional land uses increases housing premiums while commercial and industrial land use did not show meaningful effects.

Mixed land use was often examined by the **proportional distribution** of land uses within a certain boundary from a house. These were areas defined by urban blocks, grids, buffer radius, census geography, subdivisions, or traffic analysis zones frequently appointed as neighborhoods. First, the impact of the proportion of single-family housing was examined in six studies. Although 50% of the studies reported a positive impact of having a larger proportion of single-family housing on housing prices, it had a non-significant effect ($\bar{r}$ = -0.03) and was minimally consistent across studies. Similarly, commercial land use showed insignificant effects ($\bar{r}$ = 0.00) and was minimally consistent across studies (33%). Of nine studies examining industrial land uses, 33% indicated positive and 67% negative effects on housing premiums with a statistically negative effect size of $\bar{r}$ = -0.09. Non-residential uses showed non-significant effects on housing price, which was highly consistent among eight studies (88%). Overall, the ratio of non-residential land use has been repeatedly reported as a non-significant factor, except for industrial land use. The larger the industrial land use, the lower the housing values.

Diversity index counts the number and proportion of land use types (called richness) and distribution patterns (called evenness) simultaneously. The diversity index were often calculated in two ways, including or excluding single-family housing with multi-family housing and non-residential land uses such as public, industrial, commercial, agriculture, etc. The types of non-residential land uses are slightly different by studies. Ten hedonic models that used a diversity index to examine the mixture of single-family housing and other land uses suggest a significantly negative effect ($\bar{r}$ = -0.02) with a moderate consistency (50%). Nonetheless, eight studies measuring diversity index (excluding single-family housing) reported that evenly and spatially distributed non-single-family uses had positive impacts on property values with an effect size by $\bar{r}$ = 0.03 with a high consistency (75%). Both of the results indicate that housing prices are likely to decrease where a neighborhood has a land use mix composed largely of single-family and non-single-family housing uses. Housing prices are, however, prone to increase when only non-single-family housing uses are evenly distributed.

Street patterns

The absence of cul-de-sacs, high street and intersection density, and high value of links-nodes ratios usually indicate a greater connectivity. Ten studies tested the presence of **cul-de-**

sacs. Having a cul-de-sacs in a neighborhood has been shown to have a positive effect on housing premiums by $\bar{r}$ = 0.05 with a moderate consistency (50%). Six studies examined the impact of **street density** and found that it was negatively related to housing values by a significant effect size ($\bar{r}$ = -0.02) and high support (67%). Overall, seven studies that examined **intersection density** including the ratio of intersections to nodes (five studies) and the number of intersections per unit area (two studies), 71% of them reported positive impacts whereas the synthesized result showed a non-significant effect ($\bar{r}$ = 0.00). Given that, the non-significant influence of intersection density was minimally consistent across studies (15%). Similarly, the **links-nodes ratio,** measured by the ratio of street segments to number of nodes, also showed a non-significant effect ($\bar{r}$ = 0.01). Nonetheless, this result only had a poor consistency (17%) across studies. To sum up, cul-de-sacs and low street density—both indicate low street connectivity—are likely to contribute to an increase of housing price.

Proximity to transit

The proximity to transit stops were often measured with both actual distance and network distance to the nearest transit station and the presence of stops within quarter- or half-mile. **Straight line distance to the nearest transit stop—**in other words being away from transit stops—had a negative impact on housing premiums ($\bar{r}$ =-0.04) and this was statistically significant and moderately constant across 27 studies (63%). Inversely, **network distance** was not statistically significant ($\bar{r} = 0.01$), which was moderately consistent out of twelve studies. Interestingly enough, properties within a quarter-mile distance from transit stops, which implies a closer proximity to, were likely to have a higher housing value ($\bar{r}$ =0.03) than beyond this distance, while a half-mile ($\bar{r}$ =0.01) was not a significant condition. In summary, being located close to transit stops is a positive condition that increases housing values in general, but it becomes more effective when a property is located within a quarter-mile radius.

[Table 2 and Figure 1 about here]

Discussion

Table 3 summarizes the findings in this statistical meta-analysis. First, **higher density** was shown to create discounted housing premiums, which was moderately consistent through the literature. Other than economic effects, increased density does have the ability to reduce infrastructure expenditures, increase physical activity, result in more face-to-face social interaction, provide more public realms due to decreased private space and help protect natural habitat (Jabareen 2006; Forsyth et al. 2007; Ewing 1997; Talen 1999). Despite the benefits of high density, this study did find that people are less likely to invest in houses in higher density neighborhoods. This may be because high density can be perceived as a "crowded" environment and prone to causing stress (Yang 2008; Frank and Engelke 2001). Possibly, home buyers or owners may be less aware of the external benefits of having high density such as the reduction of expenditures for infrastructure and the increased protection of natural habitat since they are directly paying for these costs. Perhaps the use of housing premiums as a surrogate measure for neighborhood satisfaction neglects many of the non-economic benefits of the variables utilized. In some cases, invisible social capital in neighborhoods such as increased relationships, emotional support, and collective efficacy formed by increased social contacts by higher density are rarely reflected in housing premiums (Temkin and Rohe 1998; Ross et al. 2000).

Second, the overall impact of **mixed use** can vary according to proximity to specific land uses and/or the proportion and location of land uses per neighborhood. Only the proximity toward some types of non-residential land uses was shown to likely contribute to housing premiums. For example, distance to institutional uses and the proportion of industrial uses matter. Being closer to public institutions could be a positive factor on housing premiums, while having a larger proportion of industrial land use was negative on premiums. According to our findings, the level of conflicts between single-family housing and government offices or elementary schools is lower than industrial land uses. It has been frequently mentioned that distance to a school (an institutional land use), especially an elementary school, is one of the factors to gauge the potential of walkability resulting in an increased quality of the school (Kane et al. 2006; Gibbons and Machin 2008; Li et al. 2014). On the contrary, industrial uses are typically nonconforming uses in residential areas and are the most commonly found land use conflicts in urban areas. As found in many previous studies, a large distribution of industrial land uses have negative effects on residential settings (Quigley and Rosenthal 2005). Recent increases in de-industrialized areas and related abandonment could be another possible explanation, especially in depopulating, shrinking, or legacy cities. The land use diversity index indicated that if several land uses including single-family housing were spatially and proportionally scattered, housing prices were likely to decrease. However, when only examining non-single-family housing land uses, higher and more equally mixed non-single-family housing uses were considered desirable. This suggests that housing buyers set more value on homogeneous neighborhoods with less non-residential uses (Song and Knaap 2004). But, if a neighborhood is not a dominant single-family area and characterized by multi-family housing, institutional, or open space it may be better to have evenly distributed mixed non-single-family uses to support various activities. This could be heavily influenced by the margin of endurance of negative spillovers from conflicting uses with single-family housing. In this sense, mixed land use can be both a positive or negative factor on housing premiums depending on the types of land uses, the level of conflict with single-family housing, combinations or spatial configurations.

Third, less **connected streets** were shown to be more likely to promote housing premiums. The presence of cul-de-sacs and lower street density were associated with enhanced housing prices. Even though greater street connectivity can contribute to increases in physical activity, decreases in automobile usage and enhancement of active street life (Duany et al. 1991; Lee and Moudon 2004), cul-de-sacs and less connected streets can maximize privacy by preventing random access of unknown people (Southworth and Owens 1993; Asabere 1990; Matthews and Turnbull 2007) and be more flexible to topography in laying out houses resulting in decreased construction costs (Asabere 1990; Friedman 2007). Well-defined boundaries with cul-de-sacs/less connected streets also could help integrate inhabiting residents (Asabere 1990).

Fourth, proximity to transit stops can contribute to increased housing prices. Differentiating from other New Urbanists' design suggestions such as density, mixed use or street connectivity, this is the only positive factor that could contribute to increased housing premiums. While network distance was not statistically significant in this study, this does not necessarily signify that network distance is less of a critical factor. This could be simply due to condition that the significances stated in the individual studies were so minor so that the effect sizes become non-significant when diverse variances are considered, while still giving a large number of degrees of freedom. On the other hand, there were still a moderate number of previous studies which reported insignificant results, 42% among 12 analyses that contributed more to the production of this research's non-significant results. Cross sectional studies would be less effective in showing the changes of preferences toward transit stops; Yan et al. (2012) found that the relationships of network distance on housing premiums were all positive, but decreased over time. This study also found that housing located within a quarter-mile distance was a more positive factor on housing prices. Both a quarter- and a half-mile are often recommended as walkable distances, but many planners agree that a quarter-mile, which is about a five-minute walk, is a pleasantly acceptable walking distance (Gallion 1950; Duany and Plater-Zyberk 1994; Park and Rogers 2015; Nelessen 1994). Calthorpe (1993) transit oriented development (TOD) concept suggests a ten-minute walking time to transit stations with a 2,000-foot radius (about 0.38 mile), which is still shorter than a half-mile. As expected, this finding shows that transit and walkability are tightly linked and people are sensitive to distances involved with each.

Lastly, as expected, the effect size of each design element appeared to be small; every statistically significant weighted mean coefficient was less than 0.1. As claimed in previous literature, the small effects are primarily due to the quantity and quality of housing structures such as numbers of beds, lot sizes or built-in facilities that play a more decisive role in determining the housing prices. Other physical conditions (e.g., scenic views, parks or landscapes), threads of livability (e.g., trash, traffic, or noise), and social status (e.g., race, education, tenure or social network) and economic status (e.g., poverty rate, income or school quality) also influence housing values (Bartik et al. 1992; Lansing and Marans 1969; Hite et al. 2001; Grether and Mieszkowski 1974; Weiss et al. 2011; Paquin 2007; Sirmans et al. 2006), but have relatively small impacts in comparison with housing structure. This indicates that design does not fully determine housing values, but can still have a strong influence.

[Table 3 about here]

Conclusion

Recommended design principles in urban planning projects have not been consistently global over the past hundred years. Once suburban developments flourished, but now opposite design standards have been encouraged in response to the temporal defects of suburbanization (Newman 2015). These modified design principles, called New Urbanism, have been believed to promote a better quality of life by protecting nature, saving energy, increasing social interactions, and providing activities in the public realm. Even though potential benefits of New Urbanism design principles, several empirical studies have attempted to examine whether the actual residents' preferences are equivalent to the theoretical arguments by using property value as a surrogate of neighborhood satisfaction. Findings of these empirical studies, however, are inconsistent. Hence, this study sought to quantitatively combine these contrary outcomes and found that design aspects have impacts on housing values, though they are relatively small. To sum up, people still value large lots, lower density, separation from non-conforming land-uses, secluded space with less connected streets over New Urbanism principles, but also enjoy the benefits of living close to transit stations, if available.

To enumerate in detail, a higher density (dwelling and population), proportion of industrial land use, the mixture of non-single family uses in single-family dominant areas, and high street connectivity (high street density and no cul-de-sacs) are likely to contribute to discounted housing premiums. While being closer to institutional land uses and transit stations are more likely to contribute to increasing housing values. Thus, it can be stated that people hold two different positions toward New Urbanism. On one hand, residents are still willing to pay more for a suburban style neighborhood design that supports a lower density, less land use mix and less connected streets for less crowded, more private and more secluded living at the community level. The mixture of land use can be negative or positive factors which are heavily determined by design details and specific composition. On the other hand, people know the benefits of living close to public transit and are willing to use them, if appropriate service could be provided at a city-wide level. Therefore, we can say that the full envelope of principles embedded within New Urbanism based philosophies is not yet fully accepted. This does not necessarily mean, however, that planners in academia and practice should seek to adhere to the current state of the suburban style development patterns. To fill the gap between hope and reality, planners should introduce the benefits of living in neighborhoods where New Urbanism design principles are implemented and expose people to new types of neighborhoods to encourage more rapid transition. In addition, the design principles should carefully declare details, not just propose a hegemonic agenda. Design guidelines could suggest more tangible design details and dimensions for how to combine different New Urbanists' design features on the ground by lessening congestion, unpleasantness, and invasion of privacy while promoting high density, mixed land use, street links and good public transit connections.

This study has some limitations that future studies should consider. First, statistical meta-analyses are sensitive to sample size in order to have reliable generalizations. This study adopts a minimum of six studies as guided by previous literature, but recent increasing interest in observing the association between the built environment and revealed preferences would help accumulate sufficient cases to increase the validity of generalization in the future. Second, this study generalized the impacts of neighborhood design using different definitions of housing.

Most of the studies assessed used single-family homes, but multi-family areas could be more sensitive to New Urbanists' design recommendations. To differentiate the impacts on multi- and single-family housing, future studies may consider a comparison research between these two. Third, housing prices are controlled by several other cultural, historical and geographical conditions or planning policies. For example, studies conducted in Portland, Oregon may show different results to those in Austin, Texas. Comparing the different effects of New Urbanists' principles by the level of planning interventions, regions or geography would be meaningful work for future studies. Lastly, this study does not consider different types of units of analysis. To define neighborhood characteristics, researchers used different definitions of a neighborhood. Some employed census units from census blocks to census tracts, others used radius buffers of different distances from a property. The size of a neighborhood matters since the perception of people can differ due to the proximity of a certain environment (Park and Rogers 2015). For example, mixed land use might be a negative factor in immediate surroundings, but people may be less sensitive when it is found in distant surroundings. The results of previous studies can, thus, be re-sorted by the nature of geographical units of analysis in future studies.

In addition, there are some general recommendations for future hedonic studies. Most previous work assessed the separate categories of New Urbanists' principles, but some studies found that a good combination of several of them do have positive effects. We encourage future studies to find a better mixture of New Urbanists' components, which will help planners to have more concrete design guidelines over theoretical suggestions. Furthermore, most of the research used in this study used OLS models, but recent studies show that using spatial models would be more effective and have less biased results. Future hedonic studies would consider how to properly control spatial autocorrelations. Finally, most of the research lacks the visual aesthetics measurement because of its difficulty to measure, even though it is one of the critical elements of New Urbanism principles. Although there were some efforts by Ewing and Clemente (2013) or Harvey and Aultman-Hall (2016), future studies should explore several ways to include this aspect.

Notes

1. According to Field and Gillett (2010), odds ratios (*OR*) and T-statistics (t) can be converted to correlation coefficients with the following equation:

$$r = \frac{\sqrt{OR} - 1}{\sqrt{OR} + 1} \qquad r = \sqrt{\frac{t^2}{t^2 + DF}}$$ where *DF* is the degrees of freedom

2. As Hunter and Schmidt (2004) recommended, the average effect size ($\bar{r}$) is estimated as the weighted mean of the correlations (r), which is weighted by its sample size (*n*).

$$\bar{r} = \frac{\sum_{i=1}^{k} n_i r_i}{\sum_{i=1}^{k} n_i}$$

3. As Field and Gillett (2010, p. 672) argued using weighted mean is better approach because 1) 'weighted' is usually a value reflecting the sampling accuracy, sample size in this case, and 2) helps construct a confidence interval around the estimate of the population effect. In addition, The rationale for the weighted mean can be explained with a simple example. Suppose we have 10 cases and divide them into two groups. One group has 9 cases all with scores of 9 and the other has one case with a score of 1. From this set of scores, we know that the overall mean of all 10 cases is 8.2 but I don't give you the 10 cases. Instead, I only give you only the mean and sample size for each group and tell you to estimate the overall mean. If you compute the unweighted mean, your estimate is (9 + 1)/2 = 5.0. However, if you compute the weighted mean, your estimate is (9*9 + 1*1)/10 = 82/10 = 8.2. Thus, the weighted mean gives the better answer.

4. A 95 % confidence interval (*CI*) and an 80% credibility interval (*CV*) of the effect size can be calculated by the variance of the sample effect size ($\hat{\sigma}_r^2$), the sampling error variance ($\hat{\sigma}_e^2$), and the sampling error variance ($\hat{\sigma}_\rho^2 = \hat{\sigma}_r^2 - \hat{\sigma}_e^2$).

$$95\%CI = \bar{r} \pm 1.96\sqrt{\hat{\sigma}_e^2} \qquad 80\%CV = \bar{r} \pm 1.28\sqrt{\hat{\sigma}_\rho^2}$$

$$\hat{\sigma}_r^2 = \frac{\sum_{i=1}^{k} n_i (r_i - \bar{r})^2}{\sum_{i=1}^{k} n_i}, \quad \hat{\sigma}_e^2 = \frac{(1 - \bar{r}^2)^2}{\bar{N} - 1}$$

5. Last, as Higgins et al. (2003) suggested, the χ^2 statistic is calculated to measure the consistency, in other words, the homogeneity of effect size.

$$\chi^2 = \sum_{i=1}^{k} \frac{(n_i - 1)(r_i - \bar{r})^2}{(1 - \bar{r}^2)^2}$$

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Table 1. Measurements for Each Design Component for New Urbanism Principles

Design	Measurement		Calculation
Density	Population density		Population per unit area
	Dwelling density		Single-family dwelling units per unit area
Mixed land use	Distance to	Commercial	Distance from the house to the nearest commercial use
		Industry	Distance from the house to the nearest industrial use
		Institution	Distance from the house to the nearest institutional (governmental) land use
	Ratio of	Single family	The ratio of land for single-family housing
		Commercial	The ratio of land for commercial uses
		Industrial	The ratio of land for industrial uses
		Non-residential	The ratio of land for non-residential uses to total land
	Diversity index	With Single family	Shannon's diversity index including single-family housing, other land uses such as public, commercial, industrial, agriculture, etc. $H' = -\sum_{i=1}^{c}(p_i)\ln(p_i)$, where p_i = the proportion of area in land use i, c = the number of land use types. When all land use types are included and have the same area, the value reaches the maximum.
		Without single family	Shannon's diversity index with other land uses such as public, commercial, industrial, agriculture, or, etc.
Street pattern	Cul-de-sac		The presence of cul-de-sac 1) if yes = 1, no = 0 2) if within 50ft or 100ft from the house = 1, no = 0
	Street density		The total street segments per unit area
	Intersection density		The ratio of intersections to 1) the number of intersections and nodes of cul-de-sacs 2) street nodes
	Links–nodes ratio		The ratio of street segments to street nodes
Proximity to transit	Distance		Straight line distance to the nearest transit stop
	Network distance		Network distance to the nearest transit stop
	Transit stop within ¼ mile		The presence of transit stops within ¼ mile. If yes = 1, no = 0
	Transit stop within ½ mile		The presence of transit stops within ¼–½ mile. If yes = 1, no = 0

Table 2. Results from the Statistical Meta-analysis

Design	Measurement	K	N	*r*	%PS	%NS	%Non	SD	SE	95CI-	95CI+	80CV-	80CV+	X2
Density	Population Density	31	523,832	-0.04	10%	52%	39%	0.05	0.01	-0.06	-0.03	-0.10	0.02	1147.96
Density	Dwelling Density	25	150,848	-0.03	16%	56%	28%	0.11	0.01	-0.06	-0.01	-0.18	0.11	1985.87
Land Use	Dis_Commercial Use	16	80,211	0.01	38%	19%	44%	0.05	0.01	-0.02	0.04	-0.04	0.07	167.30
Land Use	Dis_Industrial Use	10	65,164	0.02	60%	10%	30%	0.02	0.01	0.00	0.05	0.00	0.04	28.42
Land Use	Dis_Institutional Use	6	51,650	-0.05	17%	50%	33%	0.04	0.01	-0.07	-0.03	-0.09	-0.01	66.30
Land Use	Rat_Single-family	6	12,765	-0.03	33%	50%	17%	0.06	0.02	-0.07	0.01	-0.10	0.04	46.03
Land Use	Rat_Multi-family	5	2,497	0.02	60%	0%	40%	0.08	0.04	-0.07	0.11	-0.07	0.11	16.46
Land Use	Rat_Commercial Use	12	26,380	0	50%	17%	33%	0.05	0.02	-0.04	0.04	-0.06	0.07	78.07
Land Use	Rat_Industrial Use	9	23,987	-0.09	33%	67%	0%	0.03	0.02	-0.12	-0.05	-0.12	-0.05	28.60
Land Use	Rat_Non Residential Use	8	51,754	0.01	13%	0%	88%	0.02	0.01	-0.02	0.03	-0.01	0.02	18.21
Land Use	Job Ratio	4	48,574	0.08	50%	25%	25%	0.02	0.01	0.06	0.10	0.05	0.11	26.67
Land Use	With Single-family	10	167,716	-0.02	10%	50%	40%	0.03	0.01	-0.04	0.00	-0.06	0.02	162.00
Land Use	Without Single-family	8	67,407	0.03	75%	13%	13%	0.02	0.01	0.01	0.05	0.00	0.06	40.56
Street Patern	Cul-de-sac	10	68,372	0.05	50%	0%	50%	0.03	0.01	0.02	0.07	0.01	0.08	57.03
Street Patern	Street Density	6	207,817	-0.02	17%	67%	17%	0.04	0.01	-0.03	-0.01	-0.08	0.03	375.57
Street Patern	Intersection Density	7	104,638	0.00	71%	14%	14%	0.04	0.01	-0.01	0.02	-0.05	0.06	200.12
Street Patern	Link-Nodes Ratio	6	74,690	0.01	33%	50%	17%	0.04	0.01	-0.01	0.02	-0.04	0.05	96.92
Street Patern	Block Size	4	71,246	-0.02	25%	75%	0%	0.05	0.01	-0.03	0.00	-0.07	0.04	149.21
Tranist	Distance	22	636,948	-0.04	9%	68%	23%	0.05	0.01	-0.05	-0.03	-0.11	0.03	1704.79
Tranist	Network distance	12	53,789	0.01	33%	25%	42%	0.05	0.01	-0.02	0.04	-0.05	0.07	135.67
Tranist	1/4 mile	8	75,124	0.03	25%	13%	63%	0.08	0.01	0.01	0.05	-0.07	0.12	434.66
Tranist	1/2 mile	33	174,696	0.01	36%	12%	52%	0.04	0.01	-0.01	0.04	-0.03	0.06	231.13

Table 3. The Size, Sign, And Consistency Of Effect (Studied In More Than Six Cases Only).

Design	Measurement	Effect Size	Sign	Consistency
Density	Population Density	0.04	-	Moderate
Density	Dwelling Density	0.03	-	Moderate
Land Use	Dis_Commercial Use	0.01	x	Moderate
Land Use	Dis_Industrial Use	0.02	x	Low
Land Use	Dis_Institutional Use	0.05	-	Moderate
Land Use	Rat_Single-family	0.03	x	Low
Land Use	Rat_Multi-family	0.02	x	Moderate
Land Use	Rat_Commercial Use	0	x	Moderate
Land Use	Rat_Industrial Use	0.09	-	High
Land Use	Rat_Non Residential Use	0.01	x	High
Land Use	Job Ratio	0.08	+	Moderate
Land Use	With Single-family	0.02	-	Moderate
Land Use	Without Single-family	0.03	+	High
Street Patern	Cul-de-sac	0.05	+	Moderate
Street Patern	Street Density	0.02	-	High
Street Patern	Intersection Density	0.00	x	Low
Street Patern	Link-Nodes Ratio	0.01	x	Low
Street Patern	Block Size	0.02	-	High
Tranist	Distance	0.04	-	High
Tranist	Network distance	0.01	x	Moderate
Tranist	1/4 mile	0.03	+	Low
Tranist	1/2 mile	0.01	x	Moderate

Figure 1. Effect Size, 95 Percent Confidence Interval, Significance. Sign, and Consistenc of Design elements.