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Smart growth in two contrastive metropolitan areas: A comparison between Portland and Los Angeles

Hongwei Dong[1]

Pengyu Zhu[2]

Abstract

This study compares urban landscapes in the Portland and Los Angeles metropolitan areas at the neighbourhood level by operationalising six smart growth indices and mapping their spatial distribution patterns and time trends. Analysis results show that the two metropolitan areas have both strengths and weaknesses in different aspects of smart growth. Most neighbourhoods in both regions do not excel in all six smart growth measures: they are at the high ends of some smart growth indices but at the low ends of others. Some smart growth features such as mixed land use and mixed housing are already pervasive in suburban areas. Density in some mature suburban neighbourhoods is also relatively high. A large number of neighbourhoods in suburban and exurban areas exhibit high levels of socioeconomic diversity. Time trend analyses suggest that in both regions, older neighbourhoods tend to be 'smarter' than newer ones, except for racial/ethnic diversity.

Keywords

comparison study, Los Angeles, Portland, smart growth, urban landscape

Introduction

As a reaction to urban sprawl, smart growth has gained much attention in the past three decades in the USA and worldwide. Policies designed based on smart growth principles aim to reduce undesirable consequences of urban sprawl through promoting compact urban form, orderly land development and less car dependence. Have smart growth policies effectively shaped urban form and the socioeconomic landscapes in American metropolitan areas as they are expected to? In this study, we compare two contrasting American metropolitan areas – Portland, Oregon and Los Angeles, California – by developing an index system and conducting time trend analysis with a GIS data base that integrates detailed land use, housing, transportation and socio-demographic data. The goal is to illustrate the diverse and complex urban landscapes that smart growth policies aim to intervene and shed light on the impacts of smart growth policies on urban landscapes in two totally different planning systems.

In planning literature, the Portland metropolitan area has been widely cited as a model of smart growth. The metropolitan planning organisation (MPO) of the region, Metro, was established by popular vote in late 1970s and is the only directly elected MPO in the USA. Since its establishment, Metro has crafted and implemented comprehensive smart growth policies to prevent urban sprawl in the Portland region. In 1979, an urban growth boundary (UGB) was adopted by Metro to promote orderly land

[1] California State University, Fresno, USA
[2] Boise State University, USA

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development in peripheral areas. Within the boundary, compact land use patterns and transit oriented development (TOD) were encouraged through a set of policy tools, such as a long-term growth concept plan, financial incentives for new urbanist development surrounding transit centres, parking management and so on (Abbott, 1997, 2002; Dong and Gliebe, 2012; Miles and Song, 2009; Song and Knaap, 2007). In contrast, the Los Angeles metropolitan area is often associated with urban sprawl in planning literature. Cities and counties in the Los Angeles metropolitan areas, however, have also designed many growth management policies since the 1980s. Based on surveys conducted by Fulton and his colleagues (see Fulton et al., 1998; Glickfeld et al., 1999), researchers found that from 1989 through 1992, over half (54.3%) of the 166 surveyed jurisdictions in their Southern California sample adopted at least one measure designed to manage growth (Joassart-Marcelli et al., 2001), though not all of these measures are completely in line with smart growth principles. The MPO of the region, the Southern California Association of Government (SCAG), is the nation's largest MPO. Unlike Metro in Portland, SCAG mainly functions as a transportation planning agency and lacks real power in regional land use planning and growth management.

While both regions have designed a variety of growth management policies in the past three decades, they were implemented in two different planning systems. Smart growth policies have been mainly at the regional level in Portland but at the local level in Los Angeles. Have these policies made urban growth patterns in the two regions as different as their policy framework might suggest? Have the efforts in Portland been more effective than those in Los Angeles, as many people think? By analysing and comparing the urban landscapes at a detailed spatial scale and their time trends in two regions over a long period of time, this study tries to shed some light on these questions. The time trend analysis might also help the public and planners to incorporate 'what has happened in the past as they consider the future' (Miller, 2012) and enact better smart growth policies.

Related literature

In the last decade, several studies have emerged comparing physical and socioeconomic aspects of US metropolitan areas. Interestingly, almost all these comparison studies include Portland as one of their cases.

Song and Knaap (2004) pioneered the quantitative measurement of urban form at the neighbourhood level. In their study of the Washington County portions of the Portland metropolitan area, they developed several measures of urban form and showed that neighbourhoods in Washington County had made improvements in density, internal street connectivity, pedestrian access, but their external accessibility had declined and the level of mixed land use remained limited.

Using a similar set of measures developed by Song and Knapp (2004), Song (2005) compared urban development trends in three areas: the Portland metropolitan area; Orange County, Florida; and Montgomery County, Maryland. The comparison suggested that all three areas have similar development patterns. Smart growth instruments have altered their subdivision design, but have not significantly increased land use mix and regional accessibility. Wilson and Song (2009) compared recent residential development patterns in Portland and Charlotte, North Carolina to determine if the patterns are as different as the cities' existing policy frameworks and regulations might suggest. Their comparison showed that new single-family residential development was more likely to be located in the inner- and middle-ring suburbs in Portland and in the urban fringe areas in Charlotte. They speculated that such

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divergent residential development patterns may have resulted from differences in the two regions' efforts in regional planning.

Using historic maps, aerial photo and GIS software, Wheeler (2003, 2008) compared the evolution of urban form in Portland and several other North American metropolitan areas. By comparing the evolution of urban form in Portland and Toronto (Wheeler, 2003), he summarised five design values that help enable sustainable urban form: compactness, contiguity, connectivity, diversity and ecological integration. Wheeler also concluded that public-sector efforts and social movements will play key roles in promoting more sustainable urban form in the USA. In a later study, Wheeler (2008) compared the evolution of urban form in six US metropolitan areas: Portland, Boston, Atlanta, Minneapolis, Albuquerque and Las Vegas. Wheeler identified seven main historic patterns of urban form and nine types created in the 1980–2005 period. The comparison showed that US metropolitan regions are characterised by a profusion of new built landscape forms, fragmentation of these forms and an explosive rate of spatial growth.

The study by Miles et al. (2010) is one of the few comparisons that have focused on socioeconomic aspects of smart growth. It compared traditional neighbourhoods in Portland and Atlanta, and found that the majority of traditional neighbourhoods in Portland were socially diverse but in Atlanta they tended to be occupied by low-income residents.

Study areas and spatial analysis Units

This study focuses on two contrasting metropolitan areas, Portland and Los Angeles. The Portland metropolitan area includes three counties: Clackamas, Multnomah and Washington. As of 2010, the region's land area was 4300 square miles, with a population of 1.64 million. The Los Angeles metropolitan area is composed of five counties: Los Angeles, Orange, Riverside, San Bernardino and Ventura. The five-county region's land area (33,955 square miles) is roughly eight times larger than Portland's land area and its population (17.88 million as of 2010) is roughly 11 times larger than Portland's population.

This study compares urban landscapes in the Portland and Los Angeles regions at the neighbourhood level. By neighbourhoods, we refer to Census block groups, which have been used and favoured over Census tracts in previous studies (Miles and Song, 2009; Quinn and Pawasarat, 2003; Talen, 2006) because of their close approximation of human-scale neighbourhoods. Our analysis focuses on residential neighbourhoods, which are defined as Census block groups in which 25% or more land is designated for residential use. With this definition, in 2010, there were 818 and 8905 residential neighbourhoods in Portland and Los Angeles, accounting for 78.6% and 82.5% of all 2010 Census block groups in the two regions, respectively. Our GIS analyses show that in 2010, 98.0% of residential neighbourhoods in the Portland region had their centroids within its UGB and 99.6% of residential neighbourhoods in the Los Angeles region had their centroids within its Census urbanised areas.

Method

Data for this study are drawn from several sources. Land use, public transportation, bike route and employment data in year 2008 were provided by Metro and SCAG, the MPOs for the Portland and Los Angeles regions. Housing and socioeconomic data are drawn from the 2006–2010 American Community

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Survey (ACS) data set. Local street networks of the two regions are from Census 2008 TIGER/Line shapefiles.

Indices developed to measure and compare urban landscapes at the neighbourhood level in the two regions are explained in Table 1. Those indices are selected to represent four key physical aspects of smart growth in residential neighbourhoods (residential density, mixed land use, mixed housing, non-auto transportation accessibility) and two socioeconomic dimensions (income and racial/ethnic diversities). Since the analysis units of this study are residential neighbourhoods, land use patterns that are appropriate only at the regional level such as centrality and nuclearity are not measured. In addition, since we use neighbourhoods as our spatial units, intraneighbourhood diversity and segregation are not considered in this study.

We adopt the entropy index that has been widely used in similar literature (e.g. Iceland, 2004; Song, 2005; Talen, 2006) to measure the levels of mixed land use, mixed housing and socioeconomic diversity in each residential neighbourhood, which can be expressed as:

$$H_i = \sum_{1}^{r} (P_i^r ln[1/P_i^r]/ln(r_i)) \qquad (1)$$

where P_i^r is the proportion of each group and r_i represents the number of groups in neighbourhood i. H_i is a diversity index measuring the evenness of groups in the neighbourhood. H_i ranges from 0 and 1 and a higher entropy score H_i indicates a higher level of mix or diversity in that neighbourhood.

As shown in Table 1, three physical smart growth indices (mixed land use, mixed housing and non-auto transportation accessibility) are measured by more than one correlated sub-indices. Following previous studies (Cutsinger et al., 2005; Ewing et al., 2002; Miles and Song, 2009), we combine sub-indices under each index by extracting an artificial factor variable that accounts for the most amount of variance of those sub-indices through Principle Components Analysis (PCA). Extracted factor scores derived from PCAs have a mean value of zero and a standard deviation of one. Finally, we have four indices that measure physical dimensions of each neighbourhood (net residential density, mixed use, mixed housing and non-auto transportation accessibility) and two indices that measure the socioeconomic characteristics (income diversity and racial/ethnic diversity).

General comparison between Portland and Los Angeles

To compare the built landscape and socioeconomic environment in the two regions, we calculate the mean value of each variable listed in Table 1 for all residential neighbourhoods in each region, and compare them between the two regions by conducting t-tests. Because the sizes of neighbourhoods in each region vary substantially, we use population size in each neighbourhood as the weighting variable when calculating mean values and conducting t-tests. In Figure 1, we contrast the two regions by presenting a ratio indicator (R_i) for each variable (i.e. sub-indices) in Table 1. The ratio indicators are calculated as:

$$R_i = \frac{Mean_i^{Portland}}{Mean_i^{LA}} \qquad (2)$$

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Table 1. Smart growth indices and subindices.

Smart growth indices	Explanation	Data source
Residential density:		
Net residential density	Total housing units over acres of residential land (unit/acre).	MPOs and ACS[a] (2006–2010)
Mixed use:		
Land use diversity	Mix of four land use types: single-family home, multi-family home, commercial use and open space.	MPOs
Accessibility of personal service	Mix of personal service jobs and households.	MPOs and ACS (2006–2010)
Job–home balance	Mix of jobs and households.	MPOs
Mixed housing		
Housing tenure diversity	Mix of owner occupied and renter occupied houses.	ACS (2006–2010)
Housing structure diversity	Mix of four housing structure types by number of units in structure: 1 unit, 2–4 units, 5–19 units and 20 + units.	ACS (2006–2010)
Housing size diversity	Mix of housing size by number of bedrooms: 0 or 1 bedroom, 2 bedrooms, 3 bedrooms, and 4 + bedrooms.	ACS (2006–2010)
Housing value/rent diversity	Mix of houses of three value/rent levels: low, medium and high.	ACS (2006–2010)
Non-auto transportation accessibility		
Transit accessibility	Percent of residential land within 1/4 mile of bus or 1/2 mile of rail transit and/or express bus stops.	MPOs
Bike lane accessibility	Percent of land within 1/4 mile of high-quality bicycle lanes.[b]	MPOs
Street density	Length of local streets per acre of land (mile per acre).	Census TIGER
Street intersection density	Number intersections per acre of land.	Census TIGER
Socioeconomic diversity		
Income diversity	Mix of households of four income levels: low, medium-low, medium-high and high.[c]	ACS (2006–2010)
Racial/ethnic diversity	Mix of four racial/ethnic groups: non-Hispanic White, Hispanic, Black or African American and Asian and Pacific Islanders.	ACS (2006–2010)

Notes:
[a]ACS is an abbreviation for American Community Survey and MPOs refer to Metro and SCAG.
[b]By high-quality bike lane, it refers to bike lanes with separated lane or in safe low-traffic streets.
[c]In Portland, the cutoff values for the four income levels are $25,000, $50,000, $75,000. In Los Angeles, they were $30,000, $60,000 and $100,000.

where $Mean_i^{Portland}$ and $Mean_i^{LA}$ represent weighted mean values of sub-index i in Portland and LA, respectively.

As indicated by Figure 1, residential neighbourhoods in Los Angeles show significantly higher average residential density than those in Portland (13.58 versus 8.70 units/acre). We also compare regional

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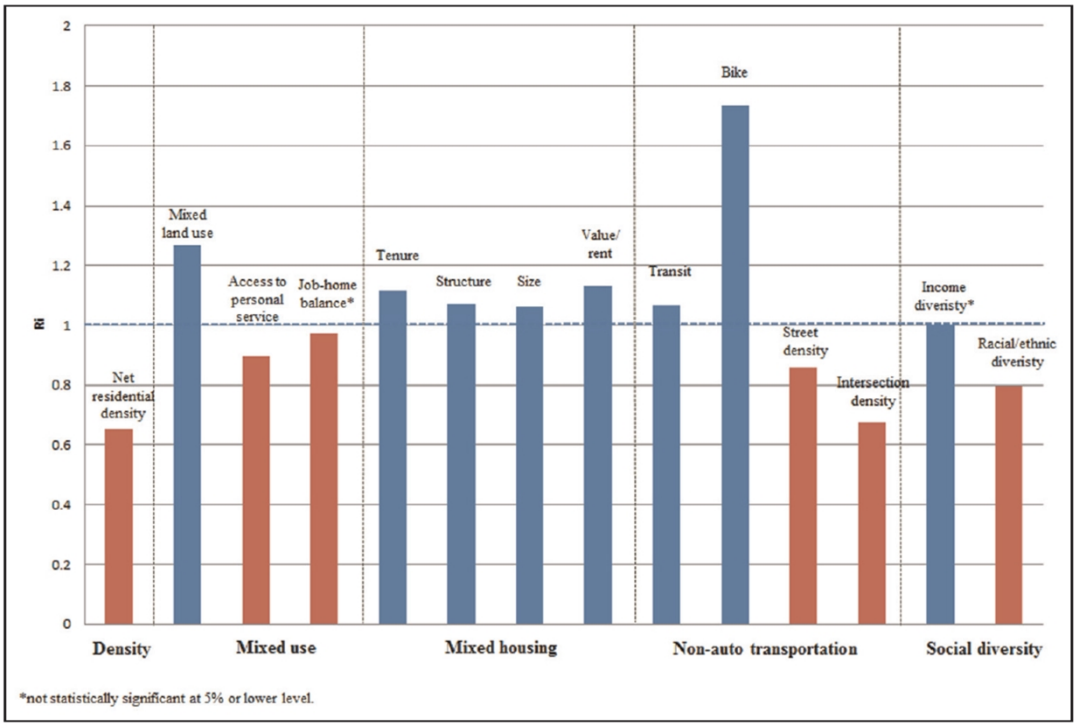

Figure 1. Ratio indicator of each variable.

residential density between the two study areas (not shown in Figure 1), which are measured by the total housing units divided by the total amount of residential land in the two regions, respectively. It shows that regional residential density is also higher in Los Angeles (6.17 versus 5.51 units/acre), but the difference is smaller than the difference in weighted average neighbourhood residential density, which can be ascribed to the fact that higher density neighbourhoods tend to have larger population, giving them more weight while calculating the weighted mean values. In general, these findings support the observations of other studies (e.g. Richardson and Gordon, 2001) that Los Angeles is denser than Portland. This is not surprising given that the Los Angeles metropolitan area is more than ten times more populous than the Portland metropolitan area. Land and housing prices are also higher in the Los Angeles region, which creates economic advantages for higher density development.

Comparisons of the three variables relevant to mixed land use yield varied results. Portland shows a higher level of mix between four land use types: single-family housing, multi-family housing, commercial and park. Los Angeles, however, exhibits a higher level of access to personal service. Job–home balance is not statistically different between the two regions.

The results of the comparison of mixed housing between the two regions are clear: Portland shows greater levels of mixed housing on all the four sub-indices. Variations in housing tenure, structure, size and value/rent are all greater in Portland than Los Angeles.

As expected, the Portland region shows a slightly higher public transit coverage rate (72% versus 69%) and a much higher high-quality bike route coverage rate (80% versus 46%). The Los Angeles region,

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however, shows slightly better street connectivity as measured by higher mean values of street density (0.055 versus 0.047 mile/acre) and street intersection density (0.28 versus 0.26 per acre).

The ratio indicators of the two socioeconomic indices suggest that residential neighbourhoods in the two regions are not significantly different in terms of income diversity, but the Los Angeles region is significantly more racially/ethnically diverse, as expected.

In summary, the comparisons between the two regions indicate that both of them have strengths and weaknesses in smart growth measures. Compared with the Portland metropolitan area, the Los Angeles metropolitan area shows higher residential density, better access to personal service, higher street and intersection densities, and a higher level of racial/ethnic diversity, but lower levels of mixed land use types, housing mix and non-auto transportation accessibility.

Spatial patterns of smart growth Indices

To illustrate the spatial patterns of the six smart growth indices, we fit loess smoothing lines for both regions by locally regressing their z-scores (mean values are 0 and standard deviations are 1) on the distance from the neighbourhoods to the city centres (Figure 2), which are represented by Portland and Los Angeles City Halls. Because the fitted lines in Figure 2 do not reflect the directional distribution of the six indices, we complement them by mapping the six indices with neighbourhood polygons and comparing the spatial distribution patterns between the two regions (Figures 3 and 4).

In general, Figure 2 indicates that the six smart growth indices exhibit quite different spatial patterns in the two regions. Many residential neighbourhoods are at the high ends of some indices, but at the low ends of other indices, indicating that neighbourhoods that comprehensively exemplify smart growth principles are rare in both regions. Figure 2 also shows that the gradients of the smooth lines are much less pronounced in Los Angeles, indicating that its building landscape is flatter, which might be partially due to its much larger physical size.

Residential density

As indicated by the density line in Figure 2, in Portland, the relationship between net residential density and distance from the city centre displays an 'L' shape smoothing line, which declines sharply from 0 to 4 miles from the centre and then flattens out. This indicates that in the Portland metropolitan area, most high-density neighbourhoods are concentrated in downtown Portland and residential density does not vary a lot beyond the downtown area. The relationship between net residential density and distance from the city centre in the Los Angeles region also exhibits an 'L' shape with a longer tail: the gradient decreases rapidly within about 15 miles from the city centre and becomes less steep beyond 15 miles. It seems that both regions demonstrate monocentric patterns in terms of residential density.

The density graphs in Figures 3 and 4, however, show that there are still some medium-high and even high-density residential neighbourhoods in suburban areas in both regions, especially in their mature inner and middle rings. Compared with the Portland metropolitan area, Los Angeles shows more numerous and larger-scale highdensity residential clusters in its suburban area. These findings are consistent with Moudan and Hess (2000) who also found many high-density residential clusters in suburban Seattle, Washington.

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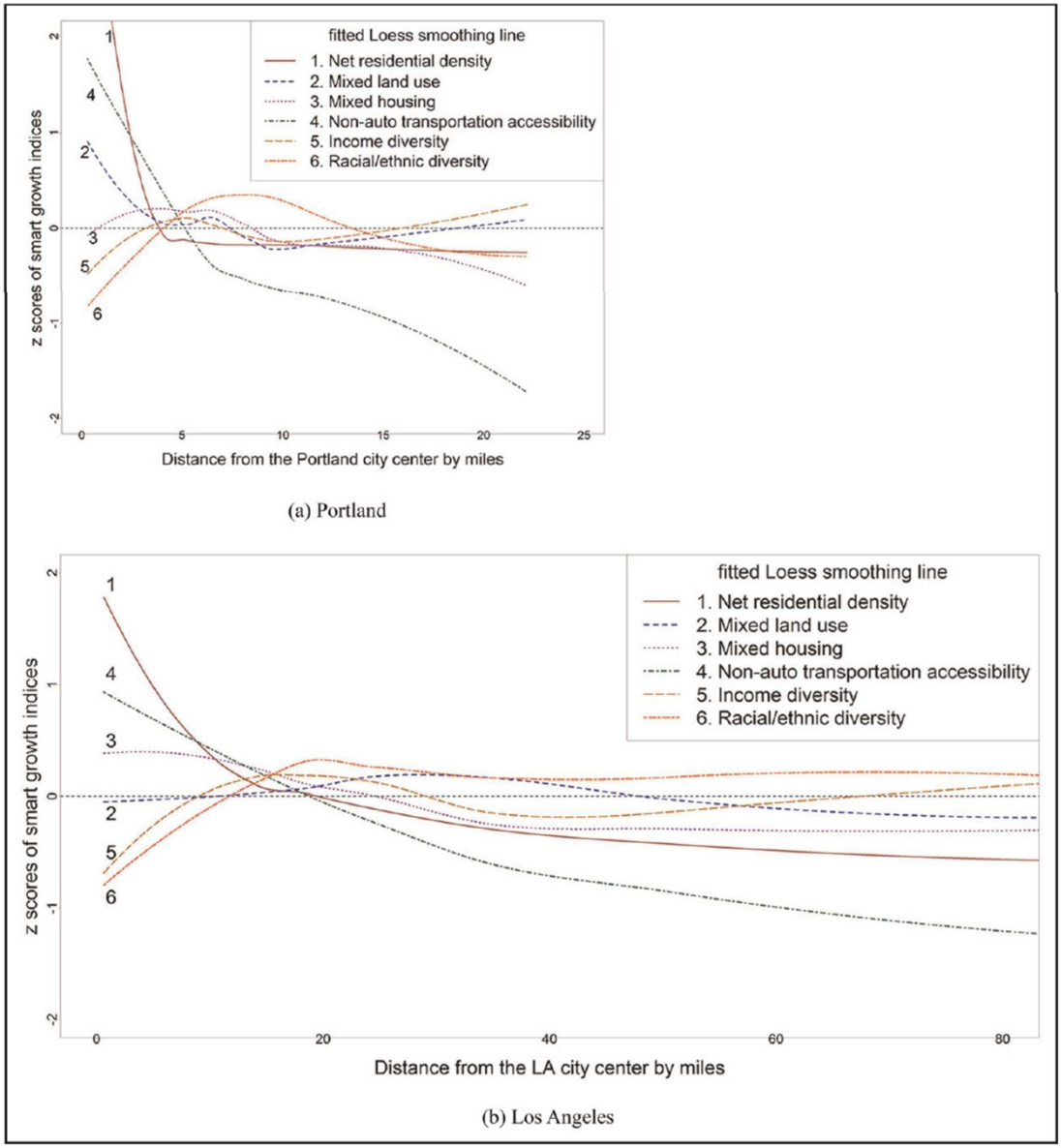

Figure 2. Smart growth indices versus distance from the city centre.

Mixed land use

The mixed land use line in Figure 2 indicates that the level of mixed land use in Portland peaks at its city centre, declines rapidly within 5 miles from the centre, increases again after that and reaches a second peak at about 6–7 miles from the centre. The level of mixed use is lowest at about 10 miles from the centre but increases gradually and slightly beyond that. Mixed-use neighbourhoods are found not only in central Portland, but also in suburban and even exurban areas (Figure 3).

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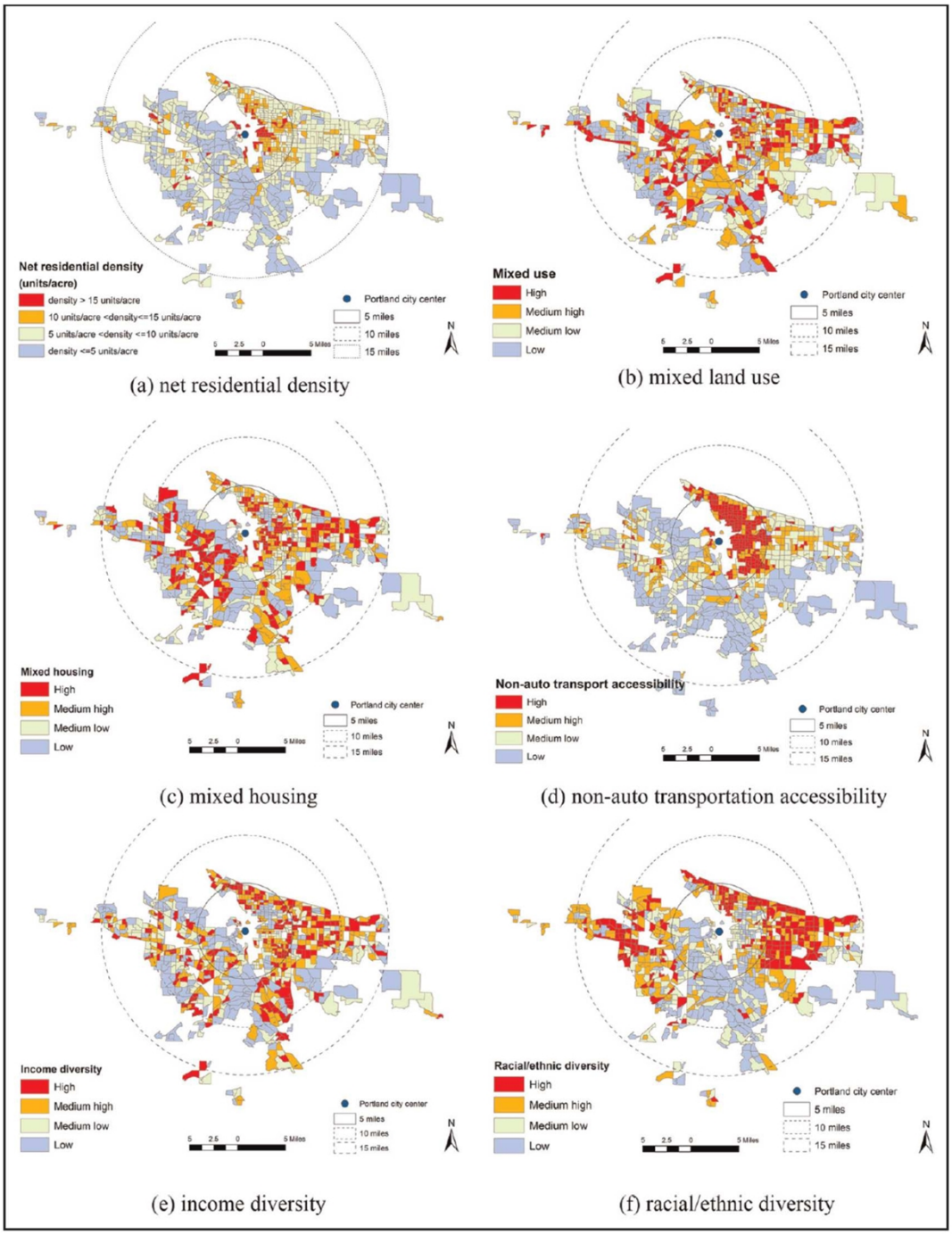

Figure 3. Physical and socioeconomic patterns in the Portland metropolitan area.

In the Los Angeles region, the smoothing line of mixed land use follows a flattened and inversed 'U' shape which peaks at about 30 miles from the city centre. Highly mixed-use residential neighbourhoods in both regions are even more decentralised and dispersed than high-density neighbourhoods (see

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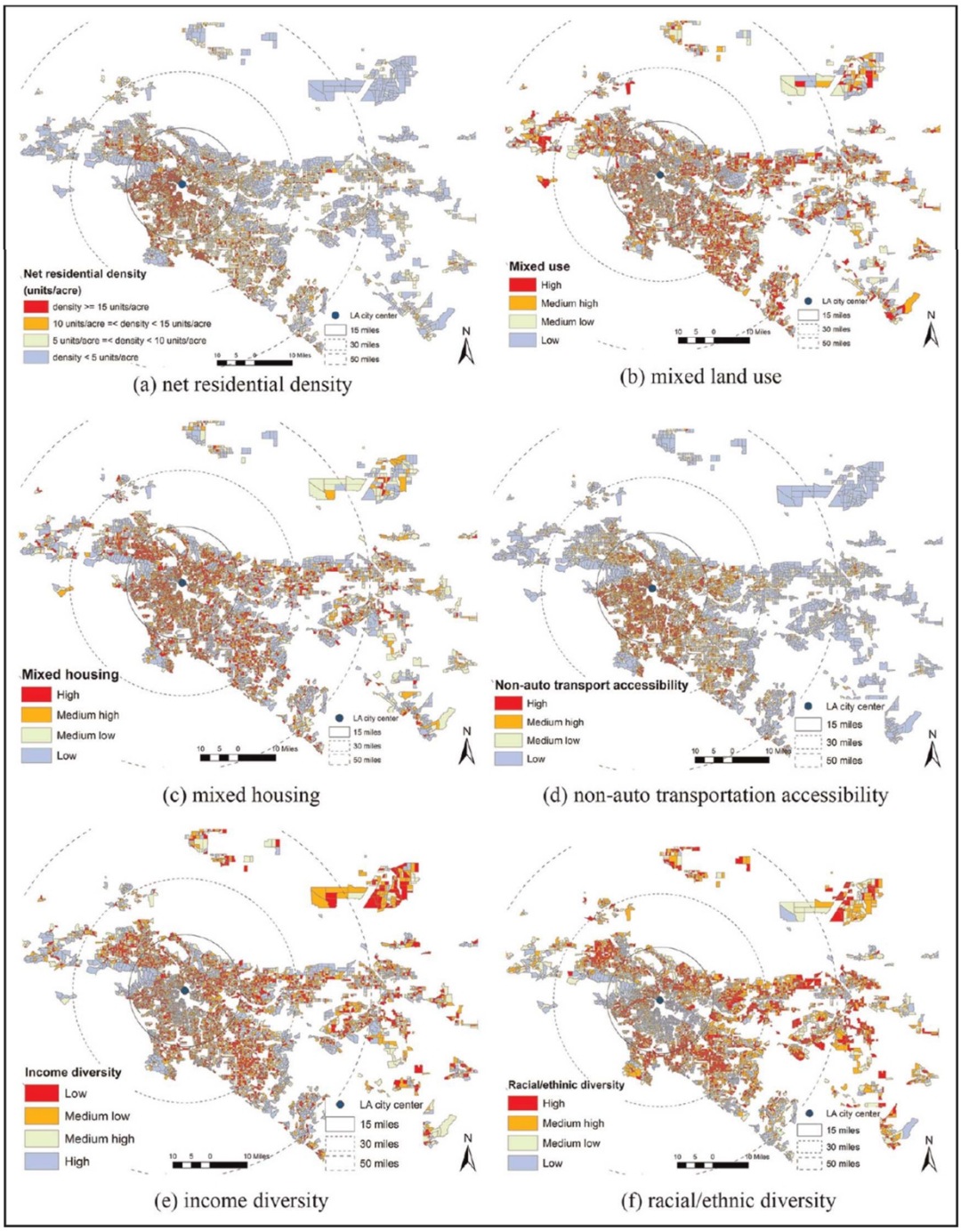

Figure 4. Physical and socioeconomic patterns in the Los Angeles metropolitan area.

mixed land use graphs in Figures 3 and 4). The decentralisation of mixed-use residential neighbourhoods in the two regions is basically a reflection of the employment decentralisation that both regions have experienced since the Second World War, which brought economic activities from central cities to

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suburban areas and mixed them with housing. In the Los Angeles region, the passage of Proposition 13, a property tax reduction ballot initiative passed in 1978 in California, might also have contributed to the decentralisation and dispersion of commercial activities. Since its passage, cities and counties in Californian metropolitan areas, including the Los Angeles region, have had to rely more on sales taxes, growth related taxes and other revenue sources that spur jurisdictions to approve non-residential development.

Mixed housing

The mixed housing line in Figure 2 shows that in Portland, the level of mixed housing is average (for the region) in the city centre, increases with distance from the centre, and peaks in areas about 4–7 miles from the city centre. The level of mixed housing is flat between 10–15 miles and declines further than 15 miles. In Los Angeles, however, neighbourhoods with highly mixed housing concentrate in its downtown area. The level of mixed housing decreases with the distance from the centre, and levels off after 40 miles from the centre.

Similar to mixed land use, neighbourhoods with mixed housing also tend to be decentralised and dispersed throughout the regions. Inner city areas have lower levels of mixed housing because they are mainly occupied by one type of housing: high-density apartments and condominiums. Outer-ring suburban areas also tend to have lower levels of mixed housing because they are dominated by single-family homes. Thus, residential neighbourhoods with higher levels of mixed housing are more likely to be in inner-ring suburban areas in both regions.

Non-auto transportation accessibility

As indicated by the lines of non-auto transportation indices in Figure 2, non-auto transportation accessibility in both regions exhibits a monocentric pattern. This pattern is confirmed by their spatial patterns shown in Figures 3 and 4. Neighbourhoods with high non-auto transportation accessibility are concentrated in the central cities and their surrounding areas. In the Portland region, most of these neighbourhoods are in the City of Portland. In the Los Angeles region, most of them are in Los Angeles County. The difference is that non-auto transportation accessibility decreases more smoothly in the Los Angeles region. In Portland, the gradient only becomes less steep after 6 miles from the city centre.

Income diversity

The income diversity line in Figure 2 shows that in Portland, income diversity is lowest at the city centre, reaches its peak at about 5 miles from the centre, hits the second lowest bottom at about 10 miles from the centre, and starts to increase again. Generally speaking, neighbourhoods with greater levels of income diversity are dispersed in suburban areas (as supported by Figure 3).

Similar to the Portland region, the inner city of the Los Angeles region shows the lowest level of income diversity and is dominated by low and medium-low income. Neighbourhoods with high levels of income diversity tend to concentrate in middle-ring suburbs that are about 10–30 miles from the city centre. Urban peripheral areas, which are dominated by large-lot single-family homes, show the lowest level of income diversity. Interestingly, the level of income diversity rises again more than 40 miles from the Los Angeles city centre, in exurban areas in Riverside and San Bernardino Counties (see Figure 4).

Racial/ethnic diversity

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In Figure 2, the smooth lines of racial/ethnic diversity in both regions show a reversed 'U' pattern, though the line is much flatter in the Los Angeles region. Racial/ethnic diversity starts at its lowest point in the central cities. In Portland, the inner city and surrounding areas are dominated by Caucasians. Neighbourhoods with high racial/ethnic diversity are mainly in a ring at 5–10 miles from the city centre, where Caucasians, Hispanics and Asians are mixed. African Americans in Portland mostly live in North Portland at about 2–5 miles from the city centre, where they are mixed with Hispanics and Caucasians.

In Los Angeles, the inner city and its south and southeast fringe areas are dominated by Hispanics, and its southwest fringe area is dominated by African Americans. There is a cluster of neighbourhoods between 5 and 15 miles from the Los Angeles city centre that are racially/ethnically diverse, but the most racially/ethnically diverse neighbourhoods are in a ring at 15– 30 miles from the city centre, mainly in Los Angeles and Orange Counties. In exurban areas that are 30 or more miles away from the Los Angeles city centre, there are also a large amount of racially/ethnically diverse neighbourhoods, mainly in Riverside, San Bernardino and Los Angeles counties. Exurban neighbourhoods in Ventura and Orange counties tend to be dominated by Caucasians and are less racially/ethnically diverse.

Overall, our findings on the spatial distribution of racial and income diversity in the Los Angeles metropolitan area are consistent with the observations of other researchers (Downs, 2005; Johnson et al., 2008). The Inland Empire of California (Riverside and San Bernardino) has been quickly diversified racially and demographically in the past decade due mainly to migration from coastal Southern California areas (i.e. Los Angeles, Orange and San Diego counties). Interestingly, our analysis suggests that the demographic diversification of exurban areas also exists in the Portland region, which is overall less racially diverse and attracts much fewer immigrants than the Los Angeles region.

Time trend analysis

Figure 5 exhibits differences in physical and socioeconomic patterns among neighbourhoods of different ages in the two regions. To do so, we fit linear regression lines by regressing the z-scores of the six smart growth indices on median year structure built of the neighbourhood. The regressions are weighted by neighbourhood population. Because our data are cross-sectional, they do not directly reflect historical evolutions of the six indices. Even so, they still shed some light on the trends of urban landscape changes in the past decades in the two regions by comparing newly built neighbourhoods with older ones. In this analysis, we are particularly interested in testing whether two totally different planning frameworks implemented in the two regions over the past three decades have made their newer neighbourhoods 'smarter' than older ones. For this purpose, we divide residential neighbourhoods into two age groups: 'older' neighbourhoods whose median structure built years were before 1990 and 'newer' neighbourhoods whose median structure built years were in 1990 or after.[i]

In each region, smart growth indices of the two age groups show quite different patterns. In Portland, the density of older neighbourhoods had declined over time since the Second World War until the 1990s. Neighbourhoods built since the 1990s tend to have higher density. The average density of neighbourhoods built around 2010 is close to the average density of those built in the 1960s. In the Los Angeles metropolitan area, the density of its older neighbourhoods also decreased from the 1940s to 1990. The declining trend seems to have ceased since the 1990s, but newer neighbourhoods are, on average, much less dense than neighbourhoods over the entire period from the 1940s to 2010.

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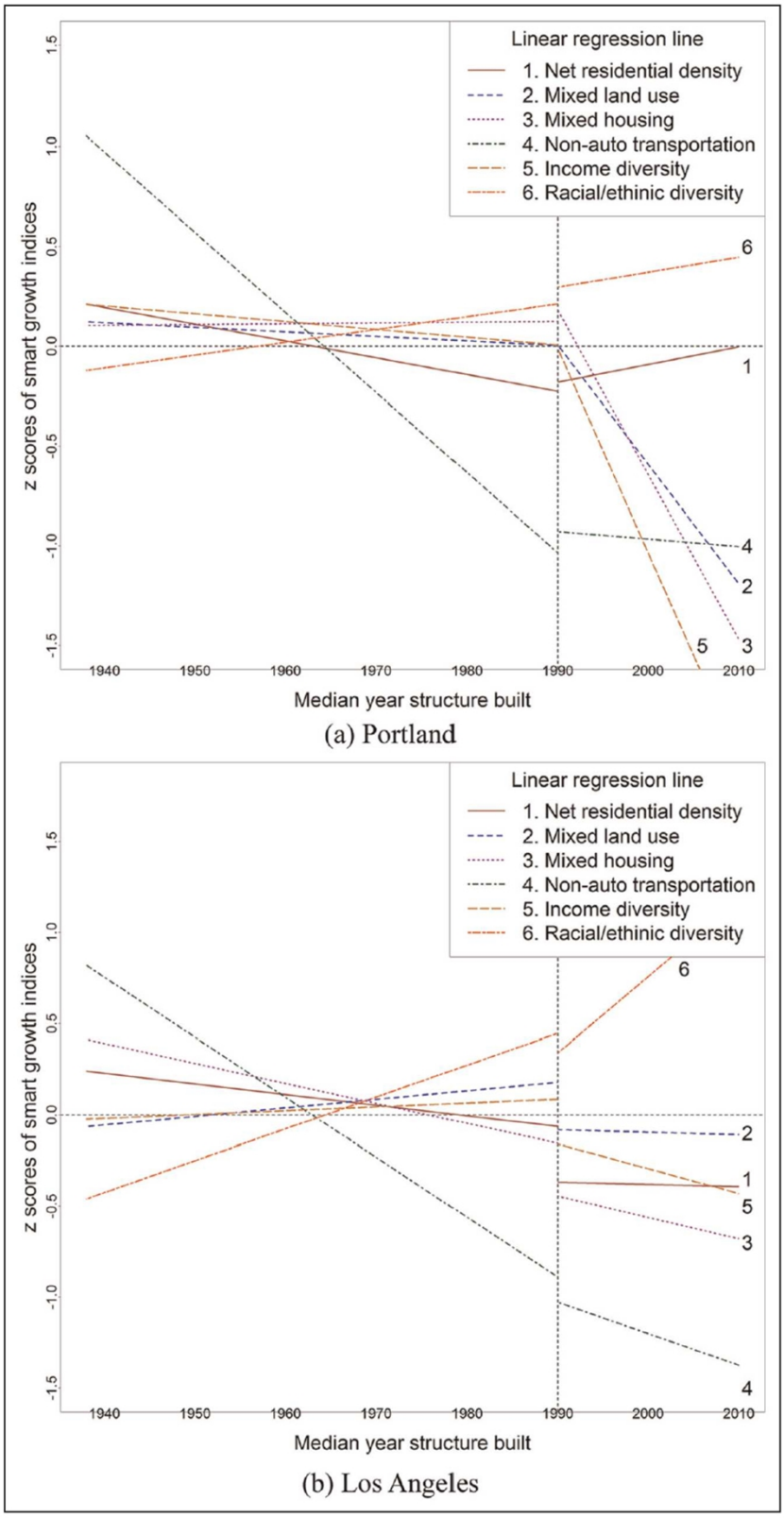

Figure 5. Time trend analysis.

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Compared with its density trend, the trend of mixed land use in Portland is more worrisome from a smart growth perspective. For older neighbourhoods, the level of mixed land use decreased slightly. The level of mixed-use level in its newer neighbourhoods, however, exhibits a sharp declining trend since the 1990s, indicating that neighbourhoods built after the 1990s are more likely to be purely residential and single-use. In the Los Angeles metropolitan area, the level of mixed use in older neighbourhoods increased slightly over time. The average level of mixed use in newer neighbourhoods is lower than the regional average, but has stayed flat since the 1990s.

The level of mixed housing in Portland was quite stable before the 1990s, but showed a sharp decline after that, indicating that housing types in newly built neighbourhoods have become increasingly less diverse. In Los Angeles, the level of mixed housing showed a declining trend in neighbourhoods of both age groups, but on average, housing in older neighbourhoods is more mixed than in newer ones.

The level of non-auto transportation accessibility shows similar declining time trends in both neighbourhood age groups in each region. In Portland, the gradient of the declining line is much less steep for newer neighbourhoods, suggesting that the fast declining trend has been somewhat slowed down in the past two decades. In Los Angeles, however, the declining trend is almost the same for neighbourhoods in both age groups. Given that newer neighbourhoods are generally located in areas that are more distant from the city centre, it is not surprising to find that they have lower nonauto transportation accessibility. But the fact that the gradient of this decline for newer neighbourhoods in Portland is less steep than in Los Angeles suggests that planning policies could improve bike and transit accessibility at the neighbourhood level, making it better than it otherwise would be.

The income diversity of Portland's older neighbourhoods decreased slightly over time, but declined sharply for newer neighbourhoods, suggesting that income segregation is a more serious problem for newly built residential communities. In the Los Angeles region, income diversity increased slightly over time for older neighbourhoods, but decreased for newer neighbourhoods. Compared with Los Angeles, the gradient is much steeper for newer neighbourhoods in Portland, indicating that newly developed neighbourhoods in Portland tend to be more segregated by income.

In both regions, racial/ethnic diversity is the only index that shows significant increasing trend over time for neighbourhoods in both age groups. This indicates that residential neighbourhoods in both regions are becoming more and more racially/ethnically diverse.

Discussion and conclusions

This study compares urban landscapes in the Portland and Los Angeles metropolitan areas at the neighbourhood level by operationalising six smart growth indices and mapping their spatial distribution patterns and temporal trends. The comparisons show that urban landscapes in the two regions are very diverse and complicated.

The two metropolitan areas generally have both strengths and weaknesses in smart growth measures. For example, the Los Angeles metropolitan area shows higher residential density, better access to personal service, higher street and intersection densities, and greater levels of racial/ethnic diversity, but lower levels of mixed land use types, mixed housing and non-auto transportation accessibility than the Portland region. Thus, it might not be accurate to label a metropolitan area solely as 'compact' or

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'sprawled'. Instead, one should specify on what dimension of urban landscapes is being measured or compared.

Our analyses show that most neighbourhoods in both regions do not excel in all six smart growth measures: they are at the high ends of some indices but at the low ends of others. Even in the Portland metropolitan area, a region widely known for its smart growth efforts, there are still very few neighbourhoods that are 'smart' by all the six indices. Among its 818 residential neighbourhoods, only 45 of them (5.5%) are above the regional averages in all the six indices. In the Los Angeles metropolitan area, that proportion is about 4.3% (385 out of 8950). This is largely consistent with Wheeler (2008), who compared six US metropolitan areas (Portland, Boston, Minneapolis, Albuquerque and Las Vegas) and found that new urbanist neighbourhoods were extremely rare within these regions. It seems to suggest that smart growth policies have produced relatively few strong examples of the type, but instead produced widespread examples with one or two key smart growth features (Wheeler and Beebe, 2011). Compared with Los Angeles, Portland has had three decades of more progressive efforts in smart growth at the regional level. But these endeavours have yet to manifest the kind of impact they are commonly thought to have. This should not be surprising given that both the form and content of urban spaces are path dependent, reflecting different histories and local forces (Ekers et al., 2012). Smart growth policies are one of many forces that have been shaping urban landscapes in American metropolitan areas. Furthermore, the effectiveness of smart growth policies is highly dependent on local political and economic environments as well as the rigidity of their implementation. The findings of this study suggest that current smart growth policies have not been able to override all other forces and reshape the urban landscapes of American metropolises as successfully as we would hope.

This, however, does not necessarily predict a gloomy future for smart growth. In fact, this study reveals several opportunities for smart growth in both regions. For example, our analyses indicate that smart growth features such as mixed land use and mixed housing are already pervasive in suburban areas. Density in some mature suburban neighbourhoods is also relatively high. A large number of neighbourhoods in suburban and even in exurban areas exhibit high levels of socioeconomic diversity. Many lowincome and minority households are moving from inner cities to suburban areas and the trend has accelerated in the past two decades. Furthermore, our time trend analysis of density suggests that smart growth tools implemented in the Portland region (e.g. the urban growth boundary) have successfully limited low-density development in urban peripheral areas. In the Los Angeles region, the de-densification trend that started after the Second World War was also halted in the 1990s. These trends lay a good foundation for planners to promote smart growth in American suburbs. While smart growth ideas have yet to influence the majority of neighbourhoods in American cities, they are influencing the revision of zoning codes and subdivision ordinances nationwide (Wheeler, 2008). It may, however, take many years for such policies to produce fruit given the huge sunk costs in existing urban patterns and the incremental nature of development in American metropolitan areas.

There are still numerous challenges to address in the road to smart growth. Our analyses indicate that compared with older neighbourhoods, newly built neighbourhoods in both regions tend to be less 'smart' in several dimensions. Among the six smart growth indices, only racial/ethnic diversity clearly shows an increasing trend over the past two decades. The average density of new development is still lower than the regional average in both regions, though Portland has seen an increasing trend in the past two decades. Mixed land use shows a decentralised and dispersed pattern in suburban areas. However, if non-residential uses in a neighbourhood have no particular neighbourhood orientation, such

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as a regional shopping centre located adjacent to a single-family home block, the notion of 'mixed use' is somewhat irrelevant and unlikely to have a positive effect (Talen, 2013). Smart growth advocates have to figure out whether and how those mature suburban neighbourhoods can be retrofitted through infill development or redevelopment so that different dimensions of smart growth can be combined in a synergistic and complementary way.

The idea of using certain urban forms to sustain and foster social diversity has been a very important theme in the Post-Second World War planning (Talen, 2006). Our spatial analyses show that many communities in suburban and exurban areas in the two regions exhibit high levels of social diversity. The time trend analyses show a clearly increasing trend of racial diversity, but a sharply declining trend of income diversity. The contrasting time trends between racial and income diversity appear to provide evidence to the hypothesis that after over 40 years of fair housing law, increasing white racial tolerance and gains in black socioeconomic status, class matters more than race in determining where people can live (Pfeiffer, 2012). It remains unclear, however, to what extent the racial/ethnical diversity in these suburban communities is caused by the built environment and smart growth policies. Previous research (Pendall and Carruthers, 2003) indicated that the interrelationship between urban form and its socioeconomic outcomes is very complex and the topic is beyond the scope of this study.

One interesting finding of this analysis is that compared with the Los Angeles region, the Portland region shows higher levels of housing diversity at the neighbourhood level, a feature that is encouraged by smart growth principles. Its income diversity, however, is not statistically different from that in the Los Angeles metropolitan area, and its residential neighbourhoods still have much lower levels of racial/ethnic diversity than in Los Angeles. This reminds us the critiques in Harvey (2000) on spatial determinism which assumes that changing people's physical environment will somehow take care of the social inequality (Fainstein, 2000). Indeed, it is important to acknowledge that smart growth policies only have limited influence in terms of addressing the broader and deeper structural dynamics of how American metropolises have been shaped in the past decades. Without critically addressing the social, political and economic forces that have produced the problems, smart growth policies alone will be unlikely to make much substantive or meaningful impact on this front.

In addition, there are many empirical studies have shown that land use regulations, including those designed based on smart growth principles pushed up housing prices and reduced housing affordability (Anthony, 2003, 2006). A direct result is that the economic barriers become even higher for medium-low and low-income households to live in neighbourhoods with better amenities that smart growth policies helped to create. All these points highlight the importance of evaluating the potential economic and social outcomes of smart growth policies, which have been under-studied compared with their impacts on urban form and transportation.

There are limitations in this study. The cross-sectional nature of the data used only reveals correlated and not causal relationships. In addition, because of data limitation and methods adopted in our analyses, we are not able to quantitatively separate the effects of smart growth policies from many other factors that have been at work in shaping the built and social landscape in the two regions. We leave these questions for future research.

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[i] Our literature review suggests that smart growth policies and efforts emerged in late 1970s in the Portland metropolitan and in the 1980s in the Los Angeles region. Given that it took at least a few years to see the effects of these efforts and policies, we use 1990 as the critical year to categorise neighbourhoods into two age groups.