Rethinking the implementation of the compact city: Factors affecting compact activity centre policy conformance in greater Brisbane, 1996 to 2016

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Abstract

Australian planning authorities have struggled to develop more compact cities for decades, yet empirical explanations for this policy challenge are lacking. This is critical to inform future sustainable planning efforts. In response, we correlate 20 years of change in greater Brisbane's activity centres against factors related to land use regulations, transport accessibility, property characteristics, and socio-economic status. We find activity centre implementation is most strongly associated with property-based factors and that land use regulations have the weakest relationship. Policymakers should therefore pursue alternative strategies that do not rely on planning mechanisms geared primarily toward creating a market for development.

Keywords: activity centres, Brisbane, Australia, compact city, urban planning

Introduction

Australian planning authorities have been attempting develop more compact cities for several decades with the intention of realising a range of urban sustainability benefits. In most capital cities, these attempts take the form of metropolitan level plans which seek to create an intense urban core, supported by a network of compact activity centres in the middle and outer suburbs characterised by higher residential densities, a greater diversity of housing types, and more mixed clusters of employment (Freestone, 2012; Forster, 2006). Policy makers argue that doing so will lead to more sustainable cities by reducing CO2 emissions from vehicle trips, conserving undeveloped areas, creating more affordable housing, improving access to employment and services, and advancing health outcomes from increases in active transportation use (OECD, 2012). Enthusiasm for the approach continues unabated with greater Brisbane maintaining the activity centre policy in its latest regional policy (The State of Queensland, 2017), Melbourne pursuing its own activity centres and 20-Minute Neighbourhoods, and Sydney aiming to become a 30-Minute City (Victoria State Government, 2017; Greater Sydney Commission, 2019).

Although popular in both public and planning imaginations, the practicality of implementing Australian policies for compact activity centres has proven difficult, with a growing body of research finding that few of the designated activity centres conform to their planned outcomes (Chhetri et al., 2013; Day et al., 2015; Newton and Glackin, 2014; Phan et al., 2009; Limb et al., 2020a). This is not the result of a lack of trying. Our previous research investigating 20 years of plan performance in greater Brisbane demonstrated that local governments are making regulatory decisions that support compact city policy yet are not achieving planned outcomes through this approach (Limb et al., 2020b). Despite this history, empirical explanations for these policy failures is lacking. This is necessary to critical inform future planning efforts to improve urban sustainability.

In response, this paper explores the factors that best explain the implementation of greater Brisbane's activity centres. We empirically test the relationships between common factors proposed in the literature with actual changes to centres overtime in greater Brisbane's activity centres. Drawing on a detailed database derived from Google Street View and aerial images of more than 26,000 sites, we correlate 20 years of change against a range of factors related to land use regulations, public transport accessibility, property characteristics, and socio-economic status. We find activity centre implementation is strongly associated with property-based factors and that the permissiveness of land use regulations had the weakest relationship with centre implementation. These results suggest that activity centre implementation is more the result of market forces rather than planning intent and therefore demonstrate the impracticalities of attempting to create a market for development through rezoning. Policy makers need to reconsider their reliance on changing the regulatory land use planning system in the hope of attracting private sector development and rethink the planning mechanisms necessary to support sustainable and equitable development in Australian suburbs.

Explaining Compact City Failure in Australia

The feasibility of compact city policies has been challenged on a number of grounds including consumer preferences and demographic patterns of employment distribution (Birrell et al., 2005; Troy, 1996), property economics (Bryant, 2013; Searle, 2004; Searle, 2010; Rowley and Phibbs, 2012; O'Connor and Healy, 2004), and transport accessibility (Dodson, 2010). Evidence from other international examples tends to support these explanations where market forces, political and institutional commitment, and demographic shifts have been shown to hinder the implementation of consolidation policies (Brewer and Grant, 2015).

The existing nature of the centres themselves is of course a key consideration for their propensity to develop and most of the existing discussion on implementation stems from such matters. The combination of centre compactness, the degree of mixed use, and integration with transit is commonly seen as both a goal, and precondition for development (Filion, 2001; Grant and Perrott, 2010). Where the intent for such development fails to align with the "reality of suburban densities and car-oriented lifestyles", planning interventions are unlikely to result in the desired transformations (Grant and Perrott, 2010: 192). For example, Melbourne's metropolitan plan locates the majority of designated activity centres outside areas with high levels of employment opportunities while seeking employment types that are more likely to occur in proximity to the CBD (Birrell et al., 2005). Birrell et al. (2005) also noted that few activity centres were in areas that demonstrated high levels of employment self-containment, and predicted that these factors will limit the implementation of the activity centre policies. Recent evidence from Melbourne confirms that activity centre policies are not correlated with a growth in employment clustering (Day et al., 2015). If such concerns are impacting centre development in Australia's largest cities (Melbourne and Sydney), smaller cities such as Brisbane are also unlikely to have the levels of population and economic activity required to support centre development at the scale envisioned by its regional plan.

Alongside this, the economics of the property market are a recurrent theme in explanations for why compact city policies may be unfeasible. As the role of supplying new housing and commercial uses falls to private property developers, persistent supply and demand arguments maintain that consolidation will not occur where market conditions do not permit developers to meet their profit margins (Bryant, 2013). From this perspective, the planning system and the constraints offered by zoning are also often blamed for the failure to develop compact activity centres. Voices from the development industry incessantly claim overly restrictive zoning and "red-tape" are constraining supply, and hindering the

achievement of strategic planning objectives such as improved housing affordability (Kendall and Tulip, 2018; PCA, 2015; UDIA, 2019). Of course, zoning by its very nature restricts land use to achieve broader policy objectives. Activity centre policy is no exception and is intended to be implemented primarily by changing development controls to be permissive of desired land uses within the centres, thereby encouraging their development. Recent research demonstrates that policy makers have acted as intended in this regard, and changed their regulatory plans to reflect activity centre policy (Limb et al., 2020b). However, some suggest that overly liberal land use regulations and development approvals may actually have the opposite effect and result in speculative land banking (Murray, 2019) or enable too many approvals which subsequently reduces the ability of any single development to be financed and constructed (Woodcock et al. (2011).

Others connect property market issues to the underlying and varied nature of the centres' economic geographies. Birrell et al. (2005) suggest that only centres with enough services to "draw demand from a surrounding regional economy" are likely to develop as intended by urban consolidation policies. Research from Canada underscores that long established consumer preferences for space and design contribute to market pressures that hinder the implementation of urban consolidation regardless of political will to counter these trends (Grant, 2009).

Dodson (2010) singles out access to public transportation as a key factor and notes that Australia's middle and outer suburbs typically lack the "nodal concentration" and public transport links necessary to support higher density development. This represents both market and government failures resulting in a "catch-22" situation where density is unlikely to proceed without improved high frequency public services, but such services are not considered to be viable without sufficient land-use intensity (Dodson, 2010). Mees (2009) however questions the role of density as a means to improving public transport mode share, a

view confirmed by Ewing and Cervero (2010) in the context of the United States. Accessibility also does not appear to translate into improved urban consolidation with research from Melbourne showing little relationship between public transport accessibility (outside of inner city areas) and the development of infill housing (Newton and Glackin, 2014; Phan et al., 2009).

Searle (2010), using South East Queensland as an example, criticises the land use plans themselves on grounds that they do not allocate sufficient activity centres in inner city areas where the demand for high density development is greatest, while Birrell et al. (2005) contend that the centres are too poorly defined both spatially and conceptually. Further, the planning system primarily focuses on rezoning land and does not have the resources or powers to bring together sufficient numbers of lots to significantly change land uses in accordance with the activity centre policies (Birrell et al., 2005). These sentiments are echoed by a number of other authors who believe the activity centre policies lack the required methods to be successfully implemented (O'Connor, 2003; Forster, 2006; Gleeson et al., 2012; Gleeson, 2012). Critiques of this nature are not new, with McLoughlin (1992) concluding that previous attempts of planning interventions to positively shape urban form were equally as unrealistic and had not properly considered implementation.

Despite this vigorous debate, few studies test the relevance of the various factors to explain the failure of compact activity centre policy. We respond to this gap in the literature by studying intensification and consolidation in greater Brisbane's activity centres over a 20-year period.

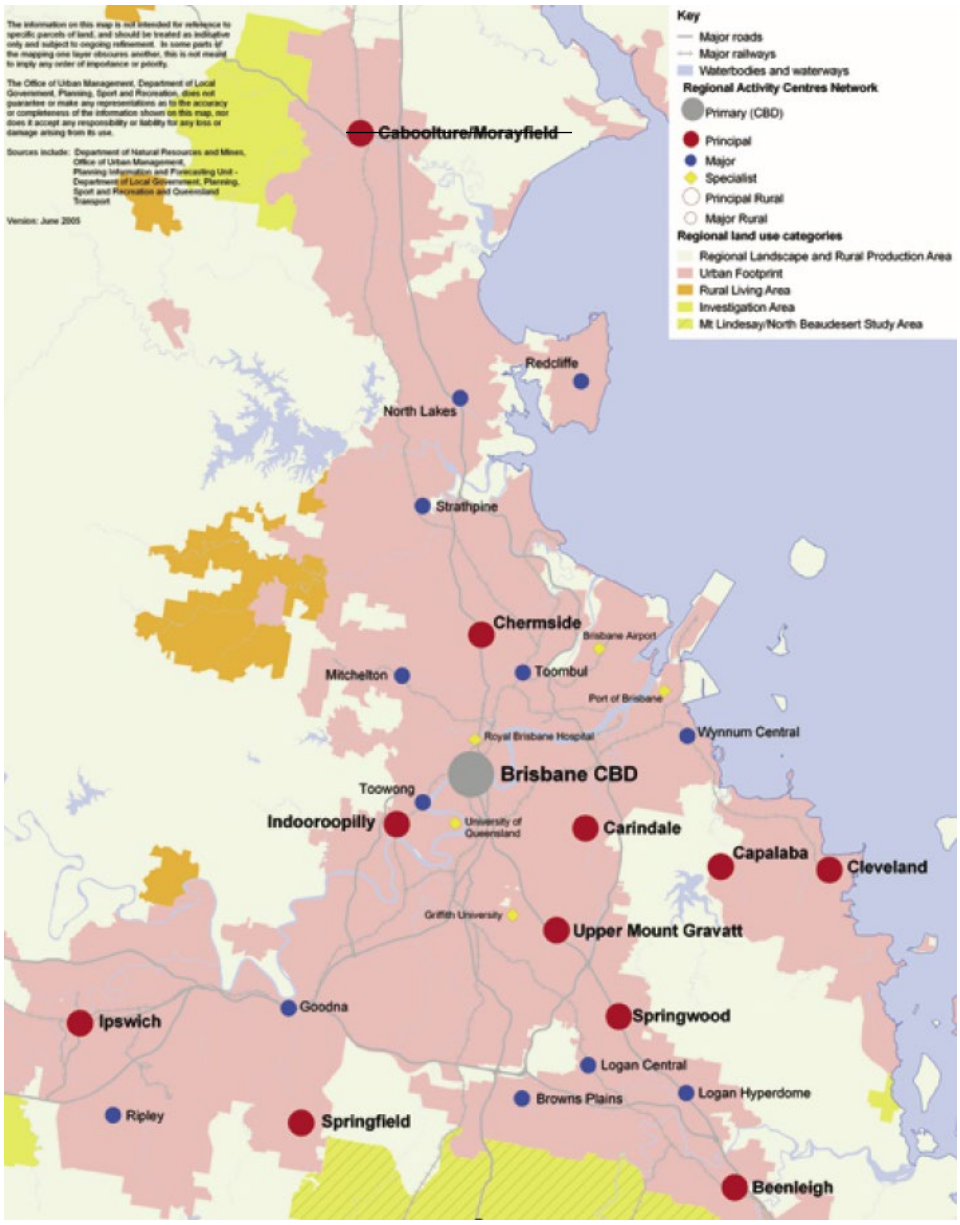
Data and Methods

This study employs simple correlation analysis to examine the relationship between centre intensification and the explanatory factors identified in the literature in Greater Brisbane, Australia. The study concentrates on all 19 activity centres in Greater Brisbane, which has

maintained policies for compact activity centres for more than two decades. As key factors for the analysis are based on census data, we commence the study from 1996; the closest census date to the commencement of the first regional plan that included the activity centre concept in South East Queensland (The State of Queensland, 1995). We selected all principal and major activity centres[1] as nominated in the various iterations of the South East Queensland Regional Plans (SEQRP) (Figure 1). Greater Brisbane is defined as the area with a 35km radius of the Brisbane CBD; a distance that approximately equates to the extent of the broader Brisbane conurbation. The centres themselves are defined by a 1,200m walkable catchment from the central public transit node of each centre to account for a primary catchment of 800m as described in the regional policy, with a 400m buffer to account for a "ripple effect exerting extra market pressures beyond the boundary onto surrounding properties" (Newton and Glackin, 2014: 131-132).

[1] Excluding the centres of Springfield, North Lakes and Ripley. These are greenfield development sites and are not directly comparable to the other centres. A total of 19 centres were therefore selected.

Figure 1 - Location of nominated activity centres (The State of Queensland, 2005b: 74)



Description of variables

We develop 15 measures of key explanatory factors identified in the literature and group these into categories of existing compactness, property, transport, planning policy, and socio-economics status Table 1. Each measure is then tested for its correlation with compact centre intensification using Pearson or Spearman rank order correlation coefficients, controlling for the influence of other variables.

Table 1 - Description of variables

Variable name	Description	Source
Initial centre compactness		
1996 Compact Score	Average score of density, dwelling mix, employment and mixed-use scores below	Average standard scores of 1996 Density Score, 1996 Dwelling Mix, 1996 Employment Score and 1996 Mixed use score
1996 Density Score	Average of standard scores for the 1996 net residential population and dwelling density, average land area of low-density dwellings, and proportion of population living at low densities	ABS 1996 Census Data, Google Street View and aerial image observations (see Limb et al., 2020a)
1996 Dwelling Mix	Average of standard scores for 1996 proportions of low density, low-medium density, medium density, and high-density dwellings	As above
1996 Employment Score	Average of standard scores for 1996 net employment density, employment intensity, the plot ratio of employment-based buildings	As above
1996 Mixed use score	Average of standard scores for the 1996 land use variation, average Euclidean distance between use types, median residential distance to other use types, proportion of residential uses with 400m of commercial uses, and proportion of active frontage lengths to all commercial frontages.	As above
Property price factors		
Unit Price 1996	Estimated unit price in 1996	REIQ (1996)
Perct Unit Price Change	Percentage change in median unit price between 1996 and 2016	REIQ (1996) and realestate.com.au, 2017
Absolute Unit Price Change	Difference in median unit price between 1996 and 2016	REIQ (1996) and realestate.com.au, 2017
Planning policy factors		
Change in residential zoning intensity - 1996 to 2016	Summed difference in grouped residential DIS multiplied by property area and normalised by centre area.	Local government planning schemes in force in approximately 1996 (see Limb et al., 2020b)
Change in commercial zoning intensity - 1996 to 2016	Summed difference in grouped commercial DIS multiplied by property area and normalised by centre area.	As above
Change in industrial zoning	Summed difference in grouped industrial DIS multiplied by property	As above

intensity - 1996 to 2016	area and normalised by centre area.	
Change in bulky goods retail zoning intensity - 1996 to 2016	Summed difference in grouped bulky goods retail DIS multiplied by property area and normalised by centre area.	As above
Transport factors		
SNAMUTS Composite	Rank from Spatial Network Analysis for Multimodal Urban Transport Systems (SNAMUTS) composite index of public transport accessibility	SNAMUTS, 2016
Road Distance to CBD	Shortest distance by road from centre's central node to CBD	Google Maps, 2017
Socio-economic factors		
1996 IEO	The decile rank of the 1996 Index of Education and Occupation – measures the educational and occupational structure of communities on issues such as occupational status and educational attainment.	ABS 1996

We use a measure of the intensification of centre compactness as the quasi-dependent[2] variable that quantifies the degree to which each centre intensified in accordance with the policy principles for compact activity centres. It is derived from the average standard score (z-score) of measures of changes to residential density, dwelling mix, and employment in all activity centres in greater Brisbane[3] between 1996 and 2016 (for further details see Limb et al., 2020a). The scores were developed from a land use database derived from

[2] The subsequent correlations are two-way tests that do not differentiate between dependent and independent variables. The term of "quasi-dependent variable" refers to its role in being the target of the investigation and against which the other variables are compared.

[3] Excluding the centres of Springfield, North Lakes and Ripley. These centres are greenfield development sites that are not directly comparable with the other centres in relative terms.

Google Street View, aerial images, and the daysmetric areal interpolation[4] of census data across more than 44,000 properties covering the 26,000 unique sites that make up all uses within the activity centre extents.

The existing compactness measures represent the degree of initial compactness of each centre in 1996 and are used to determine relationships between the initial nature of centres and the achievement of activity centre policies. Property price factors are included to test the role of consumer demand for housing as commonly discussed in the literature (Birrell et al., 2005; Troy, 1996; Bryant, 2013; Searle, 2004; Searle, 2010; Rowley and Phibbs, 2012; O'Connor and Healy, 2004; Brewer and Grant, 2015). Correlating measures derived from property values with centre intensification is undertaken to determine if there is a relationship between property price and centre development. Unit prices were selected over house prices as they better represent the form of dwelling proposed by activity centre policy and the development processes to implement it. Historical commercial property prices could not be obtained.

The planning policy factors provide an indication as to the extent to which planning regulations changed to accommodate compact activity centre policy. The intensity and type of development permitted by local government land use regulations were recorded across all properties in the study area (n=44,063) at the beginning and end of the study period. This was coded according to Development Intensity Scores (DIS) based on regulations for residential, commercial, industrial, and bulky goods retail land uses. The DIS are derived from an analysis of local government planning regulations in force in each centre throughout the study period (for further details see Limb et al., 2020b). The difference between each

[4] This method involves interpolating census data for customised extents (in this case the walkable catchment of each centre), weighted using point-based land use data to improve accuracy. Please see Limb et al. (2018); Limb et al. (2020a) for a detailed description of this approach.

property's grouped 2016 and 1996 DIS was multiplied by its shape area, summed by centre, and then normalised by each centre's area. Centres that rezoned larger areas, for more intensive land uses[5], scored more highly on this measure.

Contrary to some expectations (Birrell et al., 2005; Dodson, 2010), existing research suggests that levels of public transport accessibility bare little relationship to the actual occurrence of urban consolidation (Newton and Glackin, 2014; Phan et al., 2009). To test these aspects we include a measure of public transport accessibility using pre-existing SNAMUTS composite mapping for Brisbane (Curtis and Scheurer, 2015; SNAMUTS, 2016). Although these scores are derived from 2011 data, we use them to describe the centres' initial states as few material changes to the public transport network have occurred in the centres during the study period[6]. Similarly rigorous measures of transit accessibility from 1996 could not be sourced. We also include road distance to the CBD as a general variable of proximity.

Finally, we consider the role of socio-economic status in land use conversion (Kline and Alig, 1999; Padeiro, 2014; Padeiro, 2016), using the Australian Bureau of Statistics' Index of Education and Occupation (IEO) (ABS, 1998)[7]. The population weighted IEO was matched to each centre to create a rank ordered variable based on decile ranks for the study area (as proposed by the ABS - ABS, 1998).

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[5] Industrial land uses were scored inversely.

[6] The only significant public transport infrastructure upgrade effecting the centres was the South East Busway which linked Upper Mount Gravatt in 2001. The rail line to Redcliffe was not completed until late 2016 which is outside the study's timeframe.

[7] IEO was selected from the four ABS socio-economic indices it was the only measure that was not directly composed of aspects related to the other variables. For example, the inclusion of dwelling size measures in the index would create a bias for detached housing.

Analysis

Two common statistical approaches used to examine the relationship between variables are the Pearson Product-Moment Correlation and the Spearman Rank-Order Correlation (Corder and Foreman, 2014). The Pearson correlation tests whether a linear relation is present between two continuous variables. Of the groups of variables presented above, only the existing compactness group met all the conditions of the Pearson correlation. The other groups included variables that were not suitable for this form of correlation. In these situations, non-parametric statistics, such as Spearman correlations, can be used instead (Corder and Foreman, 2014; Siegel and Castellan, 1988). Spearman correlations covert the variable scores to ranks (essentially making them ordinal) and testing whether there is a monotonic relationship between the variables. Both Pearson and Spearman correlations result in an r value on a scale of -1 to +1, where -1 represents a "perfect" negative relationship between variables, +1 is a perfect positive relationship between the variables, and 0 represents no relationship. Determining the exact strength of a correlation on the basis of its r value is subjective and dependent on the nature of the study, with a number of different classification scales or "rules of thumb" being proposed (Cohen, 1988; Evans, 1996; Hinklle et al., 2003; Corder and Foreman, 2014). Typically, correlations greater than $r = \sim 0.4$ are considered as displaying moderate to strong relationships.

To account for cross-correlation between variables, we use non-parametric partial correlation to indicate the strength of correlation while controlling for the other variables (Reynolds, 1974; de Vries, 1993). These partial correlations were undertaken using SPSS software, where Spearman rank order correlations for the variables were outputted to a matrix and then partial correlations were calculated using the standard SPSS partial correlation procedure.

Limitations

Although this research makes use of a very large, property-level dataset, the unit of analysis is the 19 activity centres in the greater Brisbane area. Despite this selection representing all centres in the greater Brisbane area, the small number of centres prevents the reliable use of more complex statistical methods that can simultaneously model the effects of multiple independent variables (Peduzzi et al., 1996; Maxwell, 2000). Our approach of comparing correlations between variables is therefore a useful start, but limited. Correlation does not equal causation, and the conclusions reached can only show that a relationship exists, not that the independent variable predicts centre intensification. The primary purpose of the analysis is therefore undertaken on a descriptive basis to evaluate the selected centres as a part of a case-study of the greater Brisbane area.

Results: Explaining Compact City Development

The first part of the analysis finds that all groups of variables correlate with compact centre outcomes *except* for the market-oriented planning policy variables (increasing land use intensity through zoning). The results from the second analysis, which control for confounding influences of key variables, show that property and socio-economic factors maintain the strongest relationships with compact centre intensification, whilst the extent of changes to planning regulations continued to show poor relationships to centre intensification. The existing intensity of employment in the centres also proved to have an independent relationship to centre intensification. Factors of distance and public transport were often better explained by other variables. These results question the wisdom of market-oriented planning directives to achieve more sustainable urban forms.

Table 2 summarizes the results from the initial correlation analysis. Correlations with initial centre compactness show that centres that were initially more compact had greater

increases in measures of centre intensification. The results for the sub-scores reveal that the existing employment and density scores had the strongest relationships with intensification. Property prices also correlated strongly with centre intensification and centres which had larger absolute increases in unit prices overtime, were positively related to centre intensification. Relative price changes however had a poor correlation as most centres experienced price increases over the twenty-year period, and where unit prices were initially low, the relative increase was sometimes large.[8]. The results also support Searle's position too many centres are nominated in outer areas with insufficient "latent demand" for the types of development envisioned, with intensification decreasing as the road distance from the CBD increases. Finally, Socio-economic factors show a strong positive relationship between centre intensification and higher initial levels of educational attainment and occupational status. This further reinforces the existing market thesis and is likely to be closely correlated with other variables such as unit price and distance to the CBD, and the relationship is therefore reconsidered once these aspects are controlled for.

Interestingly, where profit seems to play a role in predicting compact city development, planning does not. The relationship between changes in zoning and centre intensification are weak. It could be argued that it cannot be determined if land use change is altering the regulations or if the regulations are impacting the land uses. However, previous research (Limb et al., 2020b) shows that the majority of land use change is conformant with the land use regulations in effect at the time of change. This confirms that zoning changes are preceding land use change in most instances and that the measures of planning scheme change are therefore mostly independent from the dependent variable.

[8] However, we cannot say if the relationship is due to increasing unit prices making development more profitable or if new development results in higher unit prices. We therefore use only the initial unit price in the following partial correlations

Table 2 - Relationship between centre intensification and selected factors

Variable	***r***
Initial centre compactness	
1996 Compact Score[#]	**.538***
1996 Density Score[#]	**.459***
1996 Dwelling Mix[#]	.386
1996 Employment Score[#]	**.598****
1996 Mixed use score[#]	.269
Property price factors	
Unit Price 1996	**.663****
Absolute Unit Price Change	**.552***
Percent Unit Price Change	-0.238
Planning policy factors	
Change in residential zoning intensity - 1996 to 2016	-.062
Change in commercial zoning intensity - 1996 to 2016	-.044
Change in industrial zoning intensity - 1996 to 2016	-.214
Change in bulky good retail zoning intensity - 1996 to 2016	.296
Transport factors	
SNAMUTS Composite	**.469***
Road Distance to CBD	**-.513***
Socio-economic factors	
1996 IEO Band	**.650****
* Correlation is significant at the 0.05 level (2-tailed).	
** Correlation is significant at the 0.01 level (2-tailed).	
# Pearson Product-Moment Correlation	

Relationships between centre intensification controlling for the influence of other variables

We next consider the cross-correlations between variables. We then use these results to inform several partial correlations to reconsider the initial centre intensification correlations while controlling for the influence of other variables. A cross-correlation matrix of all independent variables is shown in Table 3.

As expected, the overall compactness score correlates strongly with its sub-scores. There are also some strong relationships between the sub-scores, particularly between the density and dwelling mix scores. The dwelling mix score is derived from proportions of different dwelling types and favours the centres that include mixes of high, medium, and medium-low density dwellings. It is therefore not surprising that this variable is strongly related to measures of residential density. The employment sub-score has the greatest independence from the other compactness measures. Controlling for the density, dwelling mix, and mixed-use scores, there is a statistically significant relationship between the employment score and centre intensification ($r = 0.499$[9]). This is not the case for the other sub-scores. When controlled using the other sub-scores, the density, dwelling mix, and mixed-use scores show only weak relationships with centre intensification.

Comparing the other variables with the existing compactness scores shows a pattern of weak to moderate relationships with the distance to the CBD: as the distance increases, the existing compactness (across all measures) reduces. When controlling for distance however, only the employment measure maintained a moderate relationship with intensification ($r = 0.467$), and the other measures including the overall compactness measure, demonstrated only weak relationships with centre intensification.

The relationships between the compactness indicators and changes in land use regulations are one-way relationships; the change in zoning cannot influence the initial compactness, but the initial compactness could potentially have an influence on decisions to change zoning. The residential category in particular showed strong relationships with the density-based compactness measures. Centres that were denser, and had a greater mix of dwelling types, saw more intensive future residential and commercial zoning changes, and

[9] Significant at the 0.05 level (2-tailed)

less intensive industrial zoning changes. Controlling for the degree of initial compactness saw relationships between overall intensification and changes in residential and commercial zoning intensity become stronger, but in a negative sense, so that where zoning changes were more intense, the overall centre intensification reduced. This result aligns with the earlier discussion how liberal planning regulations potentially driving speculative land hoarding and reduced development activity (Murray, 2019).

Table 3 - Correlation matrix of independent variables

Variable	1996 Compact Score	1996 Density Score	1996 Dwelling Mix	1996 Employment Score	1996 Mixed use score	Unit Price 1996	1996 IEO Band	SNAMUTS Composite	Road Distance to CBD	Change in residential zoning intensity - 1996 to 2016	Change in commercial zoning intensity - 1996 to 2016	Change in industrial zoning intensity - 1996 to 2016	Change in bulky good retail zoning intensity - 1996 to 2016
1996 Compact Score	1.000												
1996 Density Score	**.863****	1.000											
1996 Dwelling Mix	**.784****	**.802****	1.000										
1996 Employment Score	**.475***	0.312	0.177	1.000									
1996 Mixed use score	**.767****	**.496***	**.496***	0.211	1.000								
Unit Price 1996	0.168	0.240	0.191	0.426	0.142	1.000							
1996 IEO Band	0.286	0.274	0.109	**.498***	0.263	**.715****	1.000						
SNAMUTS Composite	0.329	0.342	0.098	0.337	0.355	0.425	**.814****	1.000					
Road Distance to CBD	-0.373	**-.566***	-0.322	-0.324	-0.243	**-.530***	**-.743****	**-.736****	1.000				
Change in residential zoning intensity - 1996 to 2016	**.645****	**.794****	**.662****	-0.030	0.278	-0.140	-0.050	0.029	-0.251	1.000			
Change in commercial zoning intensity - 1996 to 2016	**.474***	0.414	0.415	0.080	0.330	-0.074	0.259	0.227	-0.336	0.323	1.000		
Change in industrial zoning intensity - 1996 to 2016	-0.326	**-.531***	-0.288	-0.319	-0.044	-0.306	-0.141	-0.093	0.414	**-.533***	0.171	1.000	
Change in bulky good retail zoning intensity - 1996 to 2016	0.155	0.187	0.124	0.124	0.035	0.135	0.301	0.196	-0.343	0.079	**.670****	0.130	1.000

*. Correlation is significant at the 0.05 level (2-tailed), **. Correlation is significant at the 0.01 level (2-tailed).

There were also moderate to strong relationships between the key variables of unit price, the SEIFA scores, public transport accessibility, and distance to the CBD. These relationships are all positive except for road distance, which indicates lower values for the other variables the greater the distance from the CBD.

The results of partial correlations controlling for these factors are shown in Table 4. Controlling firstly for distance, both unit price and the IEO continue to show moderate positive relationships with centre intensification, whereas the public transport measure displays a significantly weaker relationship. A similar result occurs when controlling for public transport accessibility demonstrating that unit price and IEO maintain relationships to centre intensification independently of distance and transport factors. The relationships between transport factors and intensification however are well accounted for by the IEO as these relationships become particularly weak when controlled for this variable. Also, of interest is the relationship between public transport accessibility and intensification controlling for distance. The strong relationship between transit and distance supports an obvious conclusion that locations closer to the city have better transport accessibility. However, if distance is controlled for, public transport has only a weak relationship with centre intensification. Although such a result suggests better public transport is not linked to centre intensification (a result similar to the finding of Newton and Glackin (2014) regarding infill residential development), this should be interpreted with caution. There is little differentiation in public transport accessibility in outer areas, with these centres all being ranked in one of the bottom two categories on the SNAMUTS index. Greater Brisbane does not have an outer centre with the same quality of public transport service as inner centres so the data cannot determine whether improved public transport to this standard may translate into more intensive centre outcomes.

Table 4 - Relationships between centre intensification and property, socio-economic and transport variables while controlling for each of these variables

Controlling for…	**Variable**	**Spearman's *r***
Road Distance to CBD	Unit Price 1996	**.537***
	1996 IEO Band	.467
	SNAMUTS Composite	.157
SNAMUTS Composite	Unit Price 1996	**.580***
	1996 IEO Band	**.522***
	Road Distance to CBD	-.281
Unit Price 1996	1996 IEO Band	.336
	SNAMUTS Composite	.276
	Road Distance to CBD	-.255
1996 IEO Band	Unit Price 1996	.374
	SNAMUTS Composite	-.136
	Road Distance to CBD	-.06

When controlling for unit price and IEO, weaker relationships are revealed with centre intensification. There is an obvious link here; it would be expected that those with higher status employment and better educational attainment would have higher paying work and be able to afford to live in areas with higher property prices and conversely, that areas with higher property prices would be more financially accessible to those with better jobs.

The final cross correlation of interest is the initial employment score and its relationships with the property, socio-economic, and transport factors. Unlike the other existing factors (density, dwelling mix, and mixed-use), the employment score has moderate relationships with all these aspects. The initial employment indicator continues to show a statistically significant relationship when distance to the CBD is controlled (r = .467). Controlling for public transport accessibility yields similar results (r = .466). Property and socio-economic factors however explain more of the initial employment score's relationship

with centre intensification. Controlling for these aspects results in a more moderate correlation with intensification (r = .388 controlling for unit price, and r = .337 controlling for IEO). Controlling for initial employment, however, has less impact on the relationship between unit price/IEO and centre intensification (r = .568 and r = .520 respectively).

Discussion and conclusion

This research explores the relationship between compact centre intensification and key explanatory factors related to property economics, physical conditions, socio-economic characteristics, and planning policy. The analysis showed that once key relationships between the different variables are accounted for, property unit price and the SEIFA Index of Education and Occupation demonstrated the strongest relationships with centre intensification. This result is consistent with the market-based explanations for compact city development. Compact city development is more likely to occur where higher unit prices make development most profitable, and where a highly qualified population with good jobs able to afford the new units is already in place. This poses equity questions for compact city policy aiming for sustainable development outcomes and is concerning in the context of Australia's increasingly high housing costs.

Of further concern is that planning policy indicators were not related to centre intensification. In other words, the act of changing zoning alone has little to no relationship with the achievement of the activity centre policy. Taken together, the results show that planning policy for compact centres is ineffectual in the absence of a market for the types of development proposed by the plan. The fact that market gain drives planning outcomes does not come as a surprise, but the utter lack of planning power to direct development into activity centres is concerning particularly if the compact city agenda continues to be held up as a sustainable approach to urban development.

One obvious conclusion is that the plan's primary implementation mechanism was inappropriate to influence outcomes in a system dependent on privately instigated property development. Since the release of the first officially endorsed regional plan in 1995, major centres are identified only by population catchment and the number of existing jobs (The State of Queensland, 1995). The nominated activity centres have therefore long been selected without proper consideration of market factors that would enable their development. The patchy conformance to planned outcomes was primarily due to some centres happening to have conditions attractive for higher density development, rather than from the considered application of regional planning policy (Limb et al., 2020a). Absent these conditions, changing land use regulations to encourage new development represented more a case of wishful thinking than a realistic approach to direct actual change.

However, simply recommending that policy makers better consider market-based factors when developing plans would ignore the fundamental issues associated with such an approach. We contend that current approaches to position planning to meet the market are problematic both normatively and practically. Land markets are notoriously difficult to predict and are subject to sudden and unexpected changes such as those brought on by the Global Financial Crisis of 2007 (Krugman, 2009). Consumer trends for housing purchases can change rapidly (Wu and Brynjolfsson, 2015), sometimes on timeframes shorter than those required to complete the drafting and approval of comprehensive land use plans such as the SEQRP. Writing policy to suit the fickle ebbs and flows of the market eschews the sustainability goals of the regional plans themselves and which are supposedly inherent in compact activity centres. Instead, potential sustainability benefits go toward those who can afford them while lower-income, car dependent outer centres which lack the demand for private sector development see little change.

Alternative approaches are needed, but these also require careful consideration around implementation. Attempts to do so in greater Brisbane have so far concentrated on infrastructure-led development, and improved coordination of government services; both of which have had limited effect to date. Supporting infrastructure was initially described in terms of calls of further planning and investigation (The State of Queensland, 1995). However, the release of the South East Queensland Infrastructure Plan and Program in conjunction with the 2005 South East Queensland Regional Plan provided more direct linkages between planning policy and infrastructure planning (The State of Queensland, 2005a). Although this plan acknowledged the importance of the activity centre concept, there was little direct link between centres and infrastructure provision which focussed mostly on transport, and some service-based development. Notable centre specific transport projects were the South East Busway connecting Upper Mount Gravatt, the development of bus interchanges, and a train line extension to Springfield and Redcliffe. Hospital upgrades also proceeded in Ipswich and Chermside. Overall though, these changes had direct effect on relatively few centres and even after the transport upgrades, the majority of greater Brisbane's centres were categorised as having either poor, minimal, or less than minimal public transport services (SNAMUTS, 2016).

The public investment and coordination of key services such as hospitals did yield some results, with increases in hospital related employment representing a large proportion of the employment growth in these centres (Limb et al., 2020a). Likewise, institutional support in the form of government services being relocated or expanded in centres also made a measurable difference to office employment levels in some centres. State and local governments also made attempts to implement centre policy through further regulatory concessions, marketing focussed "placemaking" exercises such as Logan City Council's development "summits" (Logan City Council, 2017), or by directly developing centre

locations (Ipswich City Properties, 2009). Although judgement of the more recent attempts is perhaps premature, Ipswich's scheme has already suffered several setbacks and has proven to be dependent on public investment (Ipswich City Properties, 2017; Robertson, 2018). Ultimately though, these efforts were the exception rather than the rule and have so far failed to stimulate other forms of development, particularly residential development, as intended by the policy (Limb et al., 2020a). Although these initial attempts have had somewhat disappointing results, they do suggest that the planning profession is cognisant of the limitations of its current reliance on the regulatory land use planning system to deliver strategic policy objectives. With some suggesting the profession lacks understanding of the critical geography required to tangibly address significant urban issues such as climate change and sustainable development (Gleeson, 2012), it is encouraging to see planners looking beyond land use regulations towards approaches that can integrate plans with direct government investment and actions to re-shape our cities to meet sustainability objectives.

Perhaps planning would be better served by directing its attention away from a situation where development of particular uses in nominated places is both a means and an end, and instead focus on more normative, overarching sustainability outcomes? For example, Los Angeles California's Transit-oriented Communities program provides a density bonus for the production of affordable housing near transit (Khouri, 2019). Indeed, such market-based schemes could be used to fund infrastructure that directly improves sustainability in outer centres. In Victoria, the Growth Areas Infrastructure Contribution (the GAIC), is a tax intended to fund essential infrastructure in outer suburbs. However, issues of need and resources require close investigation to ensure effective use and delivery of these programs. In any case, moving away from form-based activity centre policy to broad based regional planning with a focus on outer suburbs offers an alternative.

What is currently missing is a better understanding of what forms of policy intervention yield the greatest sustainability benefits, or even whether they provide a benefit at all. Although there is a wide field of research that links sustainability outcomes with more compact urban forms (Ewing and Hamidi, 2015), there is little research that links activity centre compactness as proposed in Australian planning policies to these sustainability benefits. Policymakers should recognise that it takes more than zoning and changes to urban form to stimulate changes in behaviour and consumer preference toward sustainability outcomes. The results of this research raise serious doubts around the capabilities of current forms of land use planning in Australia to achieve meaningful improvements to sustainability via activity centres. If we are to persist with the idea of achieving sustainability benefits by fundamentally altering the urban form around compact centres, it must be supported by further evidence. We argue such evidence needs to be drawn from further empirical investigation of plan implementation. Undertaking conformance-based evaluations that link sustainability outcomes with centre policies is essential to determine if it is worth allocating the resources necessary to continue this approach and to identify alternative implementation mechanisms to current market-led attempts.

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