



*Building out or Building up: Densification and Expansion in Irish Cities
1996 – 2021.*

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Author's note

For the sake of completeness and to facilitate comparison, some maps and figures appear in the main text *and* in the appendix as well. To avoid confusion, *numerical* titles are used in the main text (Figures 1,2,3, etc.) and *alphabetical* titles (Figures A,B,C etc.) are used in the Appendix.

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IV. Abstract

This paper explores the macro-level evolution of the urban form in the Republic of Ireland's three largest cities: Dublin, Cork and Limerick, over the last thirty years. Acknowledging both the relevant economic concepts of externalities and the role of government, it specifically explores the tensions between densification (new construction within the existing urban fabric) and expansion (new construction adding to the urban fabric).

Using both census population and precise address data, it maps the change in the density of these cities, finding more expansion than densification in all cities from their 1990 urban cover. The paper then explores some of the overarching causes of building out rather than up, suggesting that a powerful "vested interests" group and cultural attitudes within the country played a key role. Further studies can begin to causally explore these relationships, as well as focusing on smaller cities specifically.

“...the Dublin Region ... is noted as the “worst-case scenario” of urban sprawl and used as a negative example for planners in Europe” – Nedovic-Budic et al. (2016:151)

“The continuation of the present outward sprawl of Dublin is creating major future problems for the inhabitants of the region.” – Williams and Shiels (2000:38)

1. Introduction

The cities of the world are ever-changing, influenced by the advance of technologies and changes in societal trends and preferences. For example, around the 1880's, some experiments began with "Garden Suburbs" that sought to escape the "gritty urbanity" (Wheeler, 2008: 405) which characterised the industrial cities of the time.

Post World-War II, the rise of the automobile and the idea that one could live in a detached house away from the hustle and bustle of the city held a great appeal (Resnik, 2010). Combined with rising incomes and the appeal of the "cheaper and more profitable" greenfield site (Breheny, 1997), there was an enormous growth in suburban living, especially in America, during the 50's, 60's, and 70's (Wheeler, 2008). This phenomenon of a city spreading out with low-density living is known as sprawl.

However, there has recently been a renaissance in city centre living, both in North America and in Europe (Brombach et al., 2017). The population changes of these areas have been driven by increases in city-centre office jobs (Swinney and Carter, 2018; ONS, 2020) and city-centre amenity opportunities (Brueckner, Thisse and Zenou, 1999).

The city centre can only be so big, so where do the influx of new workers live? While initially, they may have vacant apartments to occupy, new accommodation must eventually be created. If cities cannot build out, they must convert brown or greyfield spaces into residential ones, construct onto or subdivide existing dwellings or demolish them and build up.

This process of "adding new houses to the existing urban fabric and thus increasing the initial density" (Claassens, Koomen and Rouwendal, 2020: 1), is known as densification. Living in the city-centre is not just attractive from a lifestyle perspective. From a longer-term economic point of view, high densities are appealing. They can allow for shorter commutes (Newman and Kenworthy, 2006), more efficient provision of public services (Rappaport, 2008) and greener cities (Wilson and Chakraborty, 2013).

The Republic of Ireland (hence Ireland) had long lagged most of the West in economic and urbanisation terms. There had been relatively successful economic periods during the 1960's and most of the 1970's, as seems to have been reflected in high housing construction at that time (Table

1), but such successes were not always forthcoming. Following a large slump in the 1980's its economy then began to grow by an average of 7% annually from 1989 – 2008, a period dubbed the “Celtic Tiger” (CSO, 2021).

Table 1: Ratio of Total Housing Construction by county, benchmarked from the decade 1971-1980

	Dublin City	DL-Rath	South Dublin	Fingal	Meath	Kildare	Carlow	Wicklow
1961 to 1970	104	101	43	38	38	38	52	39
1971 to 1980	100	100	100	100	100	100	100	100
1981 to 1990	75	81	56	74	66	83	88	75
1991 to 2000	102	75	70	108	128	150	143	99
2001 to 2010	158	120	78	207	275	225	275	160
2011 to 2016	14	17	7	16	19	18	20	15

Blue indicates part of the Dublin Agglomeration.

Yellow indicates a more “rural” county adjacent to Dublin Agglomeration

Source: CSO (2016a)

cFrom an urbanisation perspective, Ireland was still considered a “rural” society in 1966 (U.N., 2018; McCafferty, 2019), given the traditional importance of agriculture in the country (or rather the absence of industry) (Collins, 2021) and an overbearing, conservative Catholic Church (Horgan, 2004).

The Celtic Tiger also led to a revolution in Ireland's housing market and commenced a mania of construction. The overwhelming evidence suggests that there was a rising preference for development in smaller and smaller (and hence more sprawl-prone) settlements. This can be seen in Table 2, where rural villages exhibited a median growth rate double that of the next urban class.

Table 2: Median of Average Annual Population Growth Rates by settlement size 1966–2016

Settlement Size 1966	Descriptor	N	Median of Average Annual Growth Rates (%)
> 250000	Dublin	1	1.61
50000 - 250000	Other cities	2	1.29
10000 - 50000	Large towns	11	1.89
5000 - 10000	Medium-size towns	18	2.26
1500 - 5000	Small towns	66	2.01
< 1500	Rural Villages	100	5.25

Source: McCafferty (2019)

However, the city centre populations of the largest Irish cities have also recently increased, and maps that take a broad stroke view on population change suggest that densification has occurred here (CSO, 2016b). Densification and sprawl within the same city are not mutually exclusive (Williams, and Shiels, 2000) but they are processes driven from competing ideologies.

Understanding the urban form of Ireland's cities is critical; Ireland experiences many of the issues highlighted above due to its low-density. Dublin is the most congested city in Western Europe according to TomTom (2021), and Ireland is also well recognised as a climate laggard (Torney and O'Gorman, 2019).

However, perhaps the forefront issue is in housing. Ireland suffers from an acute housing shortage, which is so bad that it was deemed by several commentators as the key factor in the rise of the left-wing Sinn Féin in the 2020 Election (Field, 2020; Mueller, 2020; McWilliams, 2021). Given the greater ease of greenfield development, for politicians to encourage either densification or expansion, is a choice between promoting a more sustainable long-term against (perhaps) a more politically advantageous short-term.

Section 2 conducts a wide-ranging review of previous literature. Section 3 examines the data and Section 4, the methods used for this paper. Section 5 explores the results of a wide-ranging analysis on urban development patterns. Section 6 attempts to explain why Ireland leant towards expansion rather than densification.

2. Literature Review

To provide a more coherent review of the papers, this literature review is conducted under the following thematic headings:

- i) Broader economic relevance: externalities and the role of government
- ii) Models that can explain the densification versus expansion context
- iii) Discussion surrounding the geographical development of cities over time
- iv) Is Sprawl even that bad?
- v) Empirical studies on the densification versus expansion context
- vi) Relevant studies on the Irish context

i) Broad economic relevance: externalities and the role of government

Economic theories and concepts are littered within the literature on densification, though the impact of densification can be difficult to immediately link to wider society. This is because an individual densified development exists on a micro-level, and the decision to construct a densified development is more dependent on the costs and profits of the developer rather than the associated societal well-being.

Instead, it is important to recognise densification as a key aspect of a planning theory known as the “compact city”. Breheny (1997: 209) describes the “compact city” as a collection of policies that “typically promote urban regeneration, the revitalization of town centres, restraint on development in rural areas, higher densities, mixed-use development, promotion of public transport, and the concentration of urban development at public transport nodes”. This allows for the reduction of private car use (and hence pollution) and minimizes “the loss of open countryside to development” (Breheny, 1997: 209).

Therefore, if a densified development can contribute some of the things listed above, then densification can, as already mentioned, reduce congestion (Newman and Kenworthy, 2006), more efficiently provide of public services (Rappaport, 2008) and reduce emissions (Wilson and Chakraborty, 2013). This extra-market effect is known as an externality (Pigou, 1920), and in the case of densification, it produces positive ones which benefit society.

The second concept concerns the role of government. Governments frequently subsidise housing (e.g., social housing construction), and in many European countries, the local government directly intervenes in the housing market by purchasing suitable sites to create a landbank (NESC, 2011).

Breheny (1997) describes compaction as going against the market, given his inclinations that people possess preferences for less density, and the higher monetary and transaction costs of densification. This may mean that subsidies may be necessary to promote compaction, but is it economically efficient that the government “intervenes” and spends its (taxpayers) money in this way?

ii) Models that can explain the densification versus expansion context

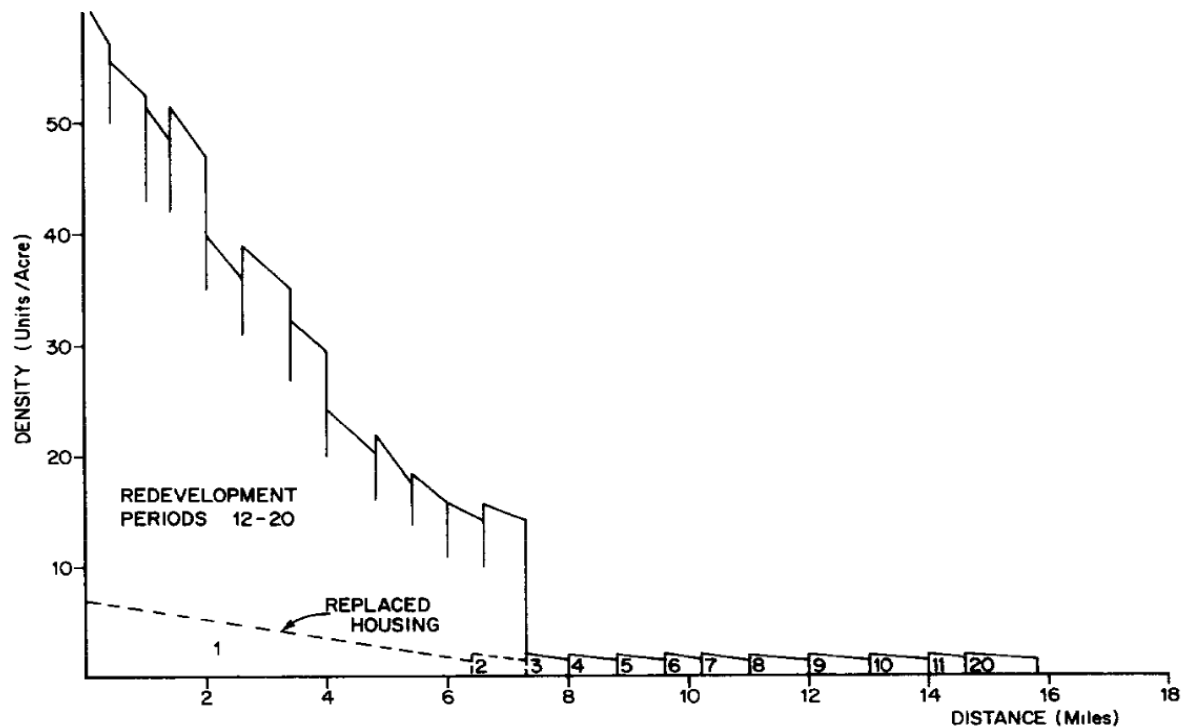
The real world is very dynamic and must be simplified so researchers can create an environment to extract useful and applicable findings. This entails building models of the world using some assumptions, without which, it is impossible to proceed. What models are commonly used that can explain the patterns of urban development?

Wheaton (1982) provides a useful model to help us understand the growth of cities in the context of this subject matter. He was one of the first authors to begin to incorporate the choice between urban expansion and densification into a city development model. That is, an increase in the population in a city does not always need to result in an expansion of the city limits.

He presents a type of monocentric-city model, which incorporates the static theory developed by Alonso (1964), Mills (1967) and Muth (1969), and the theory of incremental growth formulated by Anas (1978). Previous models had not considered the possibility of replacing existing capital. Once it becomes economically profitable to do so, Wheaton (1982) notes that rather than live in new developments further away from the centre, new workers will instead live on redeveloped city-centre land in far denser accommodation.

A nice demonstration of the effectiveness of the model can be seen in Figure 2, lifted from the paper. The structure of the graph illustrates building densities, but it looks very similar to the towering CBD skylines seen in major city centres across the globe.

Figure 1: Simulated City growth with Replaceable Capital (number indicates development period)



Source: Wheaton (1982)

Glaeser and Kahn (2003) analyse the expansion of cities and its impacts on well-being in a seminal piece of work “Sprawl and Urban Growth”. This paper examines the development of cities in America, with specific reference to the concept of sprawl.

They begin with an examination of the monocentric city model, but they emphasise different observations with more recent data than Wheaton (1982). Employment decentralisation away from the city centre make a “polycentric” (multiple centres) model possible. The model also implies falling transport costs are what make a move to low-density sprawl possible.

iii) Discussion surrounding the geographical development of cities over time

Moving on from their theoretical considerations, Glaeser and Kahn (2003) then examine 301 metropolitan areas and find a reducing density over time of both population and employment, and can implicate sprawl from this. Increases in sprawl across America are also found in other papers.

Wheeler (2008) presents a far more precise geographical study and finds a rise in sprawl. Using a vast dataset across six US metropolitan areas, he examines the type of housing developments that were constructed in America from their early colonial origins to the modern-day. Wheeler (2008: 400) notes that “This recent period [1980-2005] was characterized by a proliferation and fragmentation of built landscape types, rapid spatial expansion, and falling densities”.

In effect, sprawl has become even more prominent in much of America since the 1980’s. Driven by rural sprawl and suburban tracts (housing estates), there was a more than doubling of developed land in these metropolitan regions in this period. The lowest increase in development in any of these regions was 130%. This lines up with Glaeser and Kahn’s (2003) assertion that sprawl is not decreasing but increasing.

The flourishing of sprawl is not just a phenomenon beginning in post-WWII America. Sprawl has also occurred in Europe (European Environment Agency, 2006), and in Switzerland at least, it “remains the dominant spatial dynamics” (Rérat, 2019: 363).

Glaeser and Kahn (2003) fervently believe that it has indeed been falling transport costs that have created the sprawling expansion cities and pin this to the rise of the automobile. The advantages of the automobile are recognised as twofold: one, “cars reduce transport costs, thus increasing the possible distance between residences and jobs” and two, “they eliminate the scale economies involved in older transportation technologies” (Glaeser and Kahn, 2003: 2484). They also identify the other noted drivers of sprawl: rising incomes increasing the demand for land and certain government policies (such as subsidising highway construction) making sprawl more attractive.

Wheeler (2008) does not identify any different reasons for sprawl compared to Glaeser and Kahn (2003) but does note that local factors can influence the prominence of sprawl. In Las Vegas, he posits that the searing heat makes larger gardens which characterise sprawl less attractive. In chronically sprawled Boston meanwhile, the geography, history and politics of the area meant that

“developers may have had little choice but to leapfrog relatively small pockets of development” (Wheeler, 2008: 412).

Williams and Shiels (2000) ponder the future of Dublin in 2000 among the frantic growth of Ireland during the Celtic Tiger in this policy paper. Beginning with the “why” of sprawl in Ireland, they describe the recent development of Dublin. They identify similar drivers of sprawl to Glaeser and Kahn (2003) and Wheaton (2008) including the ease of greenfield development and major road infrastructure delivery, but also Ireland’s fragmented urban governance systems.

Noting increased demographic pressure yet falling inner-city housing development, Williams and Shiels (2000: 38) draw attention to the “contradictory set of urban development patterns” of Dublin, between its successful urban renewal programs and its inept and inadequate management of its periphery. This resulted in a sprawl showing much leapfrog development similar to Boston (Wheaton, 2008).

Rérat (2019) also draws on a few possible causes for sprawl in his literature review, such as more space and closer proximity to nature for suburban dwellers in a sprawled neighbourhood, as well as being further away from the repellent factors of the city such as noise and pollution.

However, examining sprawl is just a small part of Rérat’s (2019) paper. He presents a study of Swiss city dynamics from a different angle. It gives us a background into the dynamics driving demand into the city centres – the demand that encourages densification. He uses recent data to examine a “reurbanisation”, classed as a demographic resurgence of cities that had lost population. An increasing proportion of this resurgence has occurred in city centres.

Using population data to bring together these different causes of Swiss reurbanisation, Rérat (2019) notes many of these changes in demographics. One such cause is “youthification”, the extension of youth as younger people stay in education longer and get married later. Falling household sizes and influxes of educated migrant workers are also deemed to be driving “reurbanisation”.

iv) Is Sprawl even that bad?

On the virtues of sprawl, Glaeser and Kahn (2003) take up an interesting (and generally contrarian) position: they believe the emergence of sprawl is a good phenomenon. Suburban dwellers, for example can have larger homes (15% on average) than those who live in the city centre.

They tackle many of the common-cited problems which stem from sprawl. Congestion should be a never-ending problem in a car-based society due to induced demand (Lee, Klein, and Camus, 1999) but Glaeser and Kahn (2003) note that low-density sprawl cities actually have shorter commutes. Employment decentralisation (made possible by the car) means people don't all rush downtown to go to work at the same time.

Environmental issues are also a commonly-cited problem. Glaeser and Kahn (2003) argue that despite claims that sprawl uses valuable land, over 95% of American land remains undeveloped. They do acknowledge issues with greenhouse gas emissions due to higher car use, but the level of air pollution has in fact declined as modern cars are far more environmentally efficient than their predecessors.

They also find a lack of compelling evidence that agglomeration economies are impacted; they note: "The only difference between sprawl and conventional downtowns is that sprawl is built around the automobile, not around walking and public transportation (Glaeser and Kahn, 2003: 2516). Serious social consequences are also dismissed: suburbs are more integrated than the cities of old and there is tenuous evidence suggesting social isolation.

Breheny (1997) also writes in support of sprawl, but in a less direct fashion. Despite the well-publicised benefits of the compact city, he asks is it "feasible and acceptable" to see the "compact [densified] city" realised in concrete? Drawing on the expectations at that time in the UK that 50% of new builds would essentially be densification on existing urban fabric, he raises a number of challenges to both feasibility and acceptability that urban "compactionists" face.

Using similar arguments to Glaeser and Kahn (2003), he notes the dominant trends of sprawl and employment decentralisation as key challenges to compaction. He also points to surveys which suggest that the detached houses with gardens people would like to inhabit as the antithesis to the apartments necessary for a compact style city. He views that the decentralisation of population and employment as a natural process, and he seems to equate compactionism as a form of intervention

to the free market. He does not refute the core ideas and theories of the compact city as wrong but points out that a “dispassionate, realistic and thorough appraisal of the compaction case has to be made” (Breheny, 1997:216).

These virtues of sprawl are well-contended, however. Rérat (2019) does not condemn sprawl though notes that planners are aiming to curb it. Wheeler (2008: 414) notes the social and ecological damage that sprawl can cause and concludes that “A fundamentally different balance seems needed if more sustainable metropolitan development is to come about”.

Many papers examined later in this review also condemn sprawl: Claassens, Koomen and Rouwendal (2020) suggest densification as a way of “battling” urban sprawl, while Ahrens and Lyons (2019) mention the adverse effects of sprawl. Brady (2016) and Nedovic-Budic et al. (2016) both present heavy criticism of the sprawling development patterns in Ireland.

It is difficult to give strong credence to Glaeser and Kahn’s (2003) statements that sprawl is a good thing. Despite the fame of the paper (over 1000 citations), the paper is turning 18 this year. There is likely some outdated information in the paper. The environmental claims surrounding greenhouse gases seem particularly understated given the regular and disastrous prognoses (Slater et al., 2021) of the planet’s health.

Glaeser and Kahn (2003: 2484) state that “The growth of edge cities is associated with increases in most measures of quality of life.” However, is it not possible that these things are merely coincidences? Was higher racial integration due to the construction of suburbs and not the civil rights movement? Were shorter commutes due to the subsidies given for highway construction which could have been put into public transport infrastructure? Perhaps improved quality of life is due to technological and civil advancement?

Certainly, many of the points that Breheny (1997) introduces are still relevant, but there are counterpoints that can be raised here too. He views sprawling patterns as the equilibrium of the market, yet “Subsidies and mortgage rules induce the purchase of suburban houses” (Breheny, 1997: 211) and are a distortion to this “market”. NESC (2011: 11) suggest that the land market is “imperfect”, bringing the “will” of the market into further doubt. He also challenges the notion that large numbers of single households will just move into flats, though falling household size is recognised as a key driver of densification by many recent papers (Broitman and Koomen, 2015;

Rérat, 2019). On balance, the argument suggesting sprawl is a net positive phenomenon certainly requires newer and more compelling research.

v) Empirical studies on the densification versus expansion context

There is strong evidence in the literature that large amounts of densification are occurring in Europe and elsewhere. Broitman and Koomen (2015, 2020) and Claassens, Koomen and Rouwendal (2020) all find evidence of significant densification in the Netherlands in recent times. These papers apply Wheaton's (1982) iteration of the monocentric model.

Broitman and Koomen (2015) provide a hybrid geographic/economics study on the dynamics of urban development. They aim to observe the processes and the drivers of the expansion and densification of cities. This paper is an initial first look at these topics in the Netherlands; significant background information is provided, especially on the country's planning context.

Using raster data from the Netherlands in the period 2000 – 2010, they find evidence of significant densification across urban areas. 49% of all units added were done so within the existing urban fabric, with 38% classed as expansion to the urban fabric and the remainder as detached developments.

Most densification appears to be on quite a small-scale level, with 47% of net change coming in cells with the addition of 1 – 10 houses. They also find that much densification is concentrated in certain cells: the top 1% were responsible for 20% of the overall net change in densification.

By running regressions, they seek to find the causes of the processes that drive expansion and densification. On a regional level, there are a couple of takeaways:

- They find decreasing population has a limited impact on densification; they attribute this to a continually decreasing household size keeping demand for housing higher (in line with what Rérat (2019) suggests).
- An area with an initial high density is less likely to densify than an area of lower density
- There is a negative correlation between the share of new dwellings added in the existing urban fabric (densification share) and the density of new expansion dwellings outside the existing fabric (expansion density)

- If there is more land assigned for residential expansion, then the share of residential densification decreases.

On a local level, proximity to a train station, proximity to urban amenities and being located in the Randstad are cited as increasing the likelihood of densification.

Claassens, Koomen and Rouwendal (2020) use the change in the Dutch planning context as the catalyst for their paper. They examine the impact of national policy changes on densification in the Netherlands. The identified policy change was movement from a more “active and stringent type of planning in favour of decentralisation and deregulation” (Claassens, Koomen and Rouwendal, 2020: 1).

In many ways, this study follows Broitman and Koomen (2015) quite closely. Raster data is used here as well, and many similar variables are used in their regression. However, Claassens, Koomen and Rouwendal (2020) differentiate between densification on existing residential areas and densification by conversion of commercial/industrial areas.

There are also many similar findings in line with Broitman and Koomen (2015). They conclude that the impact of the changing national planning context reduced greenfield supply. This increased the price of housing making densification a more attractive process, especially in greyfield/brownfield sites. They also find that proximity to a railway station and being in a bundling zone increases the likelihood of densification.

Broitman and Koomen (2020) undertake further research examining density from a few perspectives. They are primarily interested in examining urban density gradients (the slope at which density decreases as construction moves away from the city centre). They also home in on the amenity-driven perspective (Clark, 2003), and find that the amenity value of historical monuments is a contributing factor to increasing densities in historical Dutch city centres. This also aligns with their previous findings (Broitman and Koomen, 2015).

Covering the longer period of 2000 – 2017, monument density was found to contribute to increasing residential density. Perhaps most interesting is the methodology used. Data is examined on a micro level, but eventually feeds into a view from a macro perspective in urban density gradients, providing a useful methodology tool for future researchers. It also aligns with the points raised in their earlier (2015) paper about a multi-scalar approach.

Densification has been shown to happen in places other than Europe. Delmelle, Zhou and Thill (2014) attempt to track the causes of urban density change in Charlotte, North Carolina in America. They compare the literature surrounding the causes of sprawl versus densification, and note some papers finding increased trends of the latter. As with R  rat (2019) and Broitman and Koomen (2015), they note that falling household size and changing accommodation preferences may increase the appeal of densification.

Using a GIS approach, they find increasing densification within Charlotte, with falling developed acreage but a rising number of land parcels sold. “New Urbanism” developments (identified in Wheeler (2008) as the future type of housing neighbourhoods) and development around new rail infrastructure (Broitman and Koomen, 2015) are identified as key drivers of densification.

They give much credit to new planning laws    la Portland’s Urban Growth Boundary, which curbed “the construction of typical ‘sprawling’ type developments” (Delmelle, Zhou and Thill 2014: 3988). Interestingly, these laws are now more-market driven, similarly to the Netherlands (Claassens, Koomen and Rouwendal, 2020), indicating that the creation of the correct market incentives can be very effective in encouraging densification.

vi) Relevant studies on the Irish context

Throughout the years, there have been quite some studies looking at the geographic distribution of population in Ireland, but academic literature that examines the geographic distribution of housing has been sparse. It’s possible that the former is an implicit study of the latter but to date there have been no papers examining densification.

Surprisingly perhaps, the only paper to seem to have mentioned densification in an Irish context is twenty-one years young. Williams and Shiels (2000) after examining the issue from a broad range of perspectives, conclude Dublin’s trajectory of uncontrolled sprawl in 2000 would have undesirable outcomes. They highlight five options available for the future. The fifth of these is the densification of Dublin, which they feel would be particularly beneficial in renewing declining inner-city neighbourhoods.

Moore-Cherry and Tomaney (2019: 365) explore the impact of the “central state stranglehold” over Dublin on the “efficient governance” and “sustainable development” of the city. Conducting a number of interviews with key public and private stakeholders, they appraise the negative consequences of Ireland’s highly centralised and powerful political system.

They argue that there is a missing tier of government at the metropolitan level, which has led to situations such as “weak and competitive local government” (Moore-Cherry and Tomaney, 2019: 374) and “politicised private actors” (Moore-Cherry and Tomaney, 2019: 376). The connection between these is explored in Section 6 as a key driver of Ireland’s sprawl. The paper provides many perspectives but this creates a lack of focus throughout the paper, making it difficult to distil the paper’s takeaways.

Howley, Scott and Redmond (2009) present a study of renters in Dublin’s city centre and survey them about their future mobility choices. Naturally, their findings are particularly relevant for the Irish context and raise particular issues around preferences of Irish renters. Beginning by succinctly exploring the tensions between urban expansion and densification in Ireland, they then move to examining their use of survey methods to assess the renters’ future aspirations. They discover similar to Breheny (1997) that preferences of renters lean towards detached houses in rural areas. In particular, they note the perceived unliveability of central Dublin for families. However, the authors also note that if these preferences are to be changed, planners need to allow for liveability to encourage people to want to stay in the city and such that a wider range of family types can live there.

Ahrens and Lyons (2019) present a geographic study on sprawl, viewed through an economic lens. They examine the evolution of Ireland’s land cover between 1990 – 2012 to identify if sprawl occurred within Ireland. The authors use satellite data from CORINE Land Cover (Copernicus, 2021) as well as Census data to find population. They develop a formal test to identify sprawl and conclude that Ireland has indeed undergone significant sprawl in recent years. Compared to Europe, they also find that Ireland has undertaken far more land conversion.

Sprawl has been identified as a car-based phenomenon (Glaeser and Kahn, 2003) and the authors here note that proximity to a motorway increases the likelihood of sprawl, giving credence to that finding. Some weaknesses of this paper are that being an initial specific examination of sprawl in Ireland, it does not deal with more aspects such as the type of housing that is constructed and the geography of where they have been constructed.

Nedovic-Budic et al. (2016) provide a paper that is in many ways like Wheaton's (2008), but it does not examine the specific type of urban form by contrast. Rather, they analyse Dublin using a "community" perspective. This perspective looks at some geographical measures that impact the inhabitants of that community: density, connectivity, accessibility, land use mix and ecological design.

Through these results, they interpret that sprawl has increased significantly in Dublin. Falling commercial and residential densities have been recorded, while connectivity has also fallen. Land use mix has remained relatively constant, which could be compared to the edge cities Glaeser and Kahn (2003) discuss. Their conclusions on the failure to develop Dublin in a sustainable manner are similar to Wheaton's (2008) conclusions on the development of American cities.

They acknowledge weaknesses in their dataset as limiting their analysis. They use the CORINE Land Cover dataset like Ahrens and Lyons (2019) but note it "is a coarse substitution for more detailed local land use information." (Nedovic-Budic et al., 2016: 161). They also note the difficulties of their data's temporal resolution.

Brady (2016) analyses why compact growth objectives for Ireland's second-tier cities (Cork, Galway, Limerick and Waterford) were not achieved. The paper follows a similar structure to R  rat (2019) in a methodology sense by examining the population evolution over time of these cities. However, the different outcomes and context in Ireland lead to quite different results being presented.

Brady initially notes findings in his literature review indicating the importance of the balance that a second-tier city can provide within a national economy. He also notes the slower growth of second-tier cities in Ireland compared to larger towns and Dublin. These larger towns added 5.2 times the absolute population of the second-tier cities, while Dublin City and Suburbs added 2.5 times over the period 1991-2011.

Ireland's failure to follow its own legislated planning practices is noted by both Nedovic-Budic et al. (2016) and Ahrens and Lyons (2019). However, it is Brady who really gives a methodical and thorough examination of this topic, and the negative outcomes that have arisen. These include "the continuation of pre-2002 trends of urban-generated suburban, exurban and rural sprawl, car-dominated and unsustainable commuting patterns" (Brady, 2016: 2231), and that "Dublin's area

(city and suburbs) is equal to that of the four second-tier cities combined, but it accommodates more than double the population.” (Brady, 2016: 2226)

However, the paper lacks a rigorous empirical element. The data that is used is accurate and legitimate of course, but it does not empirically measure any relationship. There is extensive referencing throughout the paper, but it is ultimately an opinion piece.

3. Data

This paper draws on a few different datasets to track the evolving density within Ireland.

The first dataset used is GeoDirectory (2021). This dataset contains very detailed data on the creation of new addresses within cities and was specially acquired for this study. This data is in the form of points and contains over 750,000 individual addresses. Crucially for this analysis, it tells us when a point was created, allowing inter-temporal comparison. It also features usage, so it is possible to observe preferences between residential and commercial constructions. This dataset is usable from 1999 until June 2021.

The second is population data, drawn from the 1996, 2002, 2006, 2011 and 2016 censuses conducted by the Central Statistics Office of Ireland (CSO, 2021). Though data from earlier censuses is also available, to best compare Census and GeoDirectory data across the same time span, this 20-year period is chosen. This is at the “electoral district” level, where an electoral district (hence ED) represents a traditional neighbourhood in a city. Outside this, an ED is recognised as a town or a rural area.

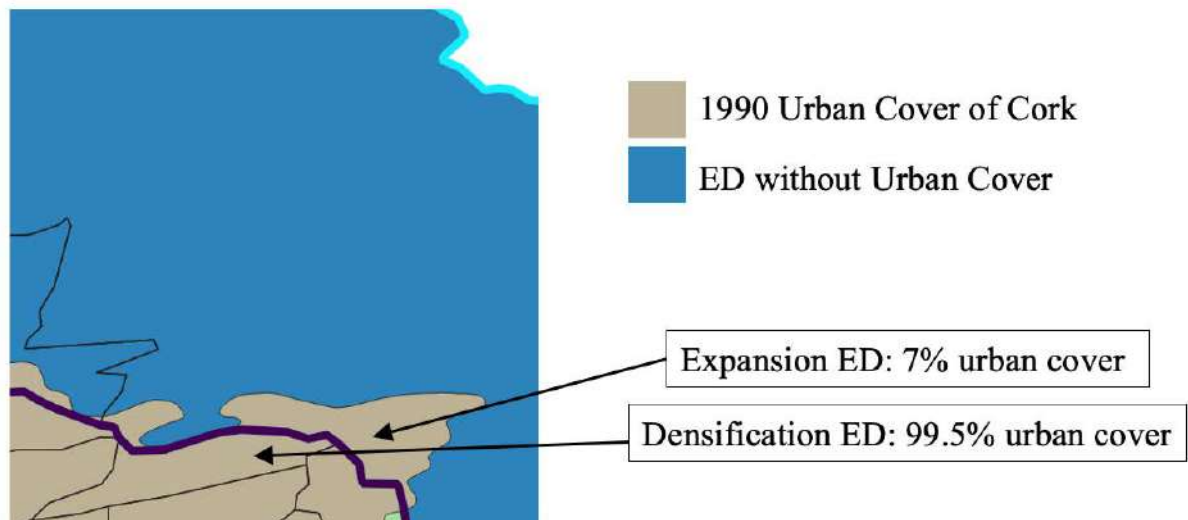
The final dataset used is Corine Land Cover (hence CLC). This provides satellite data on the land use across Europe and is used to accurately identify the actual urban cover of each city. The years used are 1990 and 2018 to measure the expansion of cities during this period. Though there is an iteration of CLC 2000, closer to the start dates of both the Census and GeoDirectory datasets, there would be an obvious risk of treating houses that were built on greenfield sites in 1999 as densification in 2000, when really this is expansion. Hence, this dataset is not used.

4. Methods:

To measure densification, it is first necessary to map out the urban area of Ireland's largest cities. Using CLC 1990, this is done by identifying the components of urban area comprising continuous and discontinuous urban fabric, industrial or commercial units and construction sites, as well as green urban areas and sport and leisure facilities. These were combined to identify the three largest contiguous urban areas in Ireland that year, these being Dublin, Cork, and Limerick cities respectively. Later in this paper, these will be referred to as the "CDL urban cover".

The methods used employing census data are population-based. Though measuring densification using population lacks the same accuracy as the GeoDirectory dataset, it allows us to capture different metrics and observe different trends beyond what just point data allows. The neighbourhood scale which ED's represent is previously used in Broitman and Koomen's (2015) paper in conjunction with more detailed data like GeoDirectory.

Figure 2: Designation of an ED as Densification or Expansion

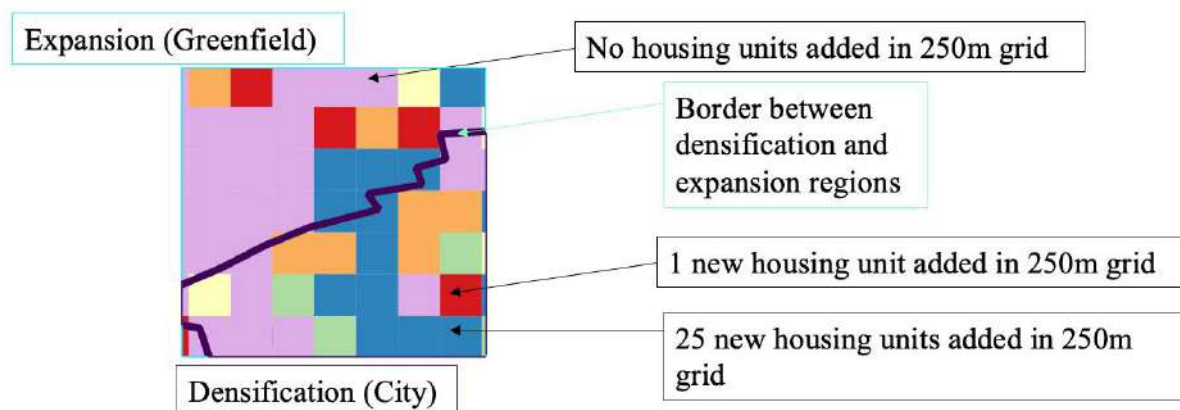


To select appropriate ED's to comprise three urban agglomerations, the 1990 CDL urban cover is overlain onto the ED map of Ireland. ED's which overlap with the 1990 CDL urban cover are automatically assigned as part of the respective urban agglomeration. The 2018 CDL urban cover is then overlaid to select more ED's which would not be chosen using the 1990 urban cover, but will play a role in the development of the city

If an ED is recognised as consisting of 90%+ urban fabric in 1990, it is possible for it to densify. Otherwise, any population increase is deemed as being due to expansion (Figure 2). These borders are clearly identified in the maps below (Appendix: Maps D – F) as well as the extent to which the 1990 urban cover goes beyond that, which is represented by the shaded areas.

If an ED is deemed possible to densify (by attaining more than 90% urban coverage), it has done so if there is a 20% increase in its population over the period 1996-2016. This 20% requirement (rather than just 1% and above for example) is imposed to ensure that a population increase is not just household fluctuation e.g., if several families start having children. 20% is arbitrary, might be too high and may lead to underestimation of densification, but it will avoid any misspecification of densification. The 1996 – 2016 population difference in each ED is then calculated to display the necessary amounts of population change which indicate densification. This is then mapped to see if trends can be seen from a spatial perspective.

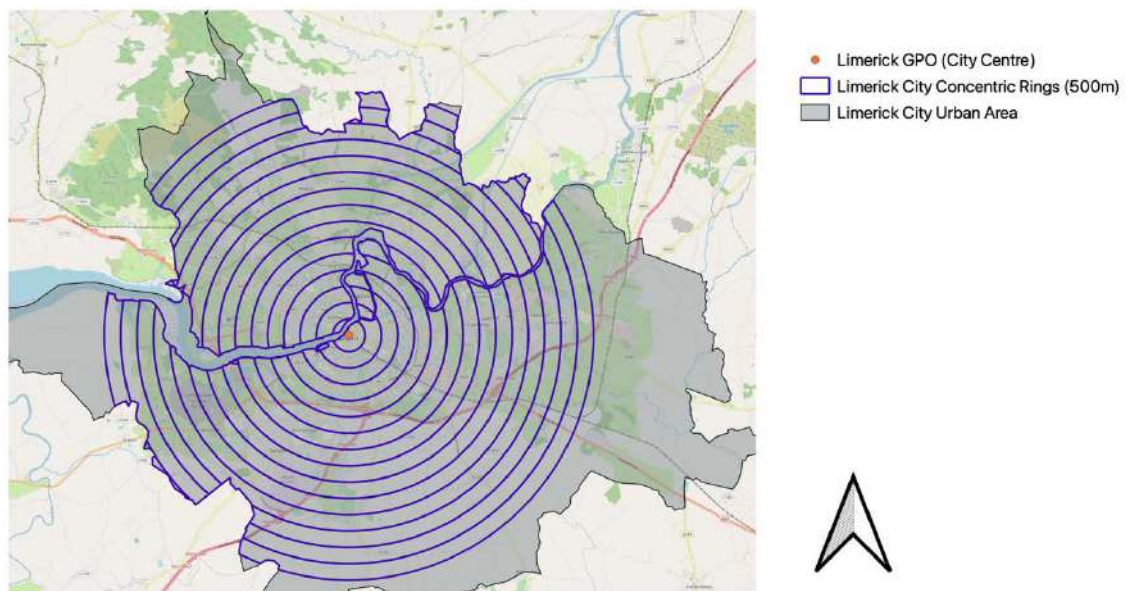
Figure 3: Breakdown of Densification and Expansion using GeoDirectory Point Data



GeoDirectory point data allows densification to be examined on a much more micro scale and using houses instead of people. This is done using 250m by 250m grids, giving a much more precise spatial representation of densification, allowing for comparable analysis to Broitman and Koomen (2015, 2020). All points are overlaid onto the ED, CLC and grid maps, and the points in each polygon are then counted, allowing the calculation of total new builds on the urban cover, each ED and grid. This data can then be extracted for use in analysis and symbolised on the map to visualise differences (Figure 3).

Also calculated in this paper is the change in the total expansion of the CDL urban cover. This is simply calculated by dividing the 2018 CDL urban cover by the 1990 iteration. Density gradients are calculated as well for Irish cities to test their monocentricity and its evolution, similarly to Broitman and Koomen (2020). To obtain density, the population of an ED is divided by the ED area obtained using the QGIS \$area command, and then this was used to get the population density per hectare. To measure an ED's distance to the city centre, a centre must first be designated. The historical foundation point or city hall is used by Broitman and Koomen (2020). For Ireland, a proxy variable representing this is readily available: the General Post Office in each city, allowing a gradient to be measured.

Map 1: Measuring Density Gradients in Limerick City by 500m Concentric Rings



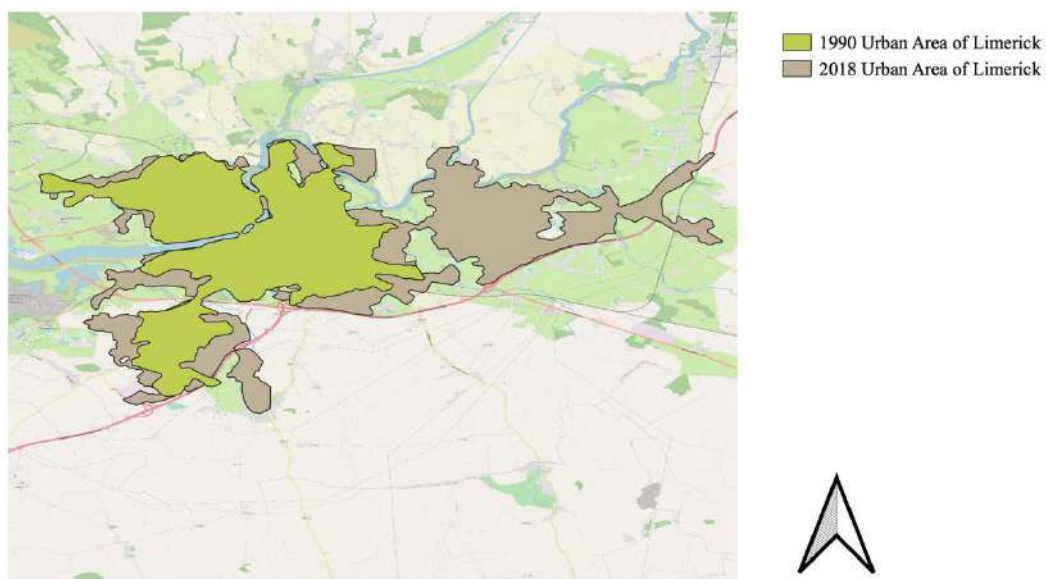
Density gradients are created in two ways. The first using ED data, measuring the total population in each ED at the beginning of the period studied and at the end, divided by that ED's respective total area. The second is measuring density in concentric rings following methodology used by Broitman and Koomen (2020). Again, the number of points in the area between each ring is counted, and this is divided by the area to obtain the density per hectare. Careful GIS work is undertaken to exclude water and other "unbuildable" land as can be seen in Limerick in Map 1.

Geographic analysis and map creation is undertaken using the QGIS software, while Microsoft Excel is used extensively for mathematical processes and to create graphs.

5. Results:

5.1 Urban Cover of the CDL

Map 2: Limerick City Urban Cover: 1990 and 2016 (Corine Land Cover)



How has the urban cover of the CDL cities evolved? All cities had quite a bit more contiguous urban area in 2018 than in 1990 lining with the evidence of sprawl from Williams and Shiel (2000) and Ahrens and Lyons (2019). There is also quite a bit of heterogeneity. As is shown in Map 2, Limerick city shows a lot of expansion, and is relatively the highest of any city, a growth of 81%. Dublin's contiguous urban area grew by 47.7% over the 28 years, while Cork's only expanded by 23.8% (Appendix: Maps A – C).

5.2 Census Population Results

Table 3: Census Population Results on Densification

	1996 Population of the 1990 Contiguous Urban CDL Area	Population Growth in Densified ED's	Population Growth in Expansion ED's	Ratio of Densification to Expansion
Dublin	936,431	95,611	191,372	1:2.0
Cork	160,468	9,557	25,417	1:2.7
Limerick	83,780	4,444	28,672	1:5.3

Source: CSO (2016); CLC (2018)

From a densification perspective, all cities clearly and identifiably experienced a sizeable increase in population density in certain areas of the city (Appendix: Maps D – F). These areas are usually close to the city centre, and almost entirely so in the smaller cities of Limerick and Cork. Dublin also experienced a lot of city centre densification but there are pockets of more focused densification, especially in the southside of Dublin.

Significant population expansion occurs alongside densification in all cities (Appendix: Maps D – F). There is more population growth in expansion ED's than in densified ones in all cities (Table 3), with smaller cities showing more expansion than densification in relative terms. There is an increasing amount of expansion compared to densification as the city size shrinks from Dublin to Cork and Cork to Limerick.

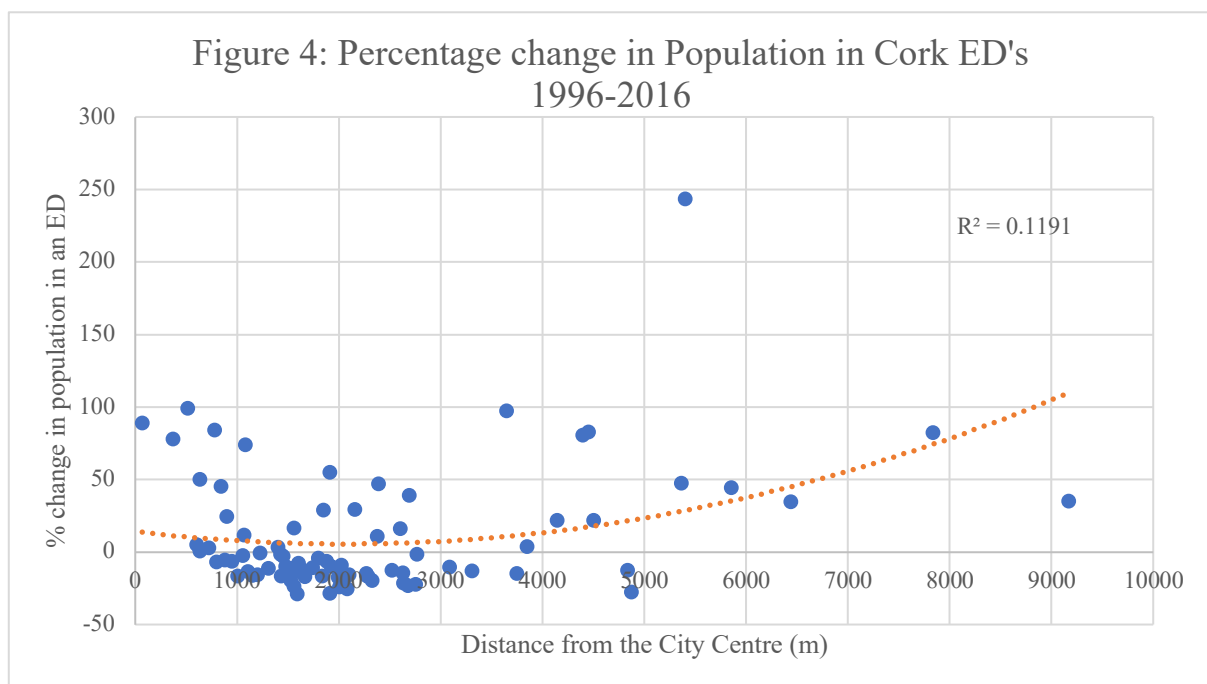
There is significant heterogeneity in the results of these cities. In Dublin, it seems that the fears of Williams and Shiels (2000) have come through, and the “continuation of pre-2002 trends” (Brady, 2016: 2231) have been confirmed. Despite having the highest densification:expansion ratio compared to the other cities, the raw increase in population expansion is 191,372 (Table 3), and is close to 4 times the combined figure of Cork (25,417) and Limerick (28,672).

Cork only increased in absolute population by 33% more than Limerick, despite being nearly double its initial size. This slower growth probably encouraged more densification given the large difference in the densification ratio between Cork and Limerick. Perhaps more focus has gone into Cork's regional growth? The population of Cork County which surrounds Cork City grew by 32% over the period 1990-2016, more than Limerick City's adjacent regional areas of Limerick County

(20%) or Clare (30%). This indicates a growth in commuter towns, and corresponds to Williams and Shields' (2000) findings for the Dublin Commuter belt.

Limerick is Ireland's third city and densifies little while also expanding a lot. This densification occurs almost exclusively around its city centre. Its urban cover has grown by an enormous amount as the traditional city has bridged the gap to the greenfield university district east of the city. Though inner-city populations fall in the other cities, in Limerick, such falls are significant on the southern and north-western fringe of the city.

Examining the changes in the five years between each census fails to show a clear pattern, though there is a depression in population growth over the period 2011-2016 given the economic difficulties in the state at that time. Much development can appear to be quite random. Many ED's increase in population over the period non-linearly, and at different periods in time compared to their neighbours.



Source: CSO, (2016)

If we relate population growth to distance from the ED, a U-shaped curve is observed in each city. Such a pattern could be interpreted from the maps (Appendix: Maps D – F), especially in Dublin,

but this provides more robust empirical evidence of this. The phenomenon is most prominent in Cork City (Figure 4) but is visible in other cities too (Appendix: Figures A – C).

This suggests an inherent tension between the two processes of expansion and densification. On the one hand, there is clearly a desire for more sprawling developments, likely due to the perceived benefits (Glaeser and Kahn, 2003; Breheny, 1997). On the other hand, factors encouraging densification noted by Broitman and Koomen (2020) and Rérat (2019), must also be in play, suggesting heterogeneous or likely evolving preferences (Howley, Scott and Redmond (2009) among Ireland’s residents. It is an interesting observation as the papers reviewed tend to discuss the dominance of one trend over the other, however few (e.g., Broitman and Koomen, (2020)) discuss the potential simultaneity of both processes, especially at the extremes.

5.3 GeoDirectory Results

Table 4: GeoDirectory Results of Densification

<u>Total points</u>	On the 1990 Urban Fabric	Outside the 1990 Urban Fabric	Ratio of Densification to Expansion
Dublin	88,970	104,459	1:1.17
Cork	15,146	14,746	1:0.973
Limerick	8,761	15,106	1:1.72
<u>Residential points</u>			
Dublin	72,435	94,997	1:1.31
Cork	11,867	13,379	1:1.127
Limerick	6,672	13,643	1:2.04
<u>Commercial points</u>			
Dublin	7369	6,338	1:0.86
Cork	1,877	1,042	1:0.56
Limerick	1175	1,090	1:0.92
<u>Mixed-Use points</u>			
Dublin	9,166	3,124	1:0.34
Cork	1402	325	1:0.23
Limerick	914	373	1:0.41

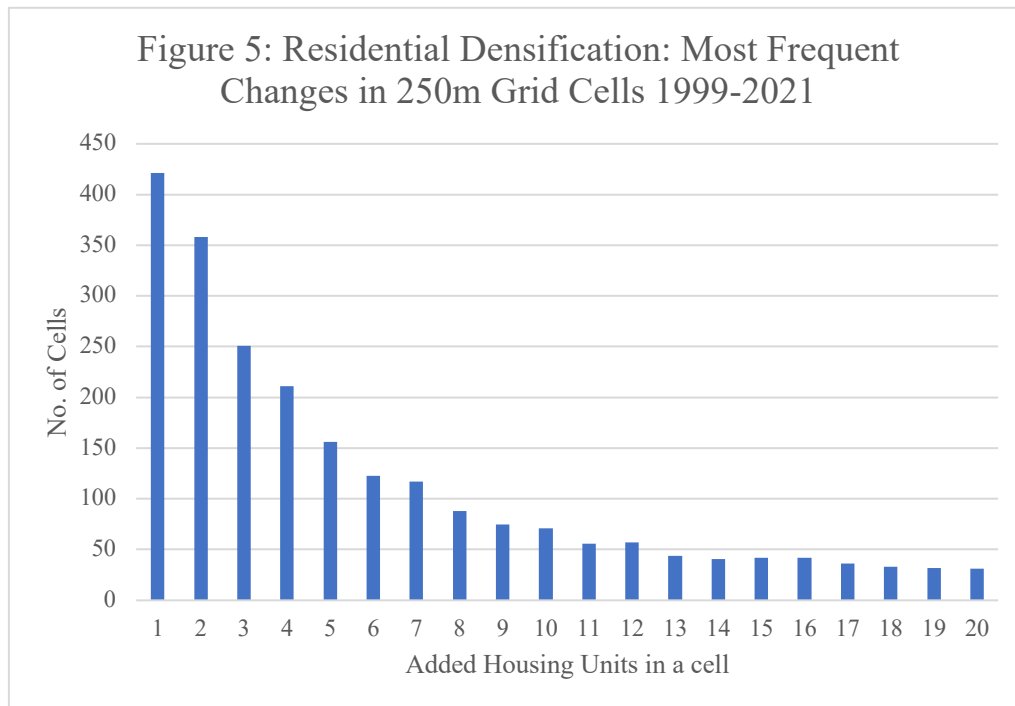
Source: GeoDirectory (2021)

An examination of more precise GeoDirectory data shows the clearly demarked trends above to be less pronounced (Table 4). By and large however, they confirm the results observed using census data. Cork now undergoes the most densification, with there being 400 more developments on the 1990 urban cover than outside it. This is somewhat in line with expectations given Cork has the lowest expansion of urban cover since 1990, but contradicts its higher ratio of population change from ED's. Dublin follows with about 1 densified development, for every 1.2 expansion ones, while Limerick still sprawls significantly.

When only residential developments are examined, increased amounts of expansion developments than the aggregated amount are observed. Firstly, this indicates an increasing separation of use of residential and commercial. Secondly, it indicates that densification is far more likely to occur for commercial properties, rather than residential ones, revealing perhaps that city centres are perceived as being for working and shopping, but not for living. Mixed-use developments, given the more complex nature of the unit, tend to be constructed on the existing urban fabric in all cities.

Visually, the trends for GeoDirectory maps (Appendix: Maps G – I) seem to be quite like those discussed for census population data. In all cities, there is densification right at the city centres, with the blue grids (indicating a grid in the upper quintile of number of new developments) quite visible here. However, there are plenty of blue grids visible from outside the urban fabric also.

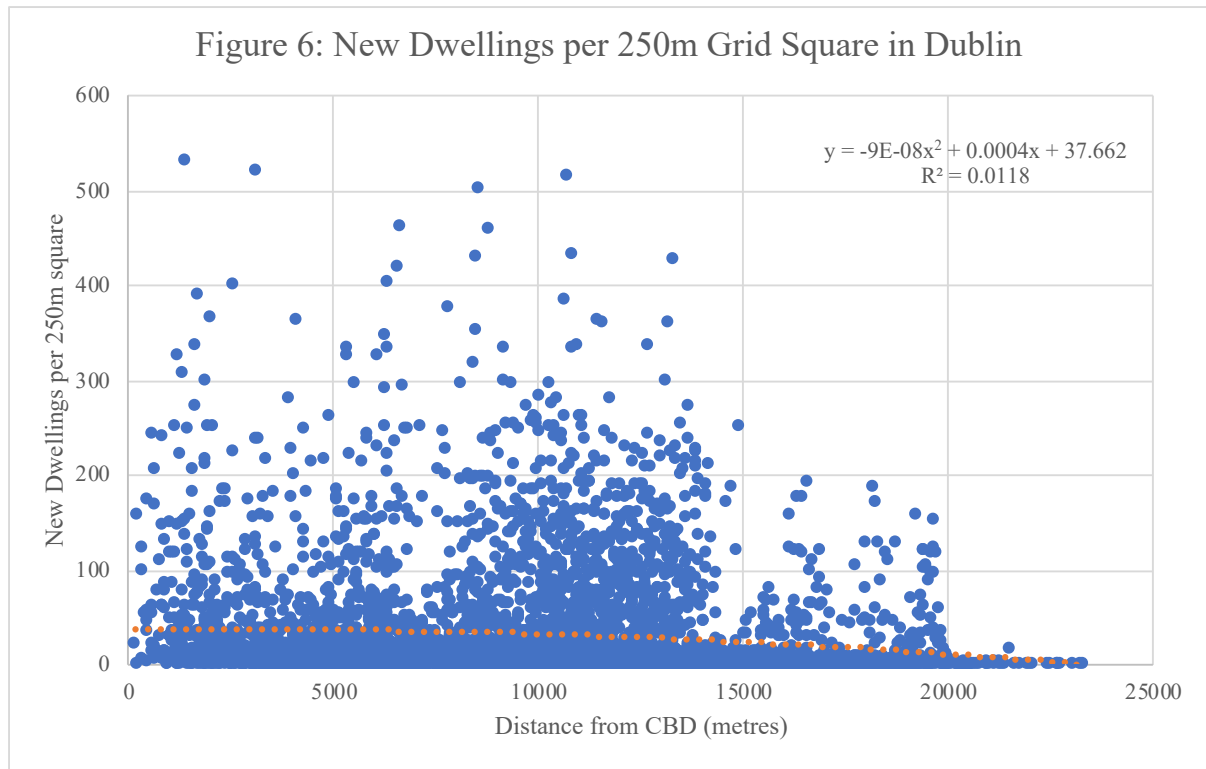
In Dublin there is an enormous amount of development close to the existing densification boundary, with a large proportion of this shooting out from the western edge of the city. In Cork, densification is spread out within the city, with new developments outside the city centre focused to the South and West. In Limerick, most developments beyond densification ED's are developments which map very closely to Limerick's 2018 CLC urban cover, contributing to its contiguous expansion.



Source: GeoDirectory (2021)

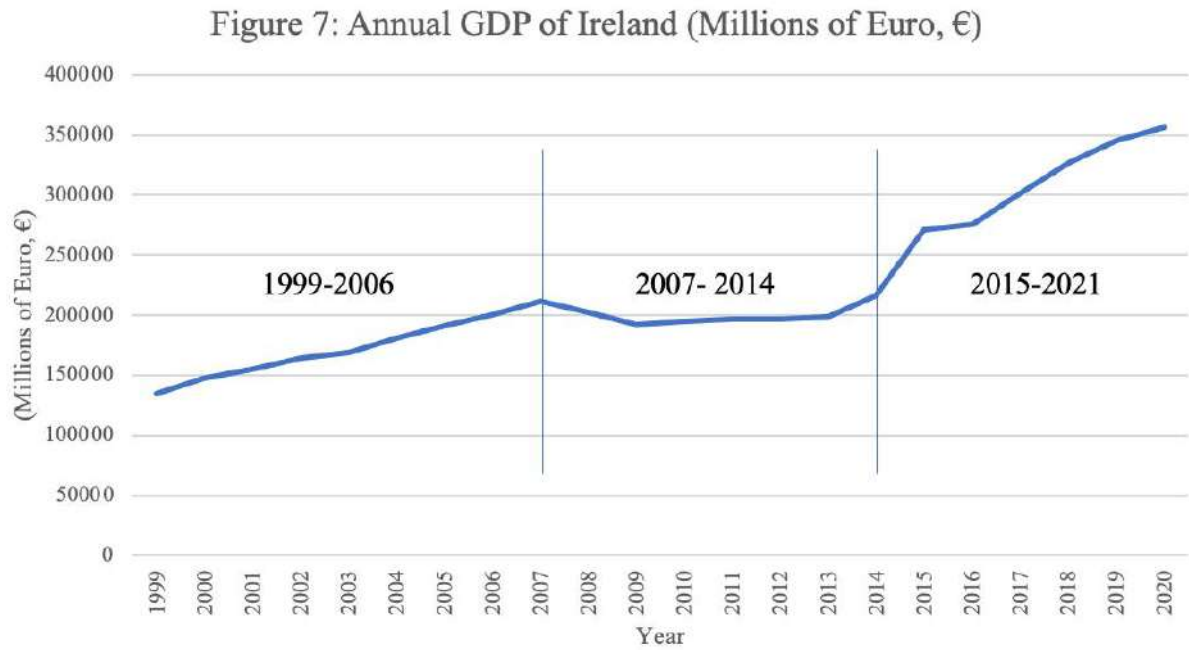
Examination of frequency distributions returns results quite close to Broitman and Koomen (2015) on their examination of added housing units. Though the prominence of just one additional unit is less pronounced compared to Broitman and Koomen’s (2015) paper, it is still the most common change; one- and two-unit changes comprise close to one-third of all cells where new development occurred.

Also similar to Broitman and Koomen (2015), much of the additional new housing units are focused in a very specific number of cells. They find that the top 20% of densification occurs in 1% of the cells. Though none of the Irish cities reach quite that, in Cork it is 2.2%, Limerick. 1.4% and in Dublin it is 1.3%.



Relating distance and density of new developments also uncovers further interesting results (Figures D – F). A U-shaped curve can be observed again in Cork and Limerick, while Dublin shows an inverse U shape (Figure 6). This indicates that the density of new developments can actually increase as distance to the city centre increases.

For Cork, seven of the eight densest developments occurred more than 4km from the city centre, with the densest in a suburb nearly 9km from the Cork CBD (Appendix: Map H). In Dublin, a similar trend is observed. Except for the top two, the next nine densest developments lie more than six kilometres away from the CBD, with such high densities far enough away to invert the curve. In Limerick, the density of developments tends to follow a more monocentric model. There is a clear cut-off of dense developments at around 7km. In terms of the density of these new developments, Dublin is far, far ahead of the rest of the cities. Incredibly, Dublin has the 37 most dense additions in a 250m grid square among the cities, with Limerick having the 38th in its centre.



Source: CSO (2021)

It is noted by Williams and Shiels (2000) that the economic growth of Ireland during the 1990's created a large demand for development that the Irish planning system had heretofore not experienced. Thus, it may be informative to break housing development data into periods, to observe the impact the prevailing macroeconomic conditions had on housing construction.

Examining the graph of Ireland's GDP above (Figure 7), three periods can be roughly defined. The "Celtic Tiger" from 1999 to 2006, "The Crash", beginning in 2007 and ending in 2014, and "The Recovery", ranging from 2015 until the present day.

Table 5: New Residential Construction by-period

	1999-2006	2007-2014	2015-2021
Cork	15,896	6,220	3,130
Dublin	87,024	28,081	52,327
Limerick	15,823	2,856	1,636

Source: GeoDirectory (2021)

Table 6: Percentage of New Residential Construction by-period
compared to Dublin

	1999-2006	2007-2014	2015-2021
Cork	18.3	22.2	6
Dublin	100	100	100
Limerick	18.2	10.2	3.1

Source: GeoDirectory (2021)

Examining the construction data shows a significant fluctuation in housing output over the different periods and large heterogeneity between cities (Tables 5 and 6). It is no surprise that housing was highest during the Celtic Tiger era of the early noughties, but the drop off in housing construction is dramatic in the subsequent periods, especially in Limerick.

It had the same housing output between 1999-2006 as Cork, despite its much smaller size. Cork performed relatively well during the initial crash period, but subsequent construction has been lower. It has been striking however, that while housing output has continued to almost halve in the minor cities from 2014, in Dublin it has rebounded by 86%.

Table 7: Percentage of new builds on the 1990 Urban Fabric

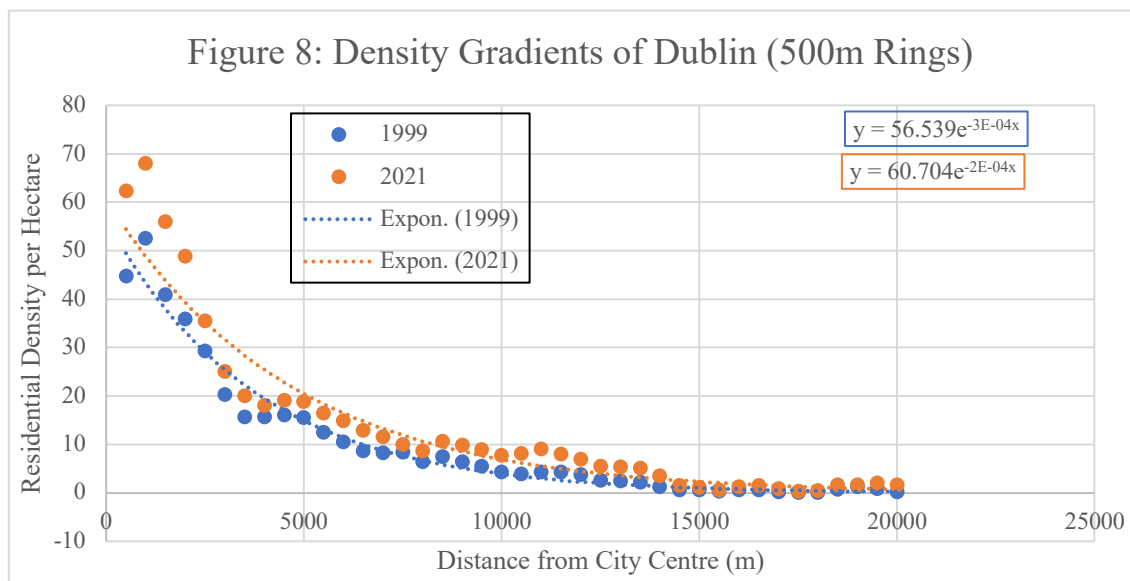
	1999-2006	2007-2014	2015-2021
Cork	45.99	52.81	40.64
Dublin	37.09	46.17	51.97
Limerick	32.98	37.39	23.53

Source: GeoDirectory (2021)

Assessing if these changes are densification or not, much heterogeneity continues to exist. Both Cork and Limerick initially increase in densified developments, but the proportion falls as time passes. Dublin on the other hand, continues to increase its densification share to 51% of new developments since 2014.

5.4 Density Gradients

Looking at the general density gradients across different methodologies suggest Irish cities follow a standard monocentric model, which is at its steepest at the city centre. Results vary whether population density or dwelling density is examined. Using the former (Figures: G – I), it can be seen in Dublin city, which experienced large population growth in its city centre, steepens the most. Limerick barely steepens, while Cork gets marginally flatter, as its traditional city centre loses some population.



If dwelling density is examined using the ring method, all cities are shown to steepen (Appendix: Figures J – L). Cork shows the steepest gradient due to its compact city footprint. Dublin (Figure 8) becomes a bit steeper as development is spread a bit more across the city but is less steep than Cork; although denser in the city centre, Dublin spreads out over a much wider distance. Limerick experiences a large increase in steepness, due to intensive development in its city centre.

Despite this, when *relative* changes in density for each ring are examined (Appendix: Figures M – O), there is a positive slope as distance from the city centre rises, which is indicative of increased sprawling developments towards the edge of the city.

6. Discussion - Expansion rather than Densification?

As noted above, Ireland has broadly tended to follow a pattern of expansion rather than densification, especially when population is examined. Here, this section shall theorise some of the reasons why this has occurred, building arguments by drawing from literature from a number of papers. There are many inter-connected reasons, which have been split into two primary groups: A “vested interests” triumvirate of government-banks-developers, who each benefitted from increasing construction and development of housing, and cultural reasons, rooted in Ireland’s history and its citizens’ preferences.

6.1 The “Vested Interests”

The former is succinctly captured by a former CEO of Dublin Chamber of Commerce in Moore-Cherry and Tomaney (2019: 376):

“You had banks who were competing viciously in the marketplace to get the attention of developers to lend them money to enhance their own scale and stature in the marketplace, you had local authorities who were being driven by the need for more development fees and then you had developers who were just looking to turn the next site into a profit and move on from there.”

i) Government

Ireland is a highly centralised state but one area where local government has a modicum of control is in planning. When the money was flowing for houses during the Celtic Tiger (Tables 5 and 6), a strong driver of more planning permission being granted by local governments for sprawling estates was the financial incentive for them to do so. One of the ways local councils could raise money was through development levies, which arise from granting of planning and the construction of new houses. Naturally, the more houses that were built, the more money a council made.

Building on greenfield sites is cheaper (Breheny, 1997), hence encouraging sprawling patterns of development ahead of densifying ones. This seems especially relevant post 1977, when local council taxes were abolished as an election sweetener (The Irish Times, 1996), putting even more emphasis on these development revenue streams. To make matters even worse, this facilitated competition between local governments who now pandered to developers to build houses in their jurisdiction to fund their services (Moore-Cherry and Tomaney, 2019).

Central government decisions also contributed. As previously noted, sprawl is a car-based phenomenon and comprehensive road infrastructure was constructed at this time. Many large motorway projects, such as the M50 (Dublin Ring Road), M8 (Cork to Dublin) and M7 (Limerick to Dublin) were fully completed at the end of the 2000's, which reinforced Ireland's high level of car dependency (Carroll, Benevenuto and Caulfield, 2021). Williams and Shiels (2000: 41) also note the contribution of "major road building programmes" to sprawl, while Ahrens and Lyons (2019) show that proximity to a motorway is a key factor in encouraging sprawl in Ireland.

ii) Banking

Though banks were not directly involved in the planning and building of new homes, they played a significant role in providing the capital for this to occur. Significant financial deregulation began to occur in Ireland at the end of the 1980's (Murphy, 1994). Enabled by low-interest rates, an enormous expansion in credit occurred, resulting in banks providing significant sums funding the construction of and purchase of new homes, though the former was more of a priority (Thomas Jr., 2009). However, in a well-worn story, over-lending occurred as banks chased higher and higher profits; profits that were earned on sprawling developments.

iii) Developers:

A developer in the Irish context is an individual or syndicate who purchases land or houses, "develops" them in some way and then hopes to sell on for a profit. Developers compete for zoned land, which they may hoard (NESC, 2011), or they may snap up agricultural land and persuade the local authority to rezone it, resulting in enormous windfalls (Clifford, 2021).

Driven by the easy credit and the insatiable desire for housing which was whipped up by the media (Mercille, 2014), developers, acting "rationally" as an economic agent, sought to maximise their profits by building out rather than up. Such behaviour is not unique to Ireland. Chiodelli (2014) observed a similar occurrence in Italy, finding large windfalls to certain developers after rezoning.

"The Triumvirate"

As noted in the quote in Moore-Cherry and Tomaney (2019:376), there was significant "mutual interests" in the development of new housing between government, banks and developers. This resulted in relationships forming between powerful actors in these fields.

For example, at major Irish property developer Seán Dunne's wedding in 2004, it was noted that the primary absentees were the Minister for Finance, Charlie Creevy, and the Taoiseach (Prime

Minister), Bertie Ahern (Harris, 2004). Seán Dunne also donated £80,000 to their respective political party in 1997 (Khan, 1997), so is it surprising that such a close link between a big businessman and politicians formed? In 2002, Dunne and a business partner succeeded in getting re-zoning for a significant 1800 homes from Wicklow County Council (Connolly, 2014). Might Dunne's close friendships with such powerful figures have left him well placed to secure such a profitable (and sprawling (Google Maps, 2021)) venture?

Though this snippet shows no “causal” evidence of corruption, corruption, favours and a “if-you-scratch-my-back-I’ll-scratch-yours” culture pervades Irish planning, then (Collins and O’Shea, 2003) and even up to this day (Clifford, 2021). In 1997, The Flood/Mahon Tribunal was set up, specifically related to corruption surrounding planning, and found widespread cases of payments to politicians by developers to ensure favourable planning outcomes (Mahon, 2012).

Ireland's weak local government did not possess the power to intervene from an ethical planning perspective; in fact, it would have been against their immediate short-term financial interests to do so. It was also in the banks' interests to fund development to make even more money; Economist Ronan Lyons noted that “the banks in Ireland did not lend recklessly to individuals; they lent recklessly to developers” (Thomas Jr., 2014). Examining the development of housing from this perspective, it seems the enrichment of the involved parties was the driving motive of sprawling developments rather than any specific planning intention to do so, a strong example of the negative externalities that can arise from profit-maximising behaviour.

6.2 The Cultural Environment for Sprawl:

The Ireland that we dreamed of would be ... a land whose countryside would be bright with cosy homesteads, whose fields and villages would be joyous with the sounds of industry”
(De Valera, 1943)

Ireland is traditionally a very rural society, with urbanisation lagging behind the rest of Europe (U.N., 2018; McCafferty, 2019). At independence, True Ireland, “Gaelic Ireland”, separate from Britain, was deemed to be the heavily rural west of Ireland; of small villages and Gaelic Athletic Association (GAA) clubs (Kiberd, 1997: 492). A famous speech by the Irish Taoiseach in 1943 spoke of the “Ireland that we dreamed of” mentioning “countryside, fields and villages”, but certainly not the large urban areas. Cities were traditionally the bastion of the British colonial power

in Ireland, and anti-colonial attitudes lingered; The Minister for Local Government in 1968 derided the classical Georgian houses of Dublin as relics of this power (Hanna, 2010).

Culturally, much of rural Ireland is dominated by indigenous Gaelic Games, played under the umbrella of the GAA. There is an ethos of community, amateurism and volunteerism in the GAA. It creates a strong sense of place and local identity (Keane, 2001) and these factors are linked with lower levels of mobility (Hanson, 2014). Hourihane (2003) goes so far to suggest that this strong sense to one's home place is linked to the absence of "civic" capital in Dublin. Measuring the cultural impact of these attitudes on planning is quite difficult, but such an environment is clearly an antithesis to building a dense urban form.

Howley, Scott and Redmond (2009) showed the unease that seemed to exist at the prospect of longer-term city centre living in Ireland and the desire for those living in Ireland to opt for less dense and more traditional housing options. Corrigan, Cotter and Hussey (2019) have recently reaffirmed this.

They find that 84.5% of aspirant owners in Ireland wish to purchase a house, with a "marked preference for three or four bedroom houses" (Corrigan, Cotter and Hussey, 2019: 1). They also note the willingness of long commutes in exchange for the homeownership of such a house. This suggests that, in line with the beliefs of Breheny (1997), that consumer demand for sprawling developments has been a strong factor in their realisation in Ireland over the past 30 years.

7. Conclusion:

This paper has comprehensively explored densification versus expansion in Irish cities, for the first-time mapping this for Dublin, Cork and Limerick in an academic context. It has also done this through the rollercoaster of Ireland's economic fortunes and has found staggering contrasts over time and space in housing construction. For Ireland at least, densification and expansion are processes which have distinctly happened simultaneously.

Each city tells its own story, and this analysis suggests that the size of a city alone is a poor predictor of densification patterns. Dublin, the capital, has (in relative terms) managed to squeeze in a higher proportion of its population on the existing fabric than any other city, but also has undergone enormous expansion of fabric and people. Cork has performed best when the raw building data is inspected, though overall growth in Cork City was perhaps limited by the growth of its strong regional towns, and its hilly geography. Limerick has seen significant sprawl occurring, especially to the East as its university continues to expand.

Drawing together literary explanations, this paper hypothesises two overarching drivers of why Ireland's cities tended to expand more than densify: urban expansion suited Ireland's "vested interests" and is more in line with Ireland's cultural apathy towards "the urban". Finally, though it provides a more geographic analysis of these patterns, there is a thorough economic grounding in this paper, and the decision to densify or expand a city has and will continue to have profound economic consequences of its users.

Further research on the Irish context can look at beginning to search for causal relationships à la Broitman and Koomen (2015) around densification or look at regulatory changes (such as financial deregulation at the end of the 1980's). Much of the literature in an Irish context has focused on the primary city of Dublin, but there is a general lack of literature on densification on smaller cities specifically (Broitman and Koomen (2020) do examine cities of differing size but do not engage much on if their differing size matters). Another observation made by Brady (2016) and McCafferty (2019) note the population increases in Ireland's towns and villages across the country, which exhibited growth rates far surpassing Ireland's second-tier cities. Such an exploration has been partially begun by O'Donoghue (2017), but further research is necessary here.

As shown in Tables 5 and 6, there appears to be some recent divergence between Dublin's increased densification and the other city's move towards expansion. There has been a well-documented

supply shortage in Ireland, and new houses may be more likely to be “one-off housing” in rural areas funded by individuals, rather than larger-scale developments on the urban fabric or fringe, leading to this dichotomy.

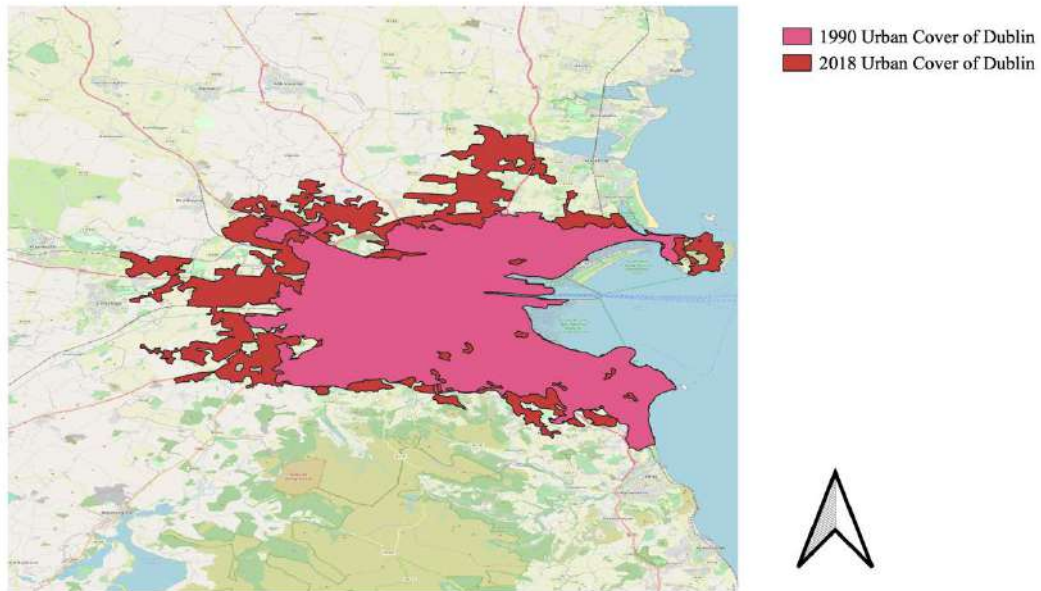
However, it may also reflect different attitudes. Dublin city planners recently declared that the days of the three-bedroom semi “are over” (Kelly, 2021), (though a chillingly similar pronouncement was suggested 23 years ago (Hogan, 1998)). In Cork meanwhile, the county council still emphasises the role smaller towns would play in accommodating the region’s increasing population (O’Riordan, 2021).

The various benefits and costs of densification have already been explored above, and Ireland must bear the consequences of its decision to construct in an expansionary, low-density fashion. So, what for the future? Ireland’s population is due to get older and continue to fall in household size (PII, 2019). The latter has been identified as a driver of densification (Broitman and Koomen, 2015 and Rérat, 2019) while the former has been predicted to be (Lauf, Haase and Kleinschmit, 2016).

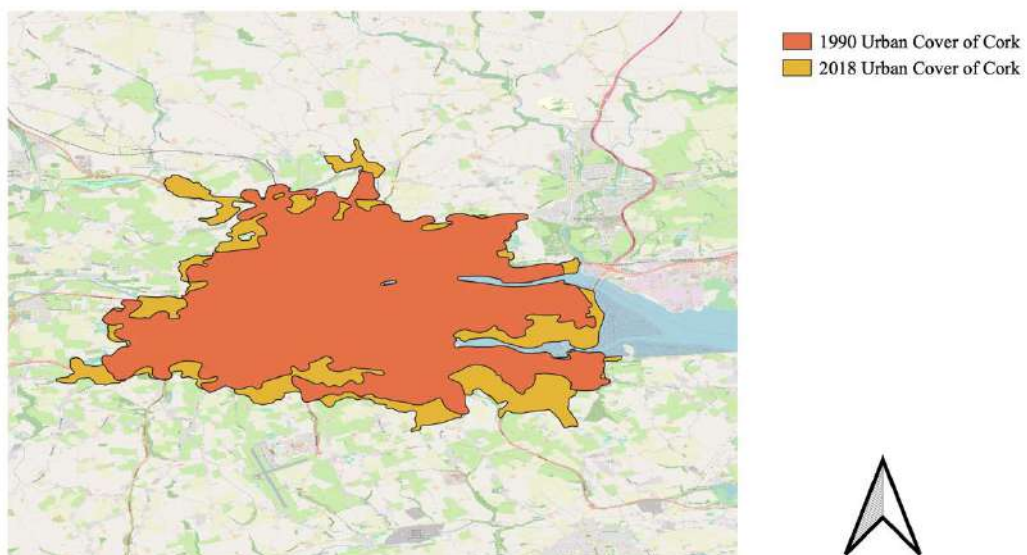
By 2040, it is expected that there will be more people living in one and two person households than in four-person households in Ireland (PII, 2019). Is it viable that these people will all live in low-density, low-rise housing estates? Increased densification in Ireland is important for many reasons, but demographically, increased densification will simply be a necessity.

8. Appendix

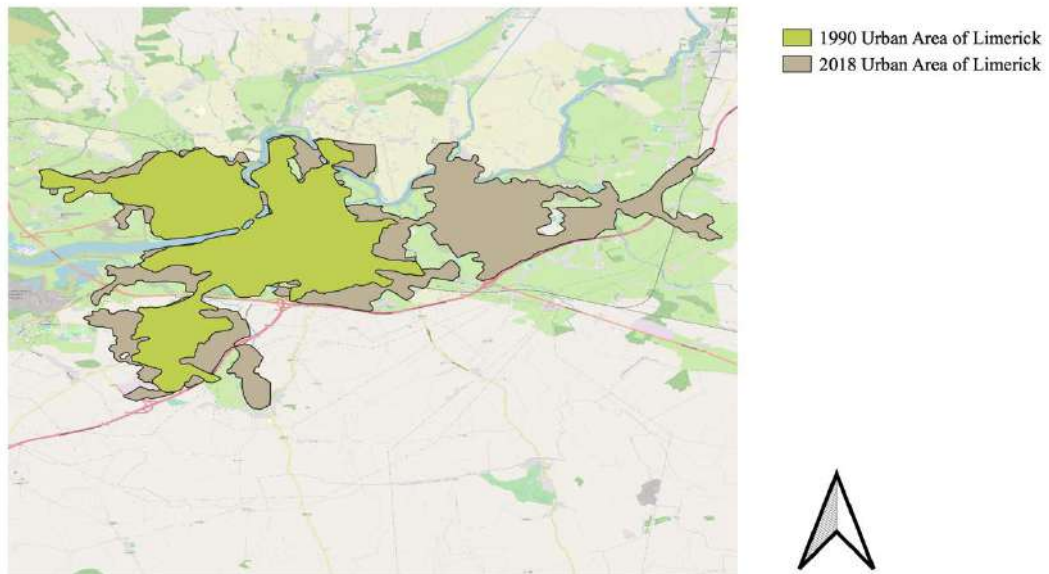
Map A: Dublin City Urban Cover: 1990 and 2016 (Corine Land Cover)



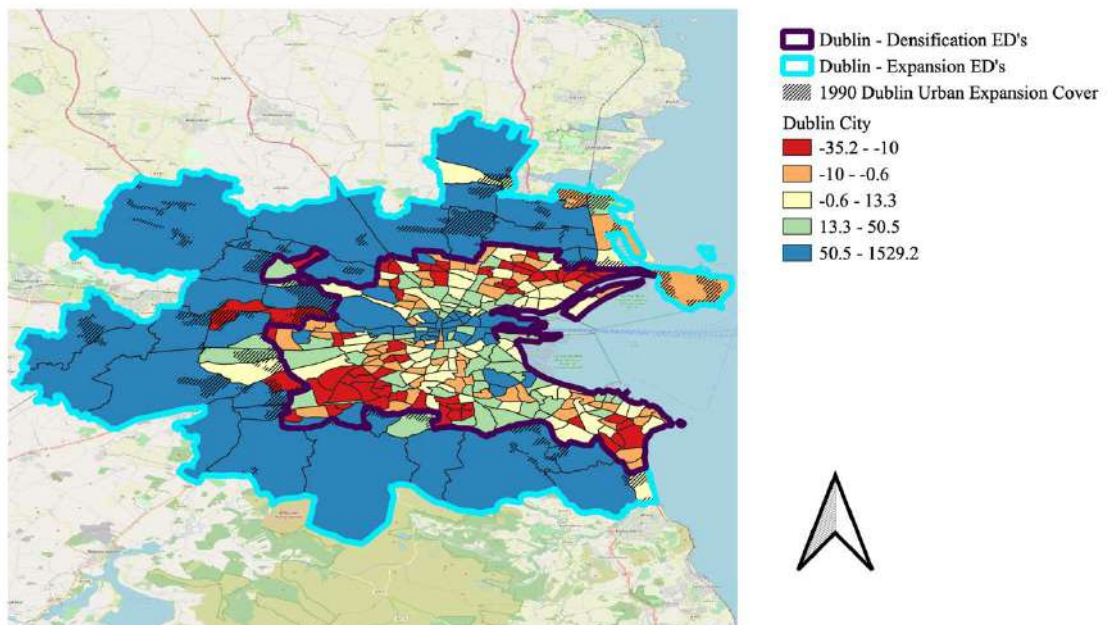
Map B: Cork City Urban Cover: 1990 and 2016 (Corine Land Cover)



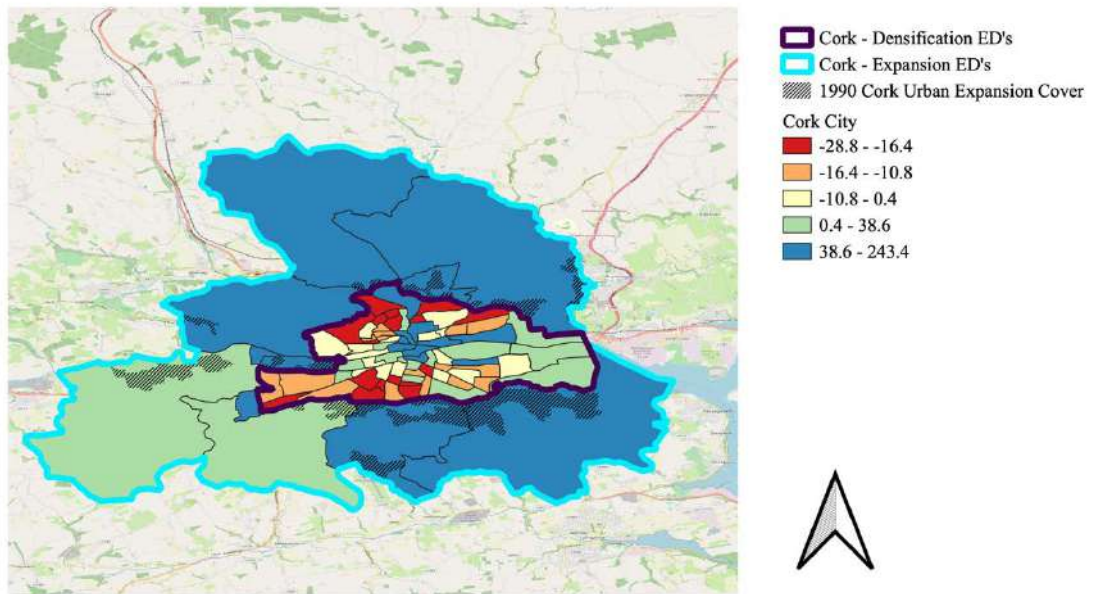
Map C: Limerick City Urban Cover: 1990 and 2016 (Corine Land Cover)



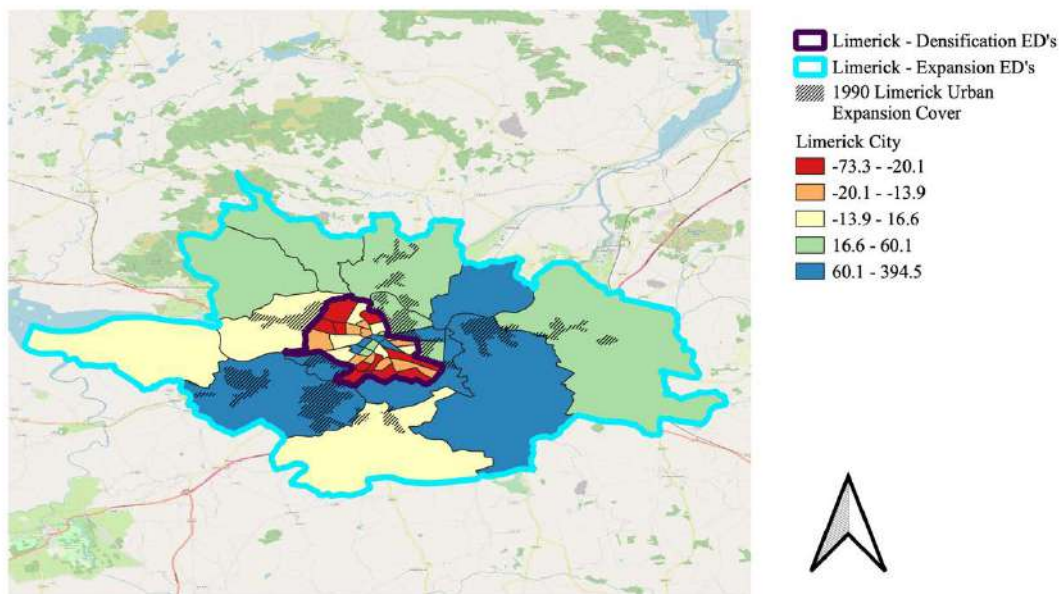
Map D: Densification vs Expansion in Dublin City 1996 - 2016 by Electoral Division



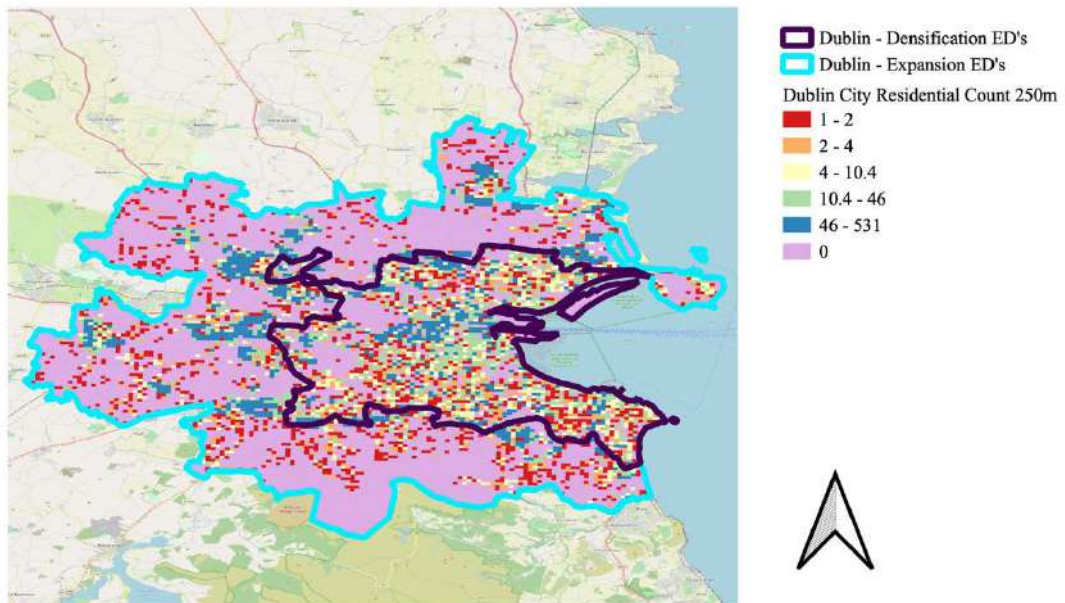
Map E: Densification vs Expansion in Cork City 1996 - 2016 by Electoral Division



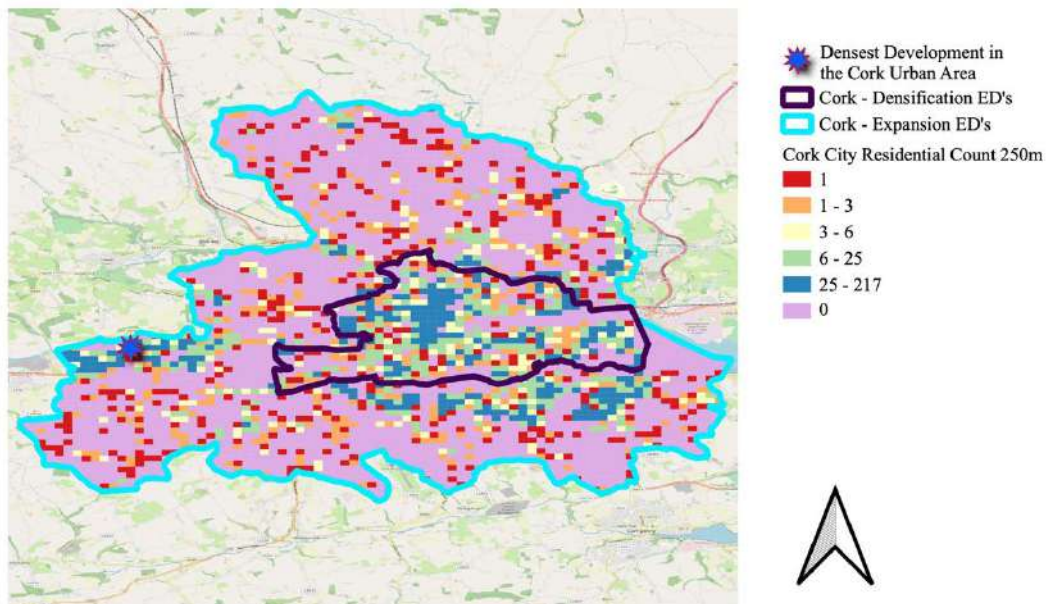
Map F: Densification vs Expansion in Limerick City 1996 - 2016 by Electoral Division



Map G: Residential Densification vs Expansion in Dublin City 1999 - 2021 by 250m Grid



Map H: Residential Densification vs Expansion in Cork City 1999 - 2021 by 250m Grid



Map I: Residential Densification vs Expansion in Limerick City 1999-2021 by 250m Grid

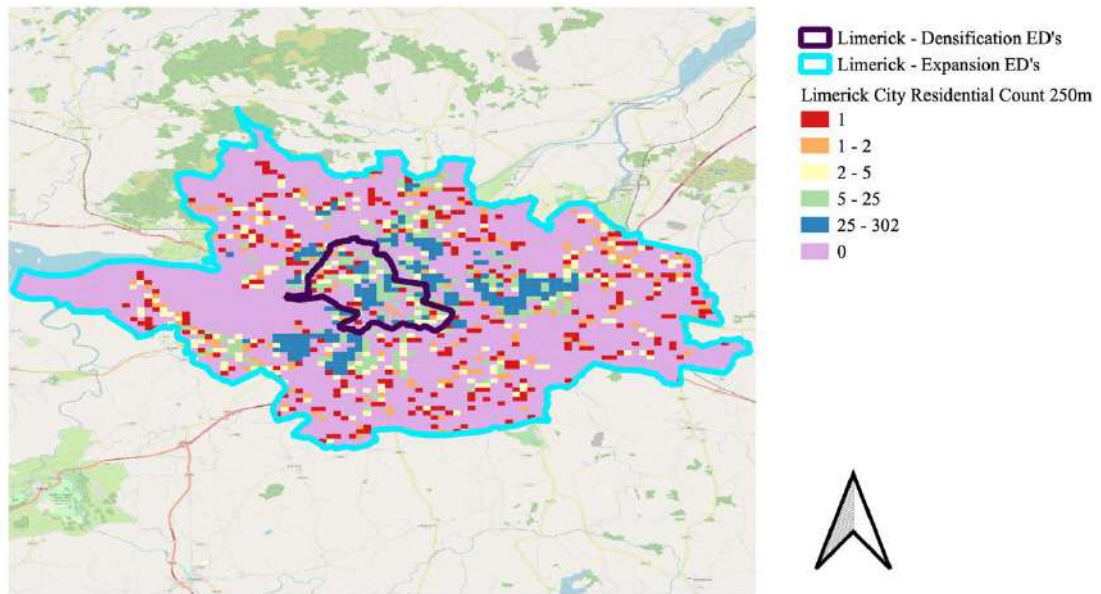


Figure A: Percentage change in population in Dublin ED's
1996-2016

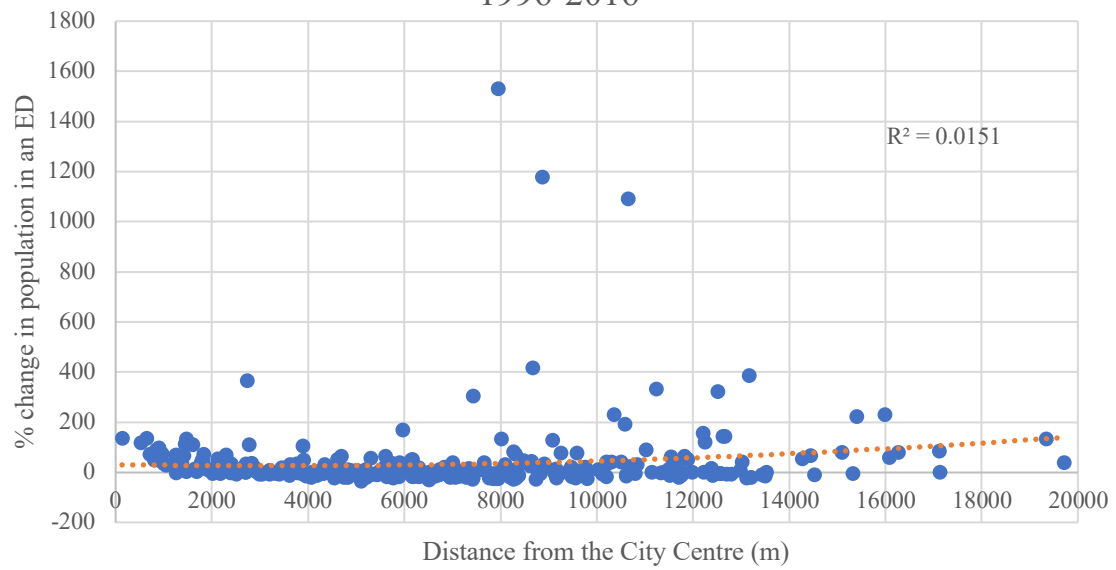
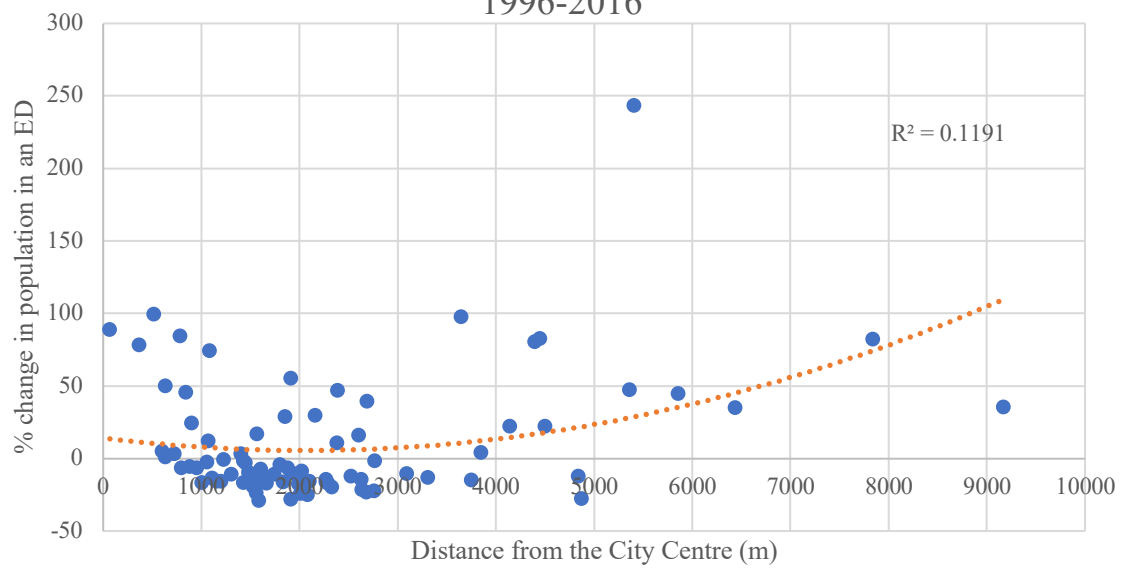


Figure B: Percentage change in population in Cork ED's
1996-2016



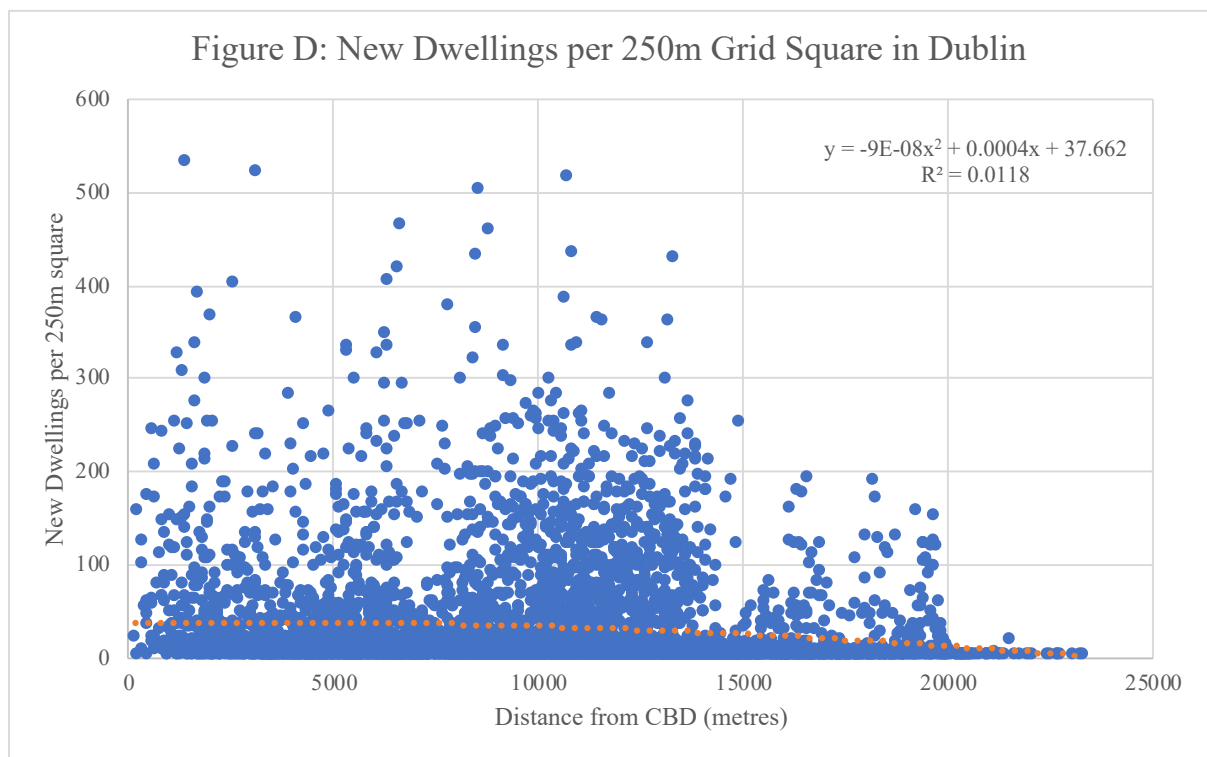
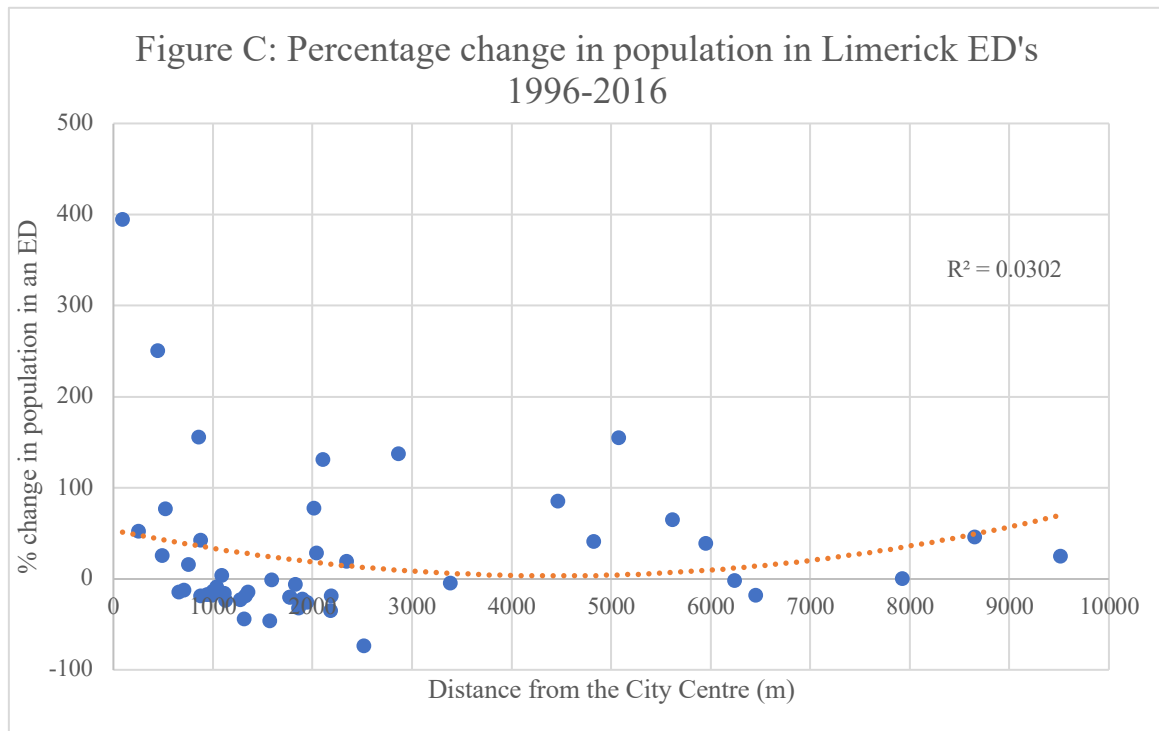


Figure E: New Dwellings per 250m Grid Square in Cork

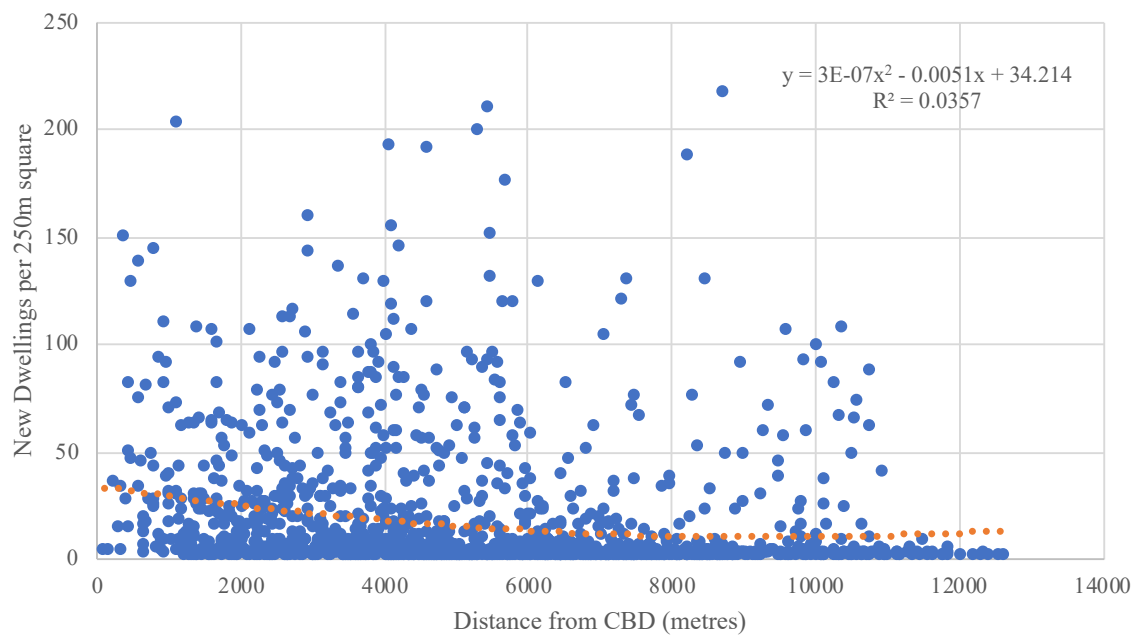


Figure F: New Dwellings per 250m Grid Square in Limerick

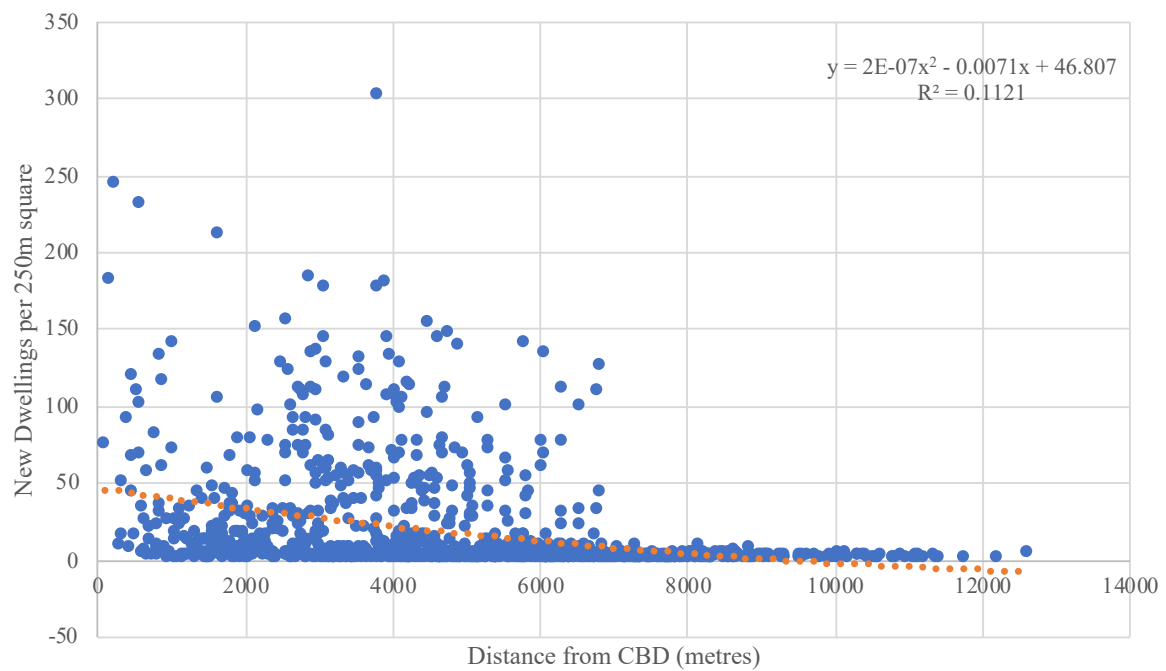


Figure G: Density Gradients of Dublin (ED's)

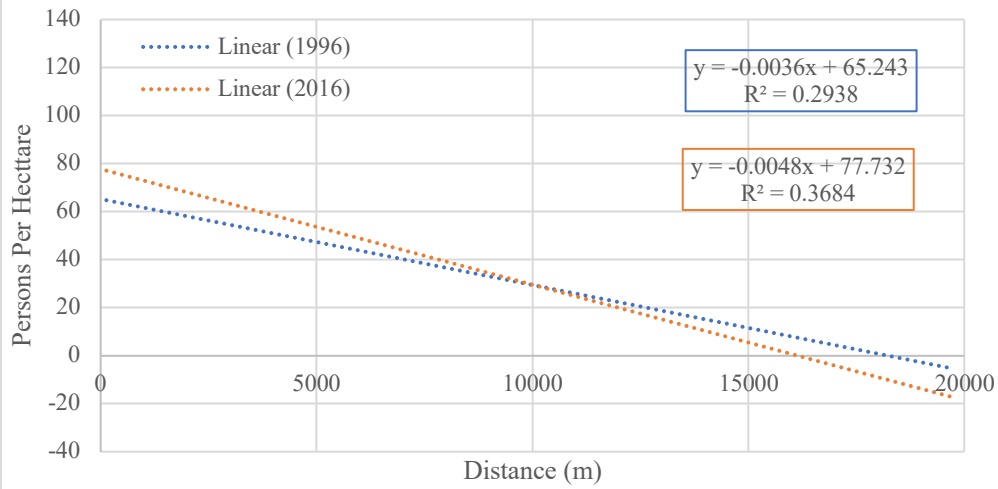


Figure H: Density Gradients of Cork (ED's)

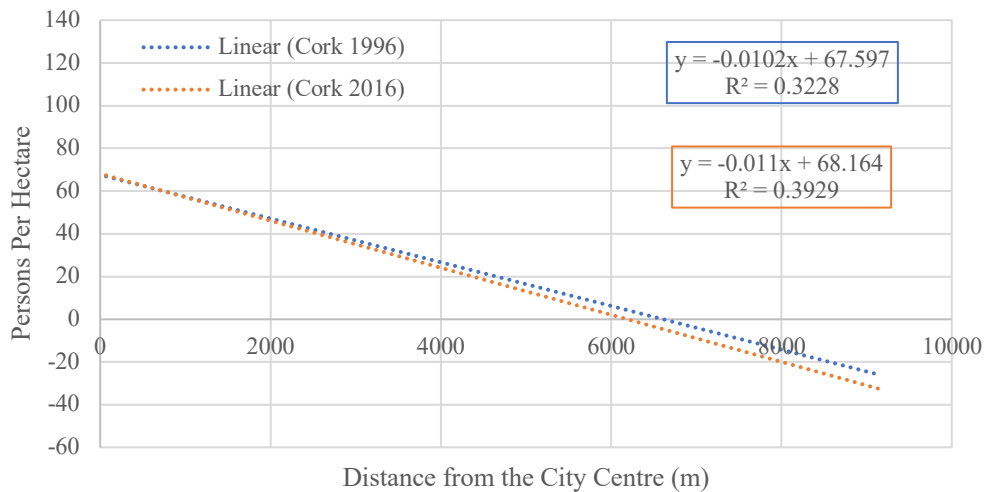


Figure I: Density Gradients of Limerick (ED's)

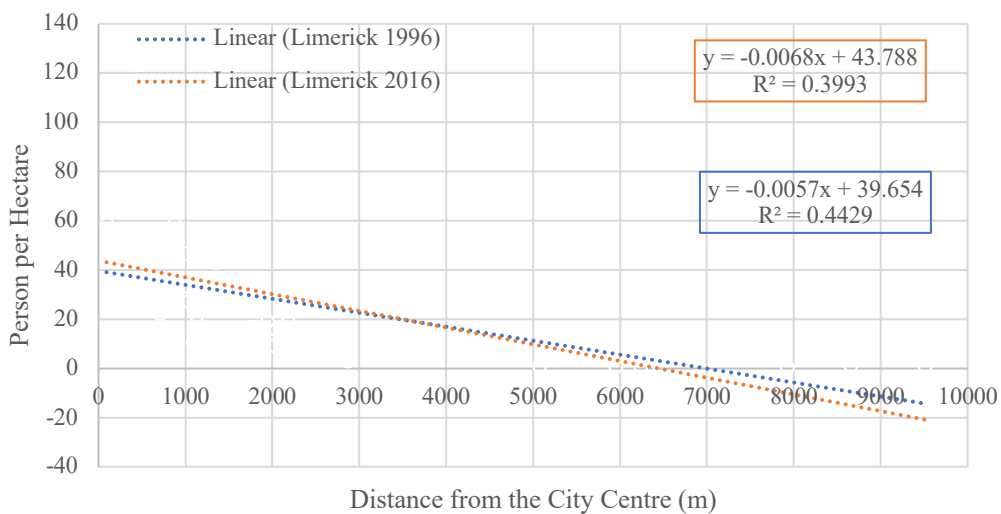


Figure J: Density Gradients of Dublin (500m Rings)

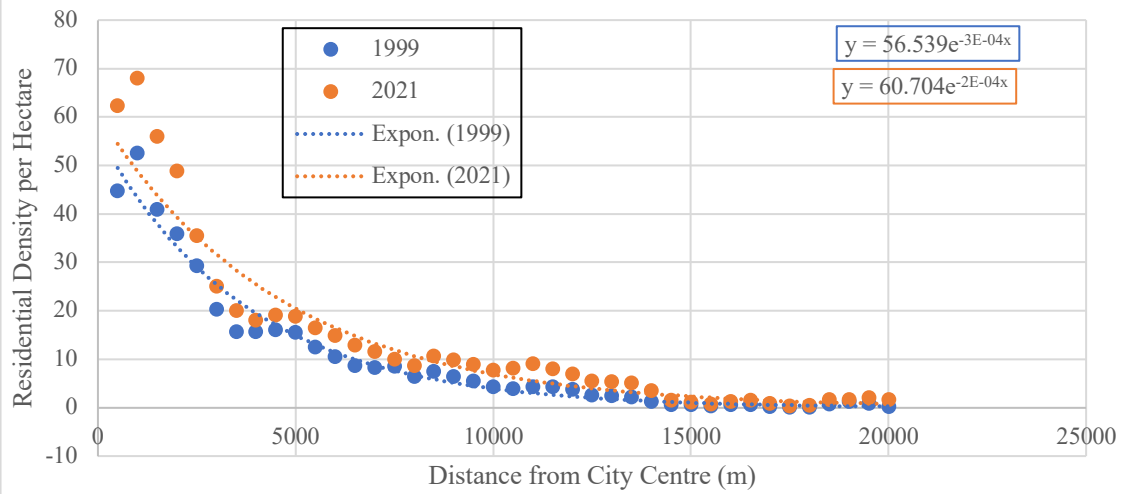


Figure K: Density Gradients of Cork (500m Rings)

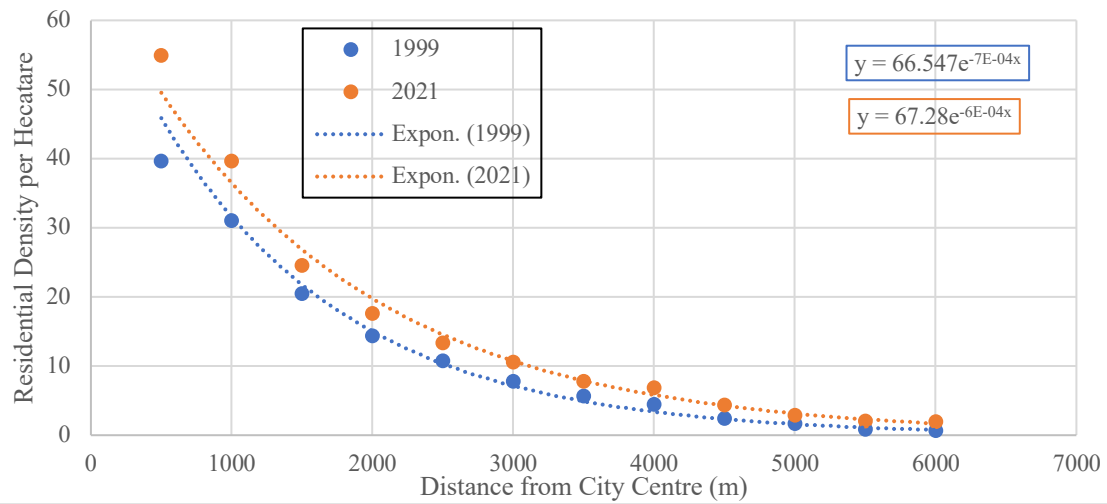


Figure L: Density Gradients of Limerick (500m Rings)

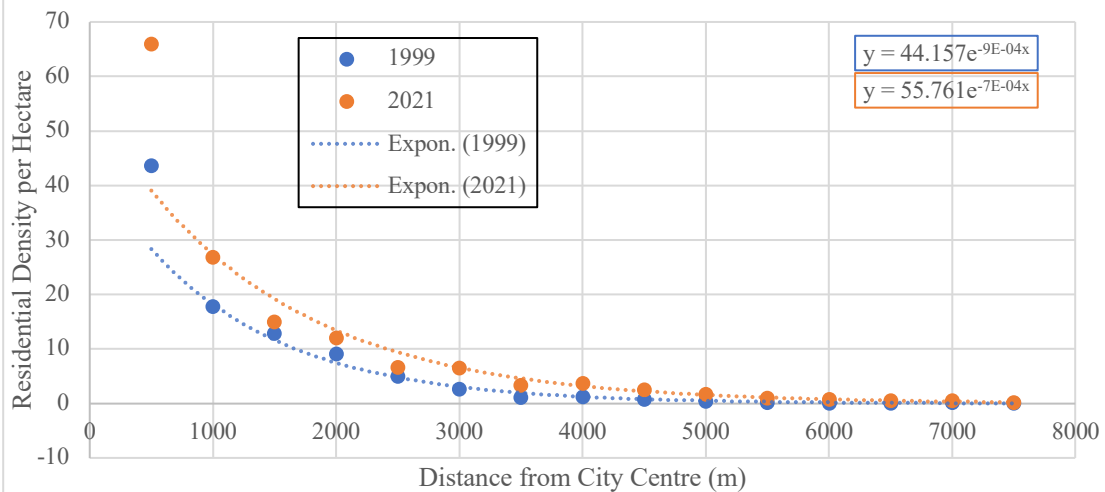


Figure M: Relative Density Change of Cork 1999-2021
(500m rings)

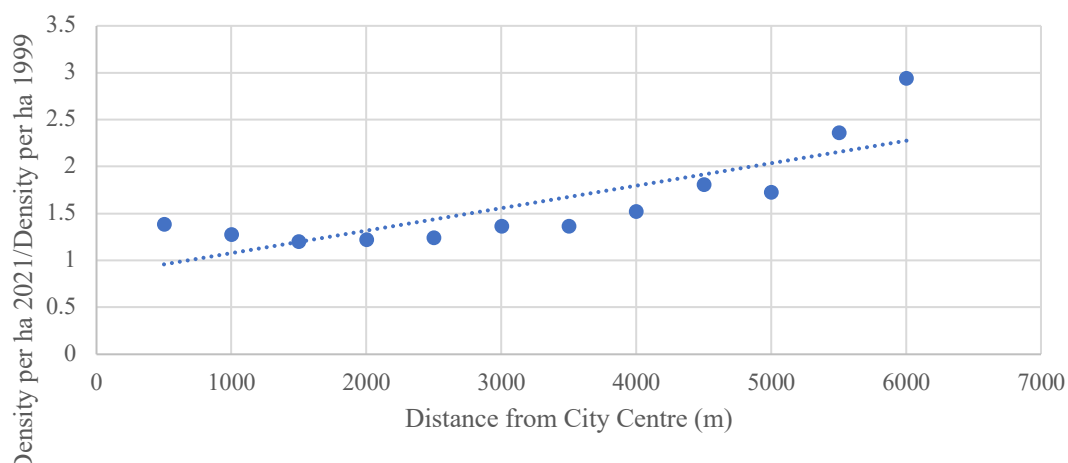


Figure N: Relative Density Change of Dublin 1999-2021
(500m rings)

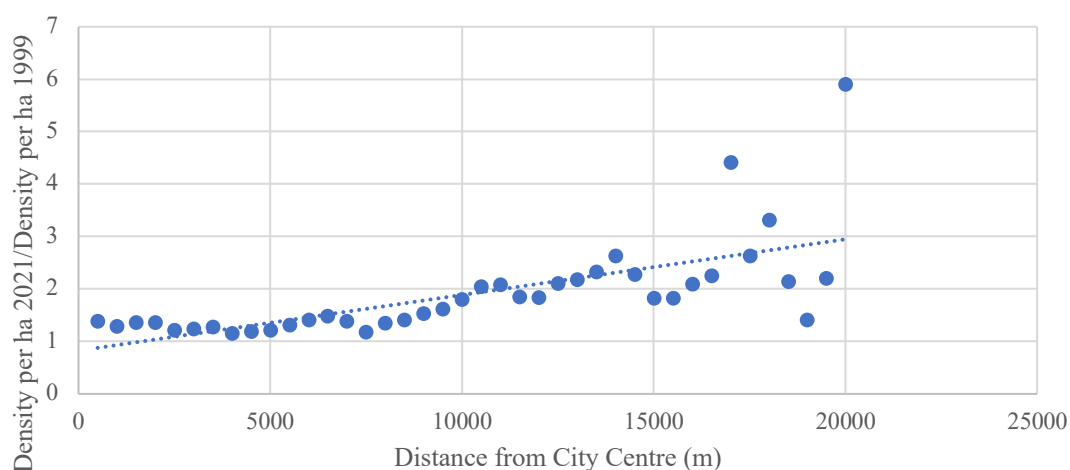
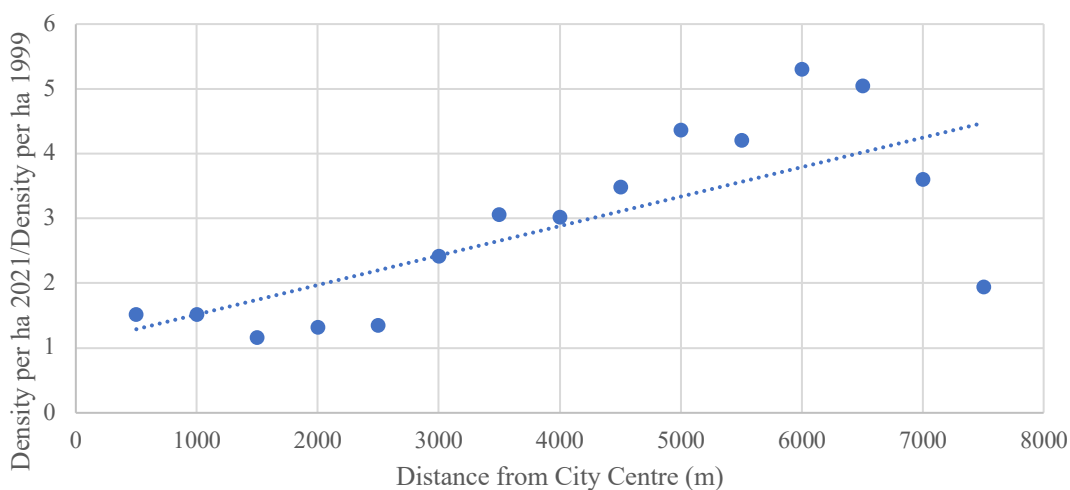


Figure O: Relative Density Change of Limerick 1999-2021
(500m rings)



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